This is a reproduction of a library book that was digitized by Google as part of an ongoing effort to preserve the information in books and make it universally accessible.

Google books

https://books.google.com

1890-91
RECAP
9280
.329

32101 050973591

Digitized by Google

Princeton University Library
32101 050973591

9280
.329

Library of
Princeton University.

Dei Sub Numine Viget

Brackett Library
Palmer Physical Laboratory

Presented by
Stephen S. Palmer
David B. Jones
Thomas D. Jones

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

VOLUME XXVI.

FROM NOVEMBER 7, 1890, TO MAY 1, 1891.

(RECAP)

LONDON:
Printed and Published for the Proprietors by GEORGE TUCKER, at the Offices of "THE ELECTRICIAN," Salisbury-court, Fleet-street, E.C.

1891.

Digitized by Google

# INDEX TO "THE ELECTRICIAN."

# VOL. XXVI.

## General Alphabetical Index.

### A


Aberdeen, 687.
Accumulator, Traction, 563, 659.
Accumulators, see Secondary Batteries.
Accumulators, A Charge Indicator for, 98.
Accumulators, High Discharge, 161.
Acid-resisting Varnish, 778.
Acquisition of the Telegraphs by the United States Governments 317.
ADDENBROOKE, G. L.
  Transformer Distribution, 599, 642.
Adelaide, 596.
Aden-Bombay Cable, Triplicate, 563.
African Cables, 687.
Agitation, The Telegraph in Times of, 594.
Agreements between Supply Companies and their Customers, 95.
Air Resistance at High Speeds, 162.
Alkaline Accumulator, 195.
Alternate Current Electric Mining Plant, 689.
Alternate Current Instruments, Some Practical Methods for the Determination of Inductive Resistances and Self Induction of: by Chas. Steinmetz, 79.
Alternate Currents through Concentric Cables, On the Propagation of: by Dr. J. A. Fleming, 258.
Alternate Current Condensers, 192.
Alternate Current Condensers: by Jas. Swinburne, 214, 260.
Alternating Current, Rectifying, 779.
Alternating Current Influence Machines: by James Wimshurst, 764.
Alternating Currents of Very High Frequency, Phenomena of: by Nikola Tesla, 549.
Alternating Currents of Very High Frequency, Notes on: by Prof. Elihu Thomson, 615.
Alternating Currents and Mathematics, 298.
Alternating Electric Arc between a Ball and a Point: by Ed. L. Nichols, 412, 429.
Alternating Electromotive Forces, The Striking Distances of: by Robert Shand, 518.

**Alternators—**
  Kingdon Inductor, 610.
  Westinghouse Arc Light, 20.
Alternators, The Coupling of, 394.
Aluminium Alloys, New, 288.
Aluminium, Electro Deposition of, 194, 778.
Aluminium Fluoride, Analysis of: by Adolphe Minet, 87.
Aluminium in the Electric Arts, 4.
Aluminium, Properties of, 661.
Aluminium Trolley Wheels, 162.
"Amber," The, 595.

**American Notes**, 20, 117, 155, 180, 216, 245, 278, 312, 339, 404, 433, 463, 495, 553, 585, 619, 651, 680, 709, 739, 767, 798.
American Patent System, A Century of the, 474.
Amsterdam, 778.
ANSELL, HAROLD W.
  Capacity of Submarine Cables, 168.
Antwerp, 3, 64, 688.
Arc and Incandescent Street Lighting in Paris, 319.
Arc (Electric) and its Use in Lighting: by Elihu Thomson, 562, 577.
Arc, Flow of Current through an Electric, 565.

**Arc Lamps—**
  Henderson Multiple Carbon, 352.
  Japy-Helmer, 470.
  Patin Alternate Current, 496.
Arc Lamps, Candle Power Classification of, 64.
Arc Lighting in the States, 321.
Arc Lights and Insects, 288.
Arc Lights, Some Remarks on Herr H. Luggins' Work on the Mode of Conduction in: by F. Uppenborn, 767.
Armature Cores, Graphic Method for Analysing Losses in, 700.
Armature Reaction, 531.
Aron Meter, 129.
Artificial Light of the Future: by Prof. Edward L. Nichols, 147.
Athens, Electric Light Station, 503, 718.
Atlantic Cable, the Laying of the First, 29.
Atlas Accumulator, 484.

**Australian Notes**, 405, 495.
Australian Cable Rates, 97, 474, 719, 728.
Austrian Telegraph Statistics, 751.
Automatic Temperature Compensation for Voltmeters, 128.
AYRTON, Prof. W. E.
  Measurement of the Power given by any Electric Current to any Circuit, 736.
  Notes on the Chemistry of Secondary Cells, 102, 127, 140, 176, 191, 215.
  On the Rise of Potential Difference in the Deptford Mains, 260.
  Proof of the Generality of Certain Formulæ published for a Special Case, by Mr. Blakesley. Tests of a Transformer, 540.


### B


BAILEY, F.
  Electric Lighting Progress in London, 159, 206.
Bale, 3.
Barking Road Line, 193, 286, 471, 562.
Barnsley, 129, 505.
BARR, PROF.
  On the Use of the Lantern in Class Room Work, 105.
Bath, 63, 445, 717, 752.

**Batteries (Primary)—**
  Hellsen Dry, 419.
  Messerole Dry, 226.
  Perrier-Lloyd, 352.

**Batteries (Secondary)—**
  Atlas, 484.
  Electric Storage Battery Company's Accumulator, 5.
  Experimental Storage Cell, 506.
  James, 751.
  Reynier Elastic, 113.
  Tommasi, 130.
  Woodward, 351.
Bavaria and Wurtemburg, Telephone Extensions in, 630.
Beacons, Electric Light, 162.
BELL, DR. LOUIS.
  Report of the Committee on the Proper Classification of the Lighting Power of Incandescent Lamps, 682.
Belting, 564.
Belts, Tight, 453.
Berlin, Electric Lighting of, 353, 444, 778.
Berlin, Proposed Exhibition at, 717.
Berlin, Telephone in, 286.
Berlin-Vienna Telephone Trunk Wire, 631.
Bernados Welding Process, 161.
Bibliography of Recent English Electrical Literature, 194.
BIDWELL, SHELFORD.
  Some Experiments with Selenium Cells, 213.
Bills of the Session, Electrical, 446, 473, 503, 717, 751.
Birmingham, Electrical Inspector for, 503.
Birmingham Electric Lighting, 751.
Blakesley's Method of Measuring Power, 529.
BLAKESLEY, T. H.
  Further Contributions to Dynamometry, 541.
  The Solution of a Geometrical Problem in Magnetism, 170.
Blast Furnace Use, Magnet for, 225.
Blasting, Electric, 564.
Board of Trade and the Protection of Telephones, 629.
Board of Trade Overhead Wire Regulations, 95, 112.
Board of Trade Rules, More, 424.
Board of Trade Unit, 563.
Boiler Competitions, 476.
Boiler Waters, An Indicator of Acidity in, 476.
Bombay, 63.
Boston Street Railway Power Station, 4, 717.
Boy Messengers and the Postmaster General, 562, 593, 751.
BOYS, C. V.
  On the Measurement of Electromagnetic Radiation, 286, 302, 335.
Bradford Municipal Station, 413.
Bremen, 194, 688.
Bridge Method when used for Periodic Currents, Lord Rayleigh on the Sensitiveness of, 777.
Brighton, 2, 352, 503, 687.
Brighton Grand Hotel, Electric Lighting of, 474.
Bristol, 129, 193, 583, 386, 631, 717.
British Association Meeting at Cardiff, 501.
British Guiana Cable, 96, 129.
British Museum, Electric Lighting of, 657, 685.
Bromley Local Board, 3, 28.
Brush Double Carbon Arc Lamp Patent, 318.
Buckingham Electric Light and Power Company, 253.
Buda Pesth Electric Tramway System, 169.
Buda Pesth, Telegraph and Telephone Wires in, 530.
Buffalo (N.Y.), Electric Railroading at, 64, 475.
Bunsen Photometer, Mr. Boulouch on the Theory of, 224.
Burmah, Telegraphic Extension in Upper, 779.


### C


Cable and Land Line Repairs, 688, 778.
Cable Cores, Testing the Centrality of: by Paul Le Goaziou, 80.
Cable Extensions, 97, 161, 194, 351, 444, 564, 778.
Cable Rates, Australian, 97, 563.
Cables, On the Determination of the Capacity of Long Submarine: by Arthur Dearlove, 537, 658.
Calais, Electric Transmission of Power at, 31.
Calais Submarine Cable Works, 161.
Calcutta-Bombay Telegraph Line, 27, 473, 631.
Cambridge, 287, 752.
Cambridge, Engineering at, 668.
Cambridge, Professorship of Mechanics at, 30, 351.
Canadian Government Telegraph and Signal Service, 52.
Canada, Proposed International Exhibition in, 29.
Candle-power Classification of Arc Lamps, 64.
Capacity and Self-Induction in Alternate Current Working: by Gisbert Kapp, 197, 229.
Carpenter-Nevens Electric Car Heater, 226.
Cars on Heavy Gradients, Electrical, 162.
Cataphoric Medication, 629.
Celluloid Covered Wire, 473.
Cement for Leather Belts, 778.
Census Counter, Electrical, 225.
Centesimal Method of Measuring Angles, 630.
Centimetre to Inch, Ratio of, 687.
Central Institution, 287, 778.
Central Lighting Station as an Investment, 195.
Central Lighting Stations of the United Kingdom, 274.
Central London Railway, 62, 353, 561, 564.
Central Station Lighting, Miniature, 287.
Central Stations of the Metropolitan Electric Supply Company: by Dr. J. A. Fleming, 9, 69, 107, 129.
Central Station Supply—Isolated Plants, 777.
Central Station, The most favourable Position for an Electric Light: by Dr. A. Föppl, 88.
Central Station Statistics, The Interchange of, 106.
Charge Indicator for Accumulators, 98.
Charging Stations for Thames Launches, 687.
"Chattering" on Overhead Circuits, Diminution of, 595.
Chelmsford, Electric Lighting of, 129, 287, 444.
Chelsea Electricity Supply Company and its Customers, 159, 163, 223, 226.
Chelsea Overhead and Underground Wires, 594.
Chelsea System, 383.
Chelsea Vestry, 532.
Chemical Society, 413, 504.
Chemical Union, Operations and Electrolytic Methods of Bleaching, 27.
Chemistry of Secondary Cells, Notes on the: by Prof W. E. Ayrton, C. G. Lamb, and E. W. Smith, 102, 127, 140, 176, 191, 215.
Chemical Elements, On certain Relations existing among the Refractive Indices of: by Rev. T Pelham Dale, 112.
Chemnitz, 2.
Chicago Exhibition, 65, 252, 319, 321, 501, 511, 751.
Chlorine, Action of Silent Discharge on, 447.
Chloro-Chromic Acid Battery, A Useful Application of, 531.
Choking Coils and Condensers in Connection with Constant Current Work, The Employment of, 750.
City and Guilds of London Institute, 98, 131.
City and South London Railway, 9, 12, 28, 97, 101, 129, 191, 285, 287, 317, 352, 385, 446, 504, 594, 631, 688.
City of London Electric Lighting (Pioneer) Company, 443.
City Notes, 25, 59, 93, 125, 157, 189, 221, 249, 283, 315, 347, 381, 409, 441, 469, 499, 527, 559, 591, 627, 655, 683, 713, 747, 805.
City, The Lighting of the, 193, 411, 415, 454, 505, 563, 632.
Civil Engineers, Institution of, 129, 254, 287, 317, 319, 530.
Coal Consumption, Curious Case of Increased, 751.
Coal Mines, Electricity in American, 194.
Coast Defence, Electric Light for, 687.
Coast Telegraphic Communication, 631.
Coffin Electric Welding System, 3.
Collection of Electrical Data, 27.
Colliery Lighting, 288, 473.
Cologne, 779.
Commutator, Davis and Stokes' Safety 630, 717.




Digitized by Google

**COMPANIES' MEETINGS, REPORTS, DIVIDENDS, &c.**

(Abbreviations:—Div., Dividend; Mtg., Meetings of Shareholders; Rev., Revenue; Rpt., Reports of Directors.)

African Direct Telegraph Company—249.
Allchin, Linnell and Co.—249, 381.
Anglo-American Telegraph Company—Rpt., 380; Div., 381, 747; Mtg., 437.
Anglo-Portuguese Telephone Company—249.
Austrian Electrical Company—315.
Bell's Asbestos Company—Div., 469; Mtg., 527.
Blackpool Electric Tramway Company—Mtg., 125.
Brazilian Submarine Telegraph Company—Rev., 25, 59, 93, 125, 157, 189, 221, 249, 283, 315, 347, 381, 409, 441, 469, 499, 527, 559, 591, 627, 655, 683, 713, 747, 775; Div., 157; Rpt., 804.
Brighton and Hove Electric Light Company—Rpt., 627; Mtg., 653.
British Insulated Wire Company—25.
British Tanning Company—Mtg., 590, 683.
Brush Electrical Engineering Company—771; Div. 527.
Cadogan Electric Light Company—Mtg., 591.
City of London Electric Lighting (Pioneer) Company—469.
City and South London Railway Company—Rev., 315, 347, 381, 409, 441, 469, 499, 527, 559, 591, 627, 655, 683, 713, 747, 775, 805; Rpt., 467; Mtg., 439, 522.
Commercial Cable Company—881; Div., 157, 591.
Continental Metropolitan Tramways Company, 805.
Cowle's Syndicate—Mtg., 249, 805.
Crompton and Co., Div. 221.
Cuba and Submarine Telegraph Company—Rev., 25, 157, 315, 469, 559, 683; Div., 409; Rpt., 441; Mtg., 467.
Direct Spanish Telegraph Company—Rev., 25, 189, 315, 441; Div., 559; Rpt., 591.
Direct United States Cable Company—Div., 315, 747; Rpt., 347; Mtg., 349, 623; Rev., 713.
Eastern and South African Telegraph Company—25, 93, 221, 381.
Eastern Telegraph Company—347, 381, 591, 775; Rev., 25, 157, 315, 441 559, 713; Div., 221; Mtg., 343, 348.
Eastern Extension Telegraph Company—Rev., 25, 157, 315, 441, 559; Mtg., 92, 772; Div., 221, 713; Rpt., 745.
Edison and Swan United Electric Light Company—Div., 469.
Electric Construction Corporation—347, 559; Div., 93; Rpt., 124; Mtg., 185.
Electrical Automatic Delivery Box Company—249.
Electricity Supply Company for Spain—409.
Elmore's Foreign and Colonial Copper Depositing Company—249, 655, 682; Mtg., 282, 407, 711, 804; Div., 409.
Elmore's French Patent Copper Depositing Company—315; Mtg., 345.
Elmore's Austro-Hungarian Company—713; Mtg., 381, 408.
Excelsior Copper Company—Mtg., 249, 315.
Foreign Electric Date and Time Stamp Company—713.
Foreign and Colonial Elmore Patent Copper Depositing Company—Div., 93.
Fowler-Waring Cables Company—Mtg., 157, 185.
General Austrian Electricity Company, 381.
Globe Telegraph and Trust Company—Div., 347, 713.
Great Northern Telegraph Company—Rev., 25, 157, 315, 469, 591, 713; Div., 221, 747.
Greenwood and Batley—Div., 221.
Gulcher (New) Electric Light and Power Company—Rpt., 189; Mtg., 219.
Hastings and St. Leonard's-on-Sea Electric Light Company—Mtg., 468.
Henley's Electric Light and Power Company—Mtg., 249.
Henley's Telegraph Works—Mtg., 249, 283.
Hornsby and Sons, R.—Div., 93, 189.
Hoster, Albert—315.
Hoster di St. Nicolas, Ateliers—315.
India Rubber, Gutta Percha and Telegraph Works Company—Rpt., 469; Mtg., 498.
Indo-European Telegraph Company—Mtg., 800.
International Okonite Company—Div., 315.
Kelvinside Electricity Company—59.
Keswick Electric Light Company—Rpt., 526.
Libiolia Copper Company—Mtg., 591.
Liverpool Electric Supply Company—Mtg., 525.
Liverpool Overhead Railway Company—Mtg., 469.
London Electric Supply Corporation—Rpt., 589; Mtg., 621.
London Platino Brazilian Telegraph Company—527; Div., 775.
Manchester Edison-Swan Company—Mtg., 526.
Manganese Bronze and Brass Company—Div., 381.
Manitoba Electric and Gas Light Company—Div., 249.
Maxim-Weston Electric Company—Mtg., 381.
Metropolitan Electric Supply Company—Rpt., 24, 775; Mtg., 56, 801.
Middlesborough (U.S.A.) Electric Light, Heat and Power Company—25.
Montevideo Telephone Company—Mtg., 22.
Montevidean and Brazilian Telegraph Company—59; Mtg., 120, 184.
Muntz Metal Company—Div., 527.
National Telephone Company—Div., 189; Mtg., 376; Rev., 559.
New Shanghai Electric Company—Rpt., 747.
New York Belting and Packing Company—Mtg., 655, 713, 746.
Oriental Telephone Company—805; Div., 591; Rpt. 712; Mtg., 744.
Vetzold and Co.—747.
Phonopore Syndicate—Mtg., 249.
Poole and White—Mtg., 712.
Portrush Electric Tramway Company—Mtg., 499.

**COMPANIES' MEETINGS, &c.** (*continued*)—

Portsmouth and South Hants Electricity Supply Company—Mtg., 315.
Reuter's Telegraph Company—747; Mtg., 124, 188, 248, 803; Rpt., 774.
Ruston, Proctor and Co.—25.
St. James' and Pall Mall Electric Light Company—347, 713; Mtg., 524, 558.
Sanitas Company—527; Div., 529.
Simonds' Steel and Iron Forging Company 221.
Societe Anonyme d'Electricite Industrielle—527.
South of England Telephone Company—Mtg., 589, 625, 745, 774.
Spiet's Petroleum Engine Company—Mtg., 283.
Stock Exchange—25, 93, 125, 189, 283, 381, 527, 655, 805.
Submarine Cables Trust, 683; Rpt., 804.
Swan United Electric Light Company—Div., 59, 805; Rpt., 93; Mtg., 122.
Taunton, Delmard, Lane & Co.—93.
Taunton Electric Lighting Company—627; Rpt., 527; Mtg., 558.
Telegraph Construction and Maintenance Company—Div., 469; Rpt., 526; Mtg., 558.
Telephone Company of Austria—Div., 655.
Telephone Company of Egypt—Rpt., 627, 655.
United Asbestos Company—Mtg., 627.
United River Plate Telephone Company—221.
Venezuela Telephone and Electrical Appliances Company—Div., 347, 441.
Wenham Lamp Company—Div., 93.
West African Telegraph Company—527; Div., 249.
West Coast of America Telegraph Company—221, 775; Rev., 25, 157, 315, 469, 627.
West India and Panama Telegraph Company—Rpt., 24; Rev., 25, 93, 157, 315, 381, 441, 527, 558, 627, 713; Mtg., 56; Div., 775.
Western and Brazilian Telegraph Company—Rpt., 24; Rev., 25, 59, 93, 125, 157, 189, 221, 249, 283, 315, 347, 381, 409, 441, 469, 499, 527, 559, 591, 627, 655, 683, 713, 747, 775, 805; Div., 771.
Western Counties and South Wales Telephone Company—Mtg., 220.
Western Union Telegraph Company—409.
Westinghouse Electric Company—283.
Westminster Electric Supply Corporation—469; Mtg., 22, 524; Rpt., 498.
White's Asbestos Company—Mtg., 283, 381.
Woodhouse and Rawson United—499; Mtg., 314, 343; Div., 441.

**COMPANIES (NEW) REGISTERED**—

*The following Companies have been Registered under the Limited Liability Acts.*

Alice Street Foundry, 249.
Anglo-American Saw Mills Company, 125.
Aspinall's Enamel, 591.
Avon India Rubber Company, 249.
Birmingham Telegraph Factory, 314.
Brill Brick and Tile Company, 775.
British Hydraulic Company, 747.
Brown's Metallic Packing Company, 747.
Burgess and Co., 591.
Carbon Electric, 775.
Chagford and Devon Electric Light Company, 125.
City of London Electric Lighting (Pioneer) Company, 499.
Collier Audible Telephone Syndicate, 775.
Corifact Syndicate, 804.
Cuttriss, Wallis and Co., 804.
Dermatine Company, 683.
Donald (John), 283.
Edinburgh and Leith Safe Deposit Company, 683.
Electric Stores, 249.
Electrical Supplies and Fittings Company, 59.
*Electricity* and *Electrical Engineering* Newspaper Company, 125.
Electrolytic Syndicate, 125.
Evans, J. H. and Co., 25.
Farnshaw and Sons, 747.
Financial Exchange and Bureau, 125.
Foreign Electric Date and Time Stamp, 221.
Froude Hurrell Torpedo Company, 713.
Glass and Metal Engineering Company, 221.
Hindle (Robt.) and Co., 747.
Horsham Ironworks, 157.
International Electric Syndicate, 775.
Jarrow Forge and Engineering Company, 655.
Johnson, Mattey and Company, 747.
Kidd (J.) and Son, 249.
Lactite, 249.
Langness Copper Company, 683.
Leeds Copper Company, 409.
Liverpool and District Pulsion Telephone Company, 627.
London Electrical Tramways Company, 804.
London Metallurgical Company, 221.
London Rubber and Packing Company, 683.
Marine and General Automatic Company, 189.
Mathieson (Alexr.) and Son, 655.
Mazapil Copper Company, 527.
Mobbs and Co., 591.
Moss Bay Hematite Iron and Steel Company, 747.
New York Belting and Packing Company, 221.
New Zealand Electrical Syndicate, 283.
North-Eastern Telephone Company, 381.
Plenty and Son, 189.
Practical Electro-plating and Enamelling Co., 249.
Priest (John) and Son, 627.
Purdon-Walters Motor Syndicate, 249.
Richmond (Joseph) and Co., 559.
Rubber Trust Syndicate, 559.
Sampan Patent Railway Sleeper and Steel Plant Syndicate, 283.
Scott (Ernest) and Mountain, 125.
Shettleston Oil and Chemical Company, 221.
Shropshire Electric Light and Power Company, 469.
Sleeman Controlled Torpedo Syndicate, 157.
Societe Anonyme d'Electricite Industrielle, 527.
Societe D'Eclairage Electrique de Cannes, 499.
South Indian Railway Company, 157.

**COMPANIES (NEW) REGISTERED** (*continued*)

South Moulton Shirt and Collar Manufacturing Company, 189.
Southern Railway of Peru, 315.
Staffordshire Chemical Company, 747.
Steam Loop Company, 189.
Tewkesbury Agricultural and General Engineering Company, 469.
Tylor and Sons, 221.
Union Engineering Company, 747.
United Alkali Company 25.
United States Power Syndicate, 591.
Weybridge Electric Supply Company, 713.
Weymersch Electric Battery Syndicate, 157.
Companies' Share List, 26, 60, 94, 126, 158, 190, 222, 250, 284, 316, 348, 382, 410, 442, 470, 500, 528, 560, 592, 628, 656, 684, 714, 748, 776, 806.
Comparative cost of Arc and Sunbeam Lamps, 780.
Concentric Cables, On the Propagation of Alternating Currents through, by Dr. J. A. Fleming, 258.
Condenser introduced into an Alternate Current Circuit, The Effect of a: by Dr. Oliver Lodge, 762.
Conductivity of Stranded Wires, 412.
Conductivity under Different Electrical Influences, Variations of, 161.
Conduits, Indurated Fibre, 5.
Contacts of Short Duration, 192.
Contracts by Telephone, 352.
Copper, An Improved Process for the Production of, 292.
Copper, 30, 129, 163, 287, 385, 687.
Coral Growths on Submarine Cables, 163.
Core Losses, A Simple Method of Testing and Analysing the, 529, 655.
Corporation and City and Guilds of London Institute, 131.
Cost of the Generation and Distribution of Electrical Energy: by R. E. B. Crompton, 708.
Coventry, 473.
Cowles Process, 413.
Cranes, Electric: by R. Bolton, 490, 504.
CROMPTON, R. E. B.
Cost of the Generation and Distribution of Electrical Energy, 708.
Crookes, Prof. William, 322.
CROOKES, Prof. WM.
Electricity in Transitu from Plenum to Vacuum 323, 354, 389.
Croydon, 225, 531.
Curtis Conduit System, 446.
Customs Laws, Electricity and Natural Gas and the United States, 415.
Cutter Arc Lamps Supporting Pulley, 432.
Cylinder Lubrication, 688.

## D

DALE, REV. T. PELHAM
On Certain Relations existing amongst the Refractive Indices of the Chemical Elements, 112.
D'ARSONVAL, A.
A Method of Simultaneously Registering the Wave of Electrical Excitation and the Resultant Muscular Contraction, 666.
DEARLOVE, ARTHUR.
On the Determination of the Capacity of Long Submarine Cables, 537, 658.
De Morgan Medal, 163.
De Beers Mine Central Station, 131.
Deptford, 471.
Deptford Mains, On the Rise of Electromotive Force Observed in the: by R. T. Glazebrook, 232.
Deptford Mains, On the Rise of Potential Difference in the: by W. E. Ayrton, 260.
Determining the Difference of Phase of Alternating Currents, 473.
Devonshire, Telephone Extensions in, 64.
Dissociation of Carbon Dioxide Gas by the Electric Spark, 233.
Distribution of Electricity, with especial reference to the Chelsea System: by Major-Gen. C. E. Webber, 399, 420; Discussion, 491.
Disturbance caused by Electro-static and Electro-magnetic Induction between Telephone Circuits, Notes on the Relative Degree of: by A. E. Kennelly, 763.
DOULE, W.
Experiments on the Magnetisation of Thin Plates of Steel at Right Angles to their Plane, 216.
Dover, 225.
Drum Armature Winding: by F. M. Weymouth, 8, 37, 72, 100, 134, 165, 199.
Dry Piles, 412.
Dublin, Electric Lighting of, 338, 447, 472.
Dublin Telephone Wires, 129.
Dundee, 130.
Duplex Method, A Novel Application of, 384.
Duty on an International Telephone Cable, 563.
Dynamo Telegraph Plants, 31.
Dynamometry, Further Contributions to: by T. H Blakesley, 541.
**Dynamos**—
Edison Arc Light, 413.
Kingdon Inductor, 610.
Dynamos and Thermopiles, Comparative Efficiencies, 322.
Dynamos, Notes on, 236.
Dynamos, Notes on the Design of: by Felix Melotte, 646.

## E

East African Company's Land Lines, 351.
Eastbourne, 351.
Economy of Electric Lighting, Notes on the, 333.
Edinburgh Exhibition, 3, 63, 98.
Edinburgh Municipal Electric Lighting Order, 353.
Edison Company, New York, 385, 413.
Edison Underground Work in Boston: by A. C. Shaw, 82.
Effect of the Electric Spark on the Resistance of Bad Conductors, 350.



241979 = cop. 2

Digitized by Google

Eisenach Installation, 473.
Electric and Magnetic Screening: by Sir Wm. Thomson 722.
Electric Current and its Laws: by J. T. Sprague, 443 513, 543, 576, 608, 670, 697, 729.
Electric Light and the Defence of the Thames, 3.
"Electric Light Cables," 780.
Electric Light Mains in the West End, 659.
Electric Lighting, Founders of, 660.
Electric Lighting in London: by F. Bailey 59, 206.
Electric Lighting Memoranda, 386.
Electric Lighting Notices for 1891, 276.
Electric Lighting Orders, 779.
Electric Lighting Provisional Orders, 130.
Electric Lighting Statistics, 3.
Electric Ploughing, 29.
Electric Power, Introduction of, 30.
Electric Railway Advertiser, 130.
Electric Railway Device, 369.
Electric Railway, Notes on the: by F. L. Pope, 455.
Electric Railways and Tramways in the United Kingdom, 276.
Electric Railways, The Operation of, 242.
Electric Spark, On the Influence of, and of the Surrounding Gas on the Rate of Electric Discharge, 254.
Electric Street Railways at Minneapolis and St. Paul, 31.
Electric Traction, 63, 161.
Electric Traction in Marseilles, 531.
Austria, 530.
Berlin, 385, 631, 653.
Boston, 130, 445.
Brussels, 687.
Gera, 384.
Guernsey, 414, 631.
Naples, 286.
New South Wales, 563.
The United States, 225.
Electric Traction, Local Authorities and, 130.
Electric Traction Notices for 1891, 277, 287.
Electric Traction on the North Metropolitan System, 415.
Electric Traction on the South Staffordshire Tramway Company's System, 596.
Electric Traction, Pioneer, 661.
Electric Traction, Results of, 444.
Electric Traction, Series System of, 29.
Electric Traction Statistics, 751.
Electric Traction, Steep Gradient, 779.
Electrical Distribution by Transformers from Central and Eccentric Stations: by Dr. J. A. Fleming, 13, 42, 132, 196, 255, 300, 364.
Electrical Engineers, Institution of, 29, 63, 172, 173, 193, 286, 413, 473, 530, 658, 717, 778.
Electrical Industry in France, The Protection of, 128, 144.
Electrical Mutual Insurance, 475.
Electrical Oscillations, M. Lecher on, 318.
Electrical Standards Committee of the Board of Trade, 223, 443, 451, 503, 563.
Electrical Standardising Institution, 413, 475.
Electrical Trades' Union, 28, 96.
Electrically Welded Shells, 473.
Electricity and Gas in the United States, 29.
Electricity and Storms, 30.
Electricity in Transitu from Plenum to Vacuum: by Prof. W. Crookes, 323, 354, 389.
Electrolysis applied to Quantitative Analysis, 779.
Electrolysis, Some Points in: by J. Swinburne, 678.
Electrolytic Generation of Hydrogen and Oxygen, 506.
Electrolytic Preparation of Bleaching Agents: by A. Rigaut, 16, 45.
Electrolytic Preparation of Chlorate of Potash, 780.
Electro-Magnet—
By Prof. Silvanus P. Thompson, 17, 47, 83, 109, 151, 177, 200.
Electro-Magnetic Mechanisms: by Prof. S. P. Thompson, 238, 269, 293.
Electro-Magnetic Radiation: by Prof. A. L. Kimball, 27, 33, 77.
Electro-Magnetic Radiation, On the Measurement of: by C. V. Boys, A. E. Briscoe, and W. Watson, 286, 302, 335.
Electro-Magnetic Repulsion: by Prof. J. A. Fleming, 567, 601.
Electro-Magnetic Solutions of Equations, 285.
Electro-Magnetic Theory: by Oliver Heaviside, 257, 330, 388, 448, 507, 566, 633, 720, 781.
Electro-Metallurgy, A New Principle in, 449.
Electromotive Force, 636.
Electropathic Quack, 2.
Electrostatic Experiment, 161.
Electrostatic Measuring Instruments, 505.
Electrostatic Screening by Gratings, Nets, or Perforated Sheets of Conducting Material: by Sir William Thomson, 692.
Electrostatic Wattmeters, 561.
Elliott's Smoke Annihilator, 474.
Elmore Companies, 3, 253, 412.
Elmore Process, 398, 417, 751.
ESSON, W. B.
Notes on the Design of Multipolar Dynamos, 702, 733; Discussion, 793.
Ether as a source of Motion: by S. Tolver Preston, 750, 754, 779.
Ether in its Application to Electro-Magnetism, The Rotational: by Oliver Heaviside, 360.
Ether, Transfer of Energy by the, 74.
European Telegraph Statistics, 474.
EVERSHED, SYDNEY.
The Magnetic Circuit of Transformers: Closed *versus* Open, 477, 508, 534, 597, 635, 662, 690, 724, 755, 784.
EWING, Prof. J. A.
Magnetism in Iron and other Metals, 6, 75, 99, 164, 228, 291.
University Training of Engineers, 676.
Ewing's Theory of Induced Magnetism, An Illustration of: by Prof. S. P. Thompson, 128, 170.
"Exact" Science, 606.
Exeter, 160, 287, 595, 719.
**Exhibitions—**
Chicago, 65, 319, 321, 404, 511, 677, 767.
Crystal Palace, Proposed, 631.
Edinburgh, 3, 63, 98, 595.
Frankfort, 3, 96, 286, 564, 644, 779.
Naval, 687.
Prague, 288.
St. Pancras Vestry, 532, 610, 630, 687.
Toulouse, 595.
Experiments with the Electric Arc: by E. Raverot, 786.
Experiment with the Electric Arc: by W. Stanley, jun., 646.
Eye, Action of Electric Currents on the Human, 609.

## F

Factories and Workshops, The Regulation of, 505.
Faraday's Insulated Room, 787.
Farm, Electricity on the, 225.
Ferranti Alternators, 447.
Ferranti Effect, 204, 349, 561.
Ferranti Meter, 544.
Ferranti System in France, 129, 719.
Field, Mr. Cyrus W., 131.
Filament Flashing Apparatus, Automatic, 243.
Fire at Siemens & Halske's St. Petersburgh Factory, 751.
Fires, Electricity and, 286, 504.
FLEMING, Prof. J. A.
Central Stations of the Metropolitan Electric Supply Company, 9, 69, 107, 129.
Electrical Distribution by Transformers from Central and Eccentric Stations, 13, 42, 132, 196, 255, 300, 364.
Electro-Magnetic Repulsion, 567, 601.
On the Propagation of Alternating Currents through Concentric Cables, 258.
The Historical Development of the Induction Coil and Transformer, 396, 416.
Flexible Glass Tubes, 563.
FÖPPL, Dr. A.
The Most Favourable Position for an Electric Light Central Station, 88.
Foucault and Hysteresis Losses, The Separation of: by Gisbert Kapp, 699.
France, Protection of Electrical Industry in, 386.
Frankfort International Electrical Exhibition, 3, 96, 286, 564, 644, 779.
French Electrical Mining Plant, 659.
French Navy, Electricity in the: by A. Foris, 458.
French Telegraph Officials, Honours for, 319.
French Telegraph Service, 351, 530, 660.
Funeral Trains, Electric, 687.

## G

Galvanic Action of Tidal Streams on Metals, 533.
Galvanometer, Nalder's Ballistic, 610.
Gas and Electricity in the Metropolis, Relative Consumption of, 352.
Gas and Electric Lighting and Ventilation, 212.
Gas and Electric Lighting in Rome, 687.
Gas and Electric Light Mains in Paris, 632.
Gelatinous Electrolyte for Storage Batteries: Report by Prof. W. Kohlrausch, 46, 63.
Geometry, The Applications of, to Practical Life: by Karl Pearson, 431.
General Electric Power and Traction Company, 130.
General Post Office, Electric Lighting at, 398.
**German Notes**, 88.
German Telegraph Tariff, 353, 563.
Germany, Electric Lighting, Legislation in, 473, 629, 649.
GLADSTONE, DR. J. H.
Additional Notes on Secondary Batteries, 754.
Glasgow, 97, 631, 779.
GLAZEBROOK, R. T.
On the Rise of Electromotive Force observed in the Deptford Mains, 232.
Globular Lightning Experiments, 2, 194.
Glow Lamps, Economy in the Use of, 760.
" Energy Efficiency of, 502.
" Legal Status of the Candle Power of, 252.
" Life and Efficiency of, 64, 128.
" Reduced Price in the United States, 28
Godalming, 564.
Goolden-Willans Combination, Tests of a, 36.
Gordon system of Electric Traction, 595.
Government and Telephones in Belgium, 577.
Government Regulation of Industrial Enterprise, 778.
Grand Trunk Telegraph Line, 678.
Granville Electric Log, 532.
GRAWINKEL, C.
An Electric Wave Measurer, 459.
Telegraphic Transmission on Long Subterranean Lines without the use of Relays, 241.
Grosvenor Gallery, The Break-down at, 160.
Guernsey Electric Railway, 677.
Guildhall, Electric Lighting at, 193.
Gutta-percha, 225.

## H

Hair Pin, A new use for the, 505.
Halle, 29.
Hampstead Vestry, 129, 660.
Hanover Square School of Electrical Engineering, 351, 386.
HARRIES, DR. ARTHUR.
Electricity in relation to the Human Body, its Dangers and its Uses, 582, 594.
Harrogate, 2, 63.
Havoc among the Poles and Wires, 461.
Hawaii, Telegraphic Communication with, 475.
Hazletine Carbon Protector, 194.
Heater, A Novel Use for the Electric, 445.
HEAVISIDE, OLIVER.
Heaviside's (Oliver), Researches, 251.
Electromagnetic Theory, 257, 330, 388, 448, 507, 566, 633, 720, 781.
The Rotational Ether in its Applications to Electromagnetism, 360.
Heligoland, Telephonic Communication with, 631
Hellsen Dry Battery, 419.
Helmholtz, Honour to Prof., 473.
"Helmholtz" Medal, 444.
"Henry" Electric Motor Truck, 446.
Hermite Process, 595.
HIBBERT, W.
Additional Notes on Secondary Batteries, 154.
High Pressure Transmission of Power Experiments 386, 637.
High Speed Electric Railway Work: by O. T. Crosby, 765.
HIPPISLEY, Major R. L.
Electricity and its Tactical Value for Military Operations, 489.
HOLMES, A. BROMLEY.
The Liverpool Electric Supply Stations, 401.
Hotel Lighting in America, 91.
Hours of Lighting in Milan, 531.
Hull, 385, 504, 717.
Human Body, Electricity in relation to the, its dangers, and its uses: by H. Newman Lawrence and Dr. Harries, 582, 594.
Hysteresis, Note on the Law of, by Chas. Steinmetz, 251, 261.
Hysteresis in the Presence of Alternating Currents: by Dr. G. Finzi, 672.

## I

Ice on Trolley Wires, 97.
Illumination of a Horizontal Plane, On the: by F. Loppé, 169.
Illumination, Problems connected with Indoor, 480, 501, 511.
Imparting Electric Charges by Friction, by E. Riecke, 796.
Impedance and Self-Induction Methods of Measuring 62.
Incandescent Lamp Litigation in France, 687.
Incandescent Lamps, Lower Prices for, 30.
Incandescent Lamps, Report of the Committee on the Proper Classification of the Lighting Power of, Dr. Louis Bell (Chairman), 582.
Incandescent Platinum Wire when traversed by an Intermittent Current, Vibrations of, 4.
Indian Telegraphs, 631.
India Rubber, Cultivation of, 661.
India, The Telephone in, 503.
Inductance and its Proposed Unit, the Henry: by A. E. Kennelly, 267, 305, 385.
Inductance in Henrys of Common Instruments, 290.
Induction Coil and Transformer, The Historical Development of: by Dr. J. A. Fleming, 396, 416.
Inductive Disturbances in Telephone Circuits: by J. J. Carty, 705.
Industrial Electricity, A Chair of, 63.
Influence of an Electric Spark on the Discharge in Gases: by P. Backmetjeu, 420.
Installation (Electric) at Patenkirchen and Garmisch, 226.
Institution of Electrical Engineers, 29, 63, 172, 173, 193, 286, 413, 473, 530, 658, 717, 778.
Institution of Electrical Engineers' Benevolent Fund, 689.
Institution of Electrical Engineers, Dinner of the, 95, 114.
Insulating Material, Recipe for a New, 687.
Insulation, Fireproof, 163.
Insulator, A New, 351.
Interchange of Central Station Statistics, 106.
Interior Conduit System, 719.
International Electrical Exhibition at Frankfort-on-Main, 310.
International Telegraph Bureau, 96, 292.
Intra, Electric Lighting of, 384.
Isolated Lighthouses, Our, 696.
Italian Telegraph Service, 631.

## J

Jablockoff Patent, 564.
Japan, The Telephone in, 225.
Johannesburg Electricity Company, 751.
Journal of the Institution of Electrical Engineers, 384.

## K

KAPP, GISBERT.
Capacity and Self-Induction in Alternate Current Working, 197, 229.
The Separation of Foucault and Hysteresis Losses, 699.
KENNELLY, A. E.
Inductance and its proposed Unit, the Henry, 267, 305, 385.
Note on the Relative Degree of Disturbance caused by Electro-Static and Electro-Magnetic Induction between Telephone Circuits, 763.
KIMBALL, Prof. A. L.
Electro-Magnetic Radiation, 27, 33, 77.
Kingston-on-Thames, 3.
Kingdon Inductor Dynamo, 610.
KOHLRAUSCH, PROF. W.
Report on Gelatinous Electrolyte for Storage Batteries, 46, 63.

LAMB, C. G.
Notes on the Chemistry of Secondary Cells, 102, 127, 140, 176, 215.
Lamp, A Long Lived, 225.
Lamp Revenue, 777.
Lane-Fox Patents, 27, 385, 777.
Lantern in Class-Room Work, On the: by Profs. Barr and W. Stroud, 105.



Digitized by Google

Launches, Electric, 473, 564.
Lawrence, H. Newman.
  Electricity in Relation to the Human Body: its Dangers and its Uses, 582, 594.
Laws, J. Parry.
  Note on the Probable Explanation of a Peculiar Class of Faults occurring in Submarine Cables, 169.
Leamington, 29, 717, 752.
Leclanché Cells, Agglomerate for, 97, 718.
Leeds, 63, 160, 717, 751.

**Legal Intelligence—**
  Allison v. City and South London Railway Company, 406.
  Attorney-General v. Boy Messengers' Company, 743.
  British Tanning Company v. Groth, 341, 369.
  Chatham, Rochester, and District Electric Lighting Company v. The South-Eastern Railway Company, 770.
  Dickins and Another v. Metropolitan Electric Supply Company, 118, 465.
  Dowse's Patent Fire Check Company, 22.
  Edison and Swan Electric Light Company v. Robertson, 22.
  Fareham Local Board and the Fareham Electric Light Company v. Smith, 770.
  Groth v. British Tanning Company, 775.
  Gouraud v. Fitzgerald and Others, 254.
  Halifax and Bermuda Cable Company v. Magniac, 22.
  Jablochkoff Patent, 742, 769.
  Kensington and Knightsbridge Electric Lighting Company v. Lane Fox Electrical Company, 797.
  Lane-Fox v. Drake and Gorham, 155.
  Latimer Clark, Muirhead and Co. v. Westminster Electric Supply Corporation, 797.
  London Electric Supply Corporation v. Crookshanks, 119.
  London Electric Supply Corporation v. Friese, Greene, and Collings, 769.
  Oriental Telephone Company, 770.
  Queen v. Fareham Electric Light Company and Others, 155, 587.
  Reuter's Telegram Company, 747.
  Savory and Moore v. London Electric Supply Corporation, 742.
  Schoetensack v. Heyl, 373.
  Thompson, Re Henry, 155.
  United Telephone Company and Another v. Andrew Erskine Muirhead, 406.
  Verity and Sons v. Terry, 743.
  Watt v. Maxim Electric Company, 182.
  White's Asbestos v. Hoare, 221, 249, 627.
  Woodhouse and Rawson Electric Supply Company of Great Britain, 119.
Lewes, 161.
Lieb Ball Bearing for Lifts, 2.
Lieb Trolley Base, 170, 475.
Life and Price of Glow Lamps, 64.
Light, Standards of, 483.
Lighthouses, Telephonic Communication with, 161, 696.
Lightning, A Freak of, 194.
Lightning Arrester, Elihu Thomson, 446.
Lightning Conductors: by Dr. Oliver Lodge, 753.
Lightning, Globular, 5, 194.
Lightning in a Cable Station, 353.
Lightning in Church, 7 7.
Lightning in Harness, 350.
Lightning on a Lighting Circuit, 289.
Lightning Protector, Hodges', 504.
Lightning Statistics, 385.
Lindeck, Dr.
  Alloys for Resistance Coils, 493.
Litigation, Electrical, 161.
Liverpool Electric Supply Stations: by A. Bromley-Holmes, 401.
Liverpool, Inspector for, 504.
Liverpool Overhead Railway, 413.
Llanelly, 96.
Lloyd's Rules for Electric Lighting, 138.
Load Diagrams of the St. James and Pall Mall Company, 334, 351.
Lodge, Prof. Oliver.
  An Ideal Physical Laboratory for a College, 32, 66.
  Effect of a Condenser Introduced into an Alternate Current Circuit, 762.
  Lightning Conductors, 753.
London County Council, 163, 564, 594.
London Chamber of Commerce, Electrical Trades Section of the, 402, 595, 650.
London Electric Supply Corporation, 286, 563, 564, 593, 658.
London Electric Supply Corporation and its Customers, 161, 351.
London County Council and Technical Education, 462, 482.
London-Paris Telephone Line, 531, 561, 593, 604, 632, 679, 688.
London Telephone Rates, 739.
Long-Distance Electric Lighting, 595.
Lowestoft, 351.
Lundy Cable Company, 751.
Lyon's Liquid Resistance, 759.

## M

Machine Stoking, 596.
McKinley Bill, Tariff Changes made by the, 227.
Madras, Electric Lighting and Traction in, 384.
Madrid, 97.
Magnetic Leakage of Transformers and Power Measurements, 561.
Magnetic Materials in Laboratories, 96.
Magnetic Meteorology, 595.
Magnetic Observatories, 288.
Magnetic Phenomena in Central Russia, 689.
Magnetic Proof Pieces and Proof Planes: by Prof. S. P. Thompson, 679.
Magnetic Rocks, 531, 650.
Magnetic Rocks and Ships' Compasses, 98.
Magnetic Rotation, 532.
Magnetic Screening, 787.
Magnetic Shunts, On a Property of, by Prof. S. P. Thompson, 764.
Magnetisation of Iron by the Leyden Jar Discharge, 320.
Magnetisation of Iron, Phenomena occurring at a Red Heat, 426.
Magnetisation of Thin Plates of Steel at Right Angles to their Plane, Experiments on the: by W. Doule, 216.
Magnetisations, Superimposed, 669.
Magnetising Iron, Electro-chemical Effects on, 719.
Magnetism and Recalescence, 289.
Magnetism, Experiments in, 414.
Magnetism in Iron and other Metals: by Prof. J. A. Ewing, 8, 75, 99, 164, 228, 291.
Magnetism, Lecture on, 28.
Magnetism, The Solution of a Geometrical Problem in: by T. H. Blakesley, 170.
Magneto-Optical Generation of Electricity, 192, 289.
Magneto-Telephone Receiver, On the Influence of the Strength of a Magnet in a: by C. R. Cross and H. E. Hayes, 486.
Maidstone, 193.
Mains in Paris, Electric Light, 97.
Massachusetts, Gas and Electric Lighting Undertaknigs in, 475.
Matlock, 3, 52, 563.
Matthieson's Correct Standard, 195.
Maxwell, the Scientific Papers of James Clerk, 40.
Mayer, A. M.
  Physical Properties of Hard Rubber and of Vulcanite, 487.
Measurement of Large Currents, 445.
Measurement of the Power given by any Electric Current to any Electric Circuit, by Prof. W. E. Ayrton and Dr. W. E. Sumpner, 736.
Measuring Instruments, a Novel Form of, 65.
Mechanical Equivalents in Patent Law, 362.
Medical Electricity, 778.
Melbourne Electric Light Station by Fire, Destruction of, 289.
Mercadier, E.
  The Intensity of Telephonic Effects, 368.
  Telephonic Reproduction of Speech, 485.
Meserole Dry Battery, 226.
Metallic Thermometer with Electric Recording Gear, 476.
Metallo Chromes, 387.
Meteorological Phenomena, Electric Registration of, 253.
Meter Regulator, A New Form of, 387.

**Meters, Electric—**
  Elihu Thomson (New), 332, 532.
  Ferranti, 544, 563.
  Oulton-Edmondson, 332.
  Richard Frères, 612.
Meters used in London, Types of Electric, 319.
Meters of the Future, 317.
Metropolitan Electric Supply Company and the Fogs, 226.
Metropolitan Electric Supply Company, Central Stations of: by Prof. J. A. Fleming, 9, 69, 107, 129.
Metropolitan Police Buildings (New), 790.
Mica, 503, 565.
Military Operations, Electricity and its Tactical Value for: by R. L. Hippisley, 489.
Minchin, Prof. G. M.
  Experiments in Photo-Electricity, 350, 361; Discussion, 492.
Mines, Electricity in, 320, 387, 411, 751.
Minet, Adolphe.
  Electrolysis of Aluminium Fluoride, 87.
Model Bye-Laws, 285.
"Monarch" Magnetic Separator: by C. M. Ball, 309.
Motion of Atoms in Electric Discharges, A Novel Method of Investigating, 251.

**Motors, Electric—**
  Baxter Slow Speed, 312.
  Edison Slow Speed, 709.
  Mayer, 351.
  New Thomson-Houston Street Railway, 474.
  "Short" Gearless Tramway, 708.
  Tesla Alternating (New), 472, 488.
  Westinghouse Traction, 631.
Motors for Mining Work, 368.
Motors in Mills, Electric, 161.
Multipolar Dynamos, Notes on the Design of: by W. B. Esson, 702, 733; Discussion, 793.
Muscular Contraction, A Method of Simultaneously Registering the Wave of Electrical Excitation and the Resultant: by A. D'Arsonval, 666.
Museum, Proposed Permanent Electrical, 384, 530.
Mutual Telephone Company, 225, 319, 532, 718.

## N

Nalder Ballistic Galvanometer, 610.
National Telephone Company, 63, 225, 267, 288, 383, 503, 565, 596.
New Companies of 1890, 277.
New Use for the Telephone, 63.
Newcastle-on-Tyne, 3, 63, 160, 445.
Niagara Commission, International, 446.
Niagara, Water Power of the Falls of, 144.
Nichols, Prof. Edward L.—
  Artificial Light of the Future, 147.
  On the Alternating Electric Arc between a Ball and a Point, 412, 429.
Night Signalling at Sea, 650.
Nimes, 225.
Nomenclature, 529.
North Shields, 3.
Northfleet Series Tramways, 63.
Notes on Dynamos, 236.
Nottingham (Borough) Electric Lighting, 311.

## O

**Obituary Notices—**
  Allan, J. Carruthers, 530.
  Carpenter, William Lant, 266.
  Erichsen, H. Gustav, 163.
  Mansi, Angel, 446.
  Moore, Thomas, 414.
  Mushet, Robert F., 446.
  Otto, Dr. N. A., 414.
  Reynier Emile, 363.
  Rosenbuch, Chevalier Edward, 4.
  Zédé, M., 778.
Oerlikon Works, High Pressure Transmission of Power, Experiments in, 445.
Organ Blowing Plant, 595.
Oscillations, Experiments of Electrical, 65.
Oulton-Edmondson Meter, 332.
Overhead Electric Light Conductors, 113.
Overhead Lines in Rochester (N.Y.), 688.
Overhead System of Electric Traction, A Severe Test of, 386.
Overhead Wire Rules, Board of Trade, 63.
Overhead Wires as a Permanent Investment, 476.
Overhead Wires Bill, 62, 530, 594.
Overhead Wires in London, 392.
Overhead Wires, Local Bye-Laws relating to, 285.
Overhead Wires, Safety Device for, 98.
Overhead Wires, Snowstorms and, 288, 386.
Oxford and the Electric Light, 751.

## P

Pacific Cable, 385, 530.
Paddington Vestry, 129, 162.
Palladium Plating, 563.
Paraguay, Telegraphic Communication with, 30.
Paramagnetic and Diamagnetic Bodies, Novel Distinction between, 444.
Paris, 2, 195, 254, 413, 780.
Paris Electricity Meter Competition, 97.
Paris-London Telephone Line, 531, 604, 632, 679, 688.
Paris-New York Telegraph Company, 572.
**Paris Notes**, 52, 463, 519, 586.
Paris Telephone System, 130.
Parliament, Electric Light in Houses of, 686.
Parliamentary Intelligence, 494, 551, 584, 616, 767.
Patent Fees, 718.
Patent Office, 445.
Patent Offices, English and American, 37.
Patent Office Statistics, American, 718.
Patent Record, 54, 91, 119, 156, 184, 219, 247, 282, 313, 436, 466, 497, 556, 583, 620, 681, 711, 744, 771, 800.
Patent Specifications, Abridgement of, 474.
Patents, Electrical, 193.
Patten Multiplex Telegraph, 96.
Pearson, Karl.
  The Applications of Geometry to Practical Life, 431.
Peculiar Accident, 751.
Pender, Sir John, Presentation Portrait of, 338.
Perry, Prof. J.
  On Tables of Spherical Harmonics, with Examples of their Use, 112.
Philadelphia, Accumulator Cars at, 780.
Phosphorus, Production of, by Electricity, 564.
Photo Electricity, Experiments in: by Prof. G. M. Minchin, 350, 361; Discussion, 492.
Photographic Registration of the Movements of the Seismo-Microphone, 352.
Photometers, 664.
Physical Laboratory for a College: An Ideal; by Prof. Oliver Lodge, 32, 66.
Physical Properties of Hard Rubber and of Vulcanite: by A. M. Mayer, 487.
Physiological Effects of Alternating Currents of High Frequency: by Elihu Thomson, 644.
Pickering, Prof. S. U.
  Theory of Dissociation into Ions, and its Consequences, 678.
Pittsburgh, Electric Traction, Concessions in, 530.
Planimeter, Hine and Robertson's, 432.
Platinum, 31, 129, 319.
Platinum Wire in Incandescent Lamps, A Substitute for, 20.
Poona, 130.
Pope, Franklin L.
  Notes on the Electric Railway: Historical, Statistical, and Technical, 455.
Popp Company, 52, 288.
Porcelain Insulator Fittings for Mines, 30.
Portable Electric Plants for Military Purposes, 472.
Postal and Telegraph Conference held at Adelaide, 52.
Postal Revenue, 253.
Postal Telegraph Administration, 749.
Postal Telegraph Revenue, 253.
Post Office, The French, 29.
Potential Difference between Two Dilute Solutions in Contact: by Max Plank, 73.
Potsdam, 631.
Presidential Address by Prof. Crookes, 317.
Press Messages, Counting of, 532.
Pressure, Regulation of, 414.
Preston, S. Tolver.
  The Ether as a source of Motion, 750, 754, 779.
Primary Cells, Variation of E. M. F. of, 387.
Progress, In the Van of, 328.
Projectiles, Electric Welding of, 194.
Proof Plates for use in Accumulator Tests, 61.
Proof of the Generality of Certain Formulæ published for a Special Case by Mr. Blakesley. Tests of a Transformer: by Prof. W. E. Ayrton and J. F. Taylor, 540.
Propagation of Hertzian Electrical Oscillations in Air: by MM. E. Sarasin and E. De La Rive, 701.
Provisional Orders and Licenses granted by the Board of Trade during 1890, 202.
Provisional Orders, Electric Lighting, 130, 751.
Provisional Orders, Granting of Competing, 718.
Public Companies Wound-up in 1890, 278.



Digitized by Google

## R

Railway Carriages, Electric Lighting of, 385.
Railway Congress International 717.
Railway Disasters, Electric Lighting in connection with, 659.
Railway, Electric Light Along a, 35'.
Railway Poles, Electric Street, 319.
Railway Rates, 131.
Railway Shops, Electricity in, 253.
Railway Signalling, 320.
Railway Street Convention, 20.
Railway Telegraphers, The Order of 688.
Railway Working, Electricity in, 194.
Rarefied Gases, Electric Discharge through, 501.
RAYLEIGH, LORD.
 Sensitiveness of the Bridge Method in its Application to Periodic Electric Currents, 791.
Reduction of Australasian Cable Rates, 728.
Regulation of Motors for Electric Traction 2.
Rentsch Incandescent Lamp Suspension, 555
Residual Magnetism in Telephones, Some Observations on the Existence of: by S Kalischer, 311.
Resistance Coils, Alloys for: by Dr. K. Feussner and Dr. Lindeck, 493.
Resistance, Temporary Decrease of, of Badly Conducting Mixtures, 386.

**REVIEWS OF BOOKS, &c.**--
 Annuaire pour L'An 1891, 670.
 Art of Electrolytic Separation of Metals (Dr. G. Gore), 236.
 Coal and What We Get from It, Prof. R. Meldola, 789.
 Comprehensive International Wire Tables (W. S. Boult), 364.
 Decorative Electricity (Mrs. J. E Gordon), 670.
 Dictionary of Metric and other Useful Measures (Latimer Clark), 539.
 Electric Bell Construction (F C. Allsop), 111.
 Electric Light Installations and the Management of Accumulators (Sir David Salomons), 426, 445.
 Electricity (E. M. Caillard), 539.
 Electrischen Verbrauchsmesser (E. de Fedor), 670.
 Electro-Metallurgy, A Treatise on (Walter G. Macmillan), 174.
 Electromotors (S. R Bottone), 111.
 Electroplater's Handbook (G. E. Bonney), 642.
 Histoire d'un Inventeur (G. Barral), 540.
 Impianti di Illuminazione Elettrica (E Piazzoli), 174.
 L'Année Electrique (Ph. Delahaye), 670.
 Laxton's Price Book, 540.
 Metal Workers' Handy Book of Receipts and Processes (W. T. Brant), 641.
 Practical Inorganic Chemistry (E. J. Cox), 642.
 Screws and Screw Making, 789.
 Soap-Bubbles and the Forces which Mould them, (C. V. Boys), 206.
 Spinning Tops (Prof J. Perry), 205.
 Traité des Piles Electriques (Donato Tommasi), 642.
Reynier, Elastic Accumulator, 113
Richard Frères' Electricity Meter, 612.
RIDEAL DR. S.
 Tanning by the Aid of Electricity, 768.
Robey and Company's High-Speed Compound Engine, 297
Ronald's Library, 245.
Rope Transmission, 687.
ROUX, GASTON.
 Electric Lighting of St. Brieuc, 757.
Royal Society, Election of Sir W. Thomson to Presidency of 127.
Rubber, A Government Report on, 225.

## S

Sable Island, 244, 504.
St. Brieuc. Electric Lighting of: by Gaston Roux, 757.
St. James and Pall Mall Company, 334, 351, 415, 504, 530.
St. Luke's Vestry and Electric Traction, 352.
"St. Martin's-le-Grand," 3.
St. Martin's Vestry v. Gordon, 64.
St. Pancras, 4, 254, 352.
St. Pancras Vestry Electrical Exhibition, 610.
St. Thomas, Charterhouse, Schools, 253.
Saunderson Arc Lamp, 595.
Saw, A Simple Electrical, 533.
**Scandinavian Notes**, 117, 278.
Scarborough, 225.
Schiseophone, 320.
Science, Encouragement of, 29.
Secondary Batteries, Additional Notes on: by Dr. J. H. Gladstone and W. Hibbert, 154.
Secondary Battery Plates, 474.
Secondary Cells, Charge and Discharge Curves of, 174.
Selenium Cells and Seeing by Electricity, 192
Selenium Cells, Some Experiments with: by Shelford Bidwell, 213.
Sensitiveness of the Bridge Method in its Application to Periodic Electric Currents: by Lord Rayleigh, 791.
Series System of Electric Traction, 29.
Sewage, Electrical Purification of, 475.
Sewage, Electrical Treatment of: by W. Webster, 128, 146.
SHAND, ROBERT.
 The Striking Distances of Alternating Electromotive Forces, 518.
 Variations of Current in the Primary Conductor of Open Circuit Transformers, 674.
"Shaking the Foundations of Science," 237.
Ships' Compasses and Magnetic Rocks, 98.
Shocks, Electric, 788.
"Short" Gearless Tramway Motor, The, 708.
Sibley College, (Cornell University), 565.
Silver Refining by Electricity, 4.
"Silvertown," S.S., 129.
Smithfield Club Show, 183.
Snow Ploughs, Electric, 129.
Société Internationale des Electriciens, 657, 658.
Solar Phenomena by means of an Electric Discharge, Imitation of, 35.
Soldering Glass to Metal, 413.
Some Practical Methods for the Determination of Inductive Resistances and Self Induction of Alternate Current Instruments: by Charles Steinmetz, 79.
Sophia, 129, 353.
Southampton, 779.
Southend, 29.
Southport, 63.
South Kensington and Paddington Subway, 224, 251, 254, 445, 531.
South Kensington, Science Collections at, 446, 632, 779.
South Shields, 193.
Spain, Electric Lighting in, 687.
Spain, Electric Transmission of Power in, 319.
Spain, Telephonic Development in, 413, 530.
Spanish Morocco Cables, 129, 193.
Sparking Distances of High Pressure, 502.
Spark, Potential Difference needed to produce: by F. Paschen, 727.
Specific Inductive Capacity, 657, 651.
Spherical Harmonics, with practical examples of their use, On Tables of: by Prof. J. Perry, 96, 112.
Spliced Carbons, 225.
SPRAGUE, J. T.
 The Electric Current and its Laws, 443, 513, 543, 576, 608, 670, 697, 729.
Stage, Electricity on the, 474.
Standards, Electrical, 574.
Standards Electrical and the Board of Trade, 226.
Standards of Light, 483.
Statistics, Central Station, 253.
Statistics, Interchange of Electrical, 414.
Statistics, International Telegraph, 5.
Steam Engines, High Speed, 531.
Steam Engines, Lubrication of, 65.
Steam Pipes, Lagging for, 97, 321, 718.
STEINMETZ, CHAS.
 Note on the Law of Hysteresis, 251, 261.
 Some Practical Methods for the Determination of Inductive Resistances and Self-Induction of Alternate Current Instruments, 79.
Stockport, 63.
Storage Battery Litigation in France, 287.
STRECKER, K.
 An Electric Wave Measurer, 459.
STROUD, Prof. W.
 On the use of the Lantern in Class-room Work, 105.
Submarine Cable Museum, 786.
Submarine Cables, Capacity of: by H. W. Ansell and Julian E. Young, 168.
Submarine Cables in France, The Manufacture of: by Max de Nansouty, 648, 658.
Submarine Cables, Note on the Probable Explanation of a Peculiar Class of Faults Occurring in: by J. Parry-Laws, 169.
Subway Question in Sheffield, 688.
Subway Railway Bills, 531.
Subway Rentals in New York, 3.
Subway Schemes for New York, 506.
Subways for Supply Mains, 3.
Suez Canal, The Electric Light in the, 631, 717.
Summary of Electrical Events for 1890, 271.
SUMPNER, DR. W. E.
 The Measurement of the Power given by any Electric Current to any Circuit, 736.
Supply of Electricity, 542.
Swan Patent Litigation, 193.
Swansea, 227.
SWINBURNE, J.
 Alternate Current Condensers, 214, 260.
 Note on Electrostatic Wattmeters, 561, 571.
 Some Points in Electrolysis, 678.
 Transformer Distribution, 514, 545, 612.
Switchboard, An Old Telephone, 429.
Switzerland, Electric Lighting in, 5.
Switzerland, Electric Transmission of Power in, 474.
Switzerland, Trunk Wire Extensions in, 778.

## T

Tanning by the Aid of Electricity: by Dr. S. Rideal and A. P. Trotter, 763.
Tanning in America, Electric, 160.
Technical College, Finsbury, 254.
Technical Education, County Councils and, 385.
Technical Education in Lancashire, 413.
Technical Education in Manchester, 161.
Technical Education, The London County Council and, 462, 482.
Technical Instruction Bill, 503, 595, 631.
Telegraph Apparatus, Exports of, 659, 752.
Telegraph Communication, Interruption of, 253, 506, 778.
Telegraph Department, Indian, 63.
Telegraph Department, The German, 28.
Telegraph Extension between Orkney and Shetland, 658.
Telegraph Extension under Difficulties, 689.
Telegraph Line from Bombay to Calcutta, 28, 473, 631.
Telegraph Line (New) between Berlin and Rome, 97.
Telegraph Revenue for 1890-91, 658.
Telegraph Statistics, 287.
Telegraph Statistics, International, 5.
Telegraph Work, Heavy, 4.
Telegraphic Charges, 564.
Telegraphic Currents, Duration of, 319.
Telegraphic Transmission on Long Subterranean Lines without the Use of Relays: by C. Grawinkel, 241.
Telegraphing Extraordinary, 596.
Telegraphing Without Wires, 635.
Telephone and the Law, 252.
Telephone Association for London, 595, 739, 752.
Telephone at Plymouth, 321.
Telephone Effects, The Intensity of: by E. Mercardier, 368.
Telephone, Inductive Disturbances in, 685.
Telephone in France, 287.
Telephone in Spain, 129, 659.
Telephone Line, the London-Paris, 531, 604, 632, 679, 688.
Telephone Monopoly, Expiry of, 162.
Telephone Patent, Lapse of the, 234, 414.
Telephone Rates, Reduction of, 64, 96, 160, 225, 658, 739, 752
Telephone Trunk Wire Extensions, 779.
Telephone Wires in the City, Underground, 688.
Telephone Wires, Local Authorities and, 384.
Telephonic Communication with Ships, 287, 752.
Telephonic Defences at Portsmouth, 717.
Telephonic Reproduction of Speech: by E. Mercardier, 485.
Telephony, Inter-urban, 25.
Telephony, Long Distance, 130.
Temperature Correction for Copper Wire, A Simple, 415.
Terrestrial Magnetism, 413.
Tesla Alternating Motor, New, 488.
TESLA, NIKOLA.
 Phenomena of Alternating Currents of Very High Frequency, 549.
Testing Stations, Electrical, 97.
Theory of Dissociation into Ions and its Consequences: by Prof. Pickering, 678.
Thermo-Electric Thermometer, 224.
THOMPSON, Prof. S. P.
 A Property of Magnetic Shunts, 764.
 An Illustration of Ewing's Theory of Induced Magnetism, 128, 170.
 Electro-Magnet, 17, 47, 83, 109, 151, 177, 200.
 Electromagnetic Mechanisms, 238, 269, 293.
 Magnetic Proof Pieces and Proof Planes, 679.
THOMSON, Prof. ELIHU.
 Electric Arc and its Use in Lighting, 562, 577.
 Notes on Alternating Currents of Very High Frequency, 615.
 Physiological Effects of Alternating Currents of High Frequency, 644.
Thomson's, Prof. Elihu, Pioneer Experiences, 596.
Thomson-Houston Annual Report, 798
THOMSON, Sir WILLIAM.
 Electric and Magnetic Screening, 722.
 On Electrostatic Screening by Gratings, Nets, or Perforated Sheets of Conducting Material, 692.
 On Variational Electric & Magnetic Screening, 694.
Thomson, Presentation to Sir William, 796.
Thomson, Sir William, and the Royal Society, 227.
Thunderstorm, A Winter, 687.
Thunderstorms of Sixty-Six Summers, 485.
Trade Marks in Japan, Registration of, 445.

**TRADE NOTES AND NOTICES**--
 Acme Electric Works, 587.
 Address, Change of, 710.
 Aluminium Electric Company, 710.
 Amalgamation of Businesses, 91.
 Andrews and Co., J. D. F., 54.
 Anglo-American Telegraph Company, 219.
 Archer Pipe Company, 247.
 Atlas Manufacturing Company, 710.
 Bankruptcy, 522.
 Bead Ray Diffuser, 653.
 Benham and Froud's Installation of Electric Light Fittings, 466.
 Benton and Stone, 119.
 Berend and Co., 313, 771.
 Binko and Co., H., 587.
 Blakey, Emmott and Company, 435.
 Boult's Comprehensive Wire Table, 744.
 Bristol's Portable Lamps, 184.
 Calendars Received, 313.
 Casings for Electric Wires, 407.
 Cathcart and Peto, 744.
 Central Station Companion, 771.
 Church Lighting, 281.
 Club Lighting, 587.
 Commercial Cables Company, 343.
 Consolidated Electric Company, Limited, 522.
 Cox and Co., 343.
 Crompton's Laboratory, 435.
 Crossley's "Otto" Gas Engines, 800.
 Current Index, 588.
 Cuttriss and Company, 744, 799.
 Davey, Paxman and Co., 53.
 Demon Water Motor, 620.
 Dickinson and Co., 156.
 Direct United States Cable Company, 247.
 Dissolution of Partnership, 466, 496, 587, 620.
 Dorman and Smith, 247, 522.
 Drake and Gorham, 282.
 Dunston Flour Mill, Electric Light at, 744.
 Eastern Electric Light and Power Company, 407.
 Edison Swan United Electric Light Company, 770.
 Electrical Accessories Company, 282, 312, 681.
 Electrical Engineering Corporation, 312, 681, 800.
 Electrical Supplies and Fittings Company, 219.
 *Electrician* Electrical Trades' Directory and Handbook, 521.
 Electricians', Engineers', Builders', and Ironmongers' Exhibition, 556.
 Electric Lighting at Margam Castle, 587.
 Electric Lighting Contracts, 219.
 Electric Lighting of Wynyard, 376.
 Electric Light Installation near Ascot, 435.
 Electric Meter Patents, 91.
 Electro-Metallurgical Company, 800.
 Endolithic Ivory Company, 521.
 Englebert and Co., 247.
 Errata, 376, 521.
 Expiry of Telephone Patents, 219.
 Fibre Cleat, 22
 Fires, 156, 281, 342.
 Fowler, Lancaster and Co., Fire at, 800.
 Fowler-Waring Cables, 119, 312.
 Frankfort Exhibition, Journal of, 771.
 French Telegraphs, 91.
 Gandy Belt Manufacturing Company, 681.
 General Electric Company, 342.
 General Electric Power and Traction Company 312.
 Gill and Co., Arthur B., 54, 281.
 Girdlestone, Tatham and Co., 184.
 Hartnell, Wilson, 588.
 Holmes and Co., J. H., 281.
 Humboldt Electric Power and Mining Company, 435.
 Jerome Kidder Manufacturing Company, 54.
 Incandescent Lamp Changer, 312
 Independent Condensing Apparatus, 587.
 *Ironmonger*, 681.
 Jensen Electric Bell and Signal Co., 436.



Digitized by Google

**TRADE NOTES AND NOTICES** (*continued*)—
Johnson, James, 184.
Kelway's Electric Log Syndicate, 156.
Keys' Electric Company, 376.
Lacombe and Co., 21.
Lane-Fox Electrical Company, 53.
Lighting at the Guildhall, 53.
Lighting of Belgrade, 587.
Lighting of the Globe Theatre, 184.
Linesmen's Tools, 119.
Livonia Flashing Letters, 653.
Lummer Brodhun Photometer, 710.
Lyon's Liquid Resistance, 800.
Maquay Electric Light Company, 771.
Manchester Edison-Swan Company, 343.
McGaw and Co., 620.
Measuring Instruments, 653.
Merryweather and Sons, 743.
Mills Sectional Steam Boiler, 435.
Mori and Moorhouse, 219.
Munro's Electrical Manufacturing Company, 653.
Mutual Telephone Company's Exchange, Opening, 653.
Nalder Brothers, 522.
National Telephone Company, 771.
Ness, F. W., 219.
"New Diamond" Switch, 620.
"New Era" Pendulum Movement, 496.
New Telephone Company, 312.
New York Insulated Wire Company, 22.
Northern District Telephone Company, 556.
Obermaier, Herr J., 54.
Oppermann, Carl, 313.
Osler, F. and C., 620.
Paterson and Cooper, 281.
Personal, 312, 521.
Planet Engineering Company, 22.
Plant for Sale, 155, 281, 710.
Poole and White, 313.
Poole and White's Logarithm Table, 282.
Porcelain Fittings, 91.
Porcelain Insulator Fittings for Mines, 91.
Portsmouth and South Hants Electricity Supply Company, 343.
Postal Reductions and Extensions, 282.
Prentice Napier, 620.
Priestman Bros., 710.
Primary Battery Installation for Sale, 184.
Printers' Exhibition, 653.
Regenerative Electric Light Company, 556.
Removals, 91, 119, 156, 343, 496, 522, 556.
Richard Frères, 343.
Robinson, A. and E., 184.
Rogers, F. M., 771.
Royal Naval Exhibition, 119.
St. Pancras Vestry Electrical Exhibition, 587.
Sale by Auction, 312.
Sale by Tender, 407.
Sanitas Company, 376.
Scientific Appliance Manufacturing Company, 800.
Sharp and Kent, 313.
Stanhope Water Engineering Company, 522.
Standard Electric Light and Power Co., Ltd., 312.
Stone Discs for Switch Bases, 435.
Surveying Instruments for Sale, 91.
Taylor, Tunnicliff and Co., 53.
Telegraph Manufacturing Company, 313.
Tenders, Result of, 681, 743.
Tenders received, 184, 653.
Tenders Wanted, 21, 53, 91, 119, 155, 219, 312, 435, 466, 496, 521, 587, 620, 653, 681, 770.

**TRADE NOTES AND NOTICES** (*continued*)—
Thomson-Houston Electric Company, 522.
Transfer of Business, 312.
Turbines, 653.
United Asbestos Company, 681.
Vacant Appointment, 312.
Vertical High-Speed Engine, 156.
Volk, Magnus, 53.
Volta Electrical Company, 343.
Willcox and Co., W. H., 587, 771
Woodhouse and Rawson Electric Manufacturing Company, 522.
Woodhouse and Rawson United, 313, 743.
Woodhouse Electric Supply Company, Limited, 343.
Wray and Co., Cecil, 91.
Yacht Lighting, 620.
Trades Union, Electrical, 28.
Train Lighting, 531.
Tramcar Gearing, Proposed Electric, 226.
Transformer Distribution, 512. [642.
Transformer Distribution: by G. L. Addenbrooke, 599,
Transformer Distribution: by J. Swinburne, 514, 545, 612.
Transformer Indicator Diagram, 594.
Transformer Losses, Mr. Tesla on, 62.
Transformers, Efficiency of, 533. [127.
Transformers at the Grosvenor Gallery, Breakdown of,
Transformers, The Magnetic Circuits of, Closed *versus* Open: by Sydney Evershed, 477, 508, 534, 597, 634, 662, 690, 724, 755, 784.
Transformers, Variations of Current in the Primary Conductor of Open Circuit: by Robert Shand, 674.
Transformers, Variations of Current, &c., Reply to Mr. Robert Shand: by W. Stanley, Junr., 726.
Transmission of Power, Electrical, 225.
Transmitting Electric Signals to Montreal, 318.
Transvaal Telegraphic Statistics, 717.
Trient, 28.
Trinidad-Demerara Cable, Interruption of, 473, 563
TROTTER, A. P.
Tanning by the Aid of Electricity, 763.
Tudor Accumulator, 689.
Tunis, Telephone in, 351.
Tussaud and Sons, Madame, 63.
Twisted Telephone Lines, 729.

**U**

Underground Telephone Cables in the City, 660.
Uniformity in the Use of Symbols, 530.
United States and the Telegraphs, 640.
United States, Electric Traction in, 225.
United States Patent Publications, 565.
United States Navy, Electricity in, 227.
United States, The Telegraph in, 253.
Units of the Present and Future, Electrical, 423.
University College and King's College Extension Funds, 383, 505.
University Education, 532.
University Training of Engineers: by Prof. J. A. Ewing, 676.

**V**

Variational Electric and Magnetic Screening: by Sir W. Thomson, 694.
Variation of Voltage Allowed by the Board of Trade, 150.
Variation of Volume in Liquid Dielectrics under the Action of the Electric Forces acting between the Plates of a Condenser: by E. Oddone, 679. [657.
Velocity of Electric Discharge through Rarefied Gases,
Venice, New Alternating Plant at, 384.
Ventilating Power of Gas, 192.
Victoria, Electric Lighting in, 473.
Vienna, 287, 778.
Vienna and Buda Pesth, Proposed Electric Railway between, 226.
**Vienna Notes**, 246, 519.
Village Lighting, 253, 473, 503.
Vulcanite, Expansion of, 445.

**W**

Walbrook Installation, Accident at, 632.
War Ships, The Use of Electric Motors in, 447.
War, The Civil Electrician in, 29.
Water Power, Electric Transmission of Power, 287.
Water Power of the Rhone, Utilisation of the, 751.
Water Softening, Electrolysis in, 531.
Wattmeters, Note on Electrostatic: by James Swinburne, 561, 571.
Watt *v.* Maxim-Weston Electric Company, 160.
Wave Measurer, An Electric: by C. Grawinkel and K. Strecker, 459.
Waves, Photographic Action of Electro-Magnetic, 28.
Weaving by Electricity, 253.
WEBBER, Major-Gen., C.E.
The Distribution of Electricity, with Especial Reference to the Chelsea System, 399, 420; Discussion, 491.
WEBSTER, W.
Electrical Treatment of Sewage, 128, 146.
Welding, Electric, 161, 286.
Wenstrom Hydraulic Gear for Electric Traction, 1.
Wesley as an Electrician, 530.
West Metropolitan Tramway Company, 4, 319.
Western Counties' and South Wales Telephone Company, 287.
Westinghouse Arc Light Alternator, 20.
Westinghouse Company, 193.
Westinghouse Interests, 353, 414.
Westminster Electric Supply Corporation, 659.
Weston Temperature Compensator for Electrical Measuring Instruments, 131.
WEYMOUTH, F. M.
Drum Armature Winding, 8, 37, 72, 100, 134, 165, 199.
Wheatstone Bridge Measurements with the Aid of the Telephone, 1.
Whitechapel Board of Works, 129.
Wiener's Experiments on the Direction of Vibration in a Beam of Polarised Light, 629, 686.
Willans Engines and Dynamos, Test of, 28.
Willans-Kapp Combination, Test of, 68.
WIMSHURST, J.
An Alternating Current Influence Machine, 764.
Windmill Dynamo Plant, 290.
Wine, Electrical Treatment of, 225, 533.
Winston-Salem Electric Light and Power Station, 29.
Wiring Rules for, 749.
Woking, 29, 130.
Woodhouse and Rawson, 319.
Wood's Magnet Winder, 11.

**Y**

YOUNG, JULIAN E.
Capacity of Submarine Cables, 163.

**Z**

Zinc, Chemically Pure, 3.

# Leading Articles and Editorial Notes.

**(In this Section LEADING ARTICLES are shown in Capitals.)**

Acquisition of the Telegraphs by the United States Government, 317.
Agreements between Supply Companies and their Customers, 95.
Alternate Current Condensers, 192.
ALTERNATING CURRENTS AND MATHEMATICS, 208.
ALTERNATORS, THE COUPLING OF, 394.
AUSTRALASIAN CABLE RATES, REDUCTION OF, 728. [128.
Automatic Temperature Compensation for Voltmeters,
Barking Road Cars, 471, 501, 562.
Blakesley's (Mr.) Method of Measuring Power, 529.
Board of Trade and the Protection of Telephones, 629.
Board of Trade Overhead Wire Regulations, 95.
Board of Trade Unit, 563.
Boy Messengers and Postmaster General, 562, 593.
British Association Meeting at Cardiff, 501.
British Museum, The Electric Lighting of, 657, 685.
Bunsen Photometer, Mr. Boulouch on the Theory of, 224.
Cataphoric Medication, 629.
Centesimal Method of Measuring Angles, 630.
Central London Railway, 62, 561.
Central Station Supply and Isolated Plants, 777.
Chelsea Electricity Supply Company and the Fogs, 223.
Chelsea Electricity Supply Company, Mr. E. Chamberlain and, 159.
Chelsea Overhead and Underground Wires, 594.
Chelsea System, 383.
Chemical Union, Operations of, and Electrolytic Methods of Bleaching, 27.
Chicago Exhibition, 252, 501.
CITY AND SOUTH LONDON RAILWAY, 12.
City and South London Railway, 191, 285, 317, 594.
City of London Electric Lighting (Pioneer) Company, 448.
Collection of Electrical Data, 27.
Conductivity of Stranded Conductors, 412.
Contacts of Short Duration, 192.
Core Losses, A Simple Method of Testing and Analysing the, 685.
Deptford, 471.
Determining the Difference of Phase of Alternating Currents, 473.
Dry Piles, 412.
Dublin, Electric Lighting of, 472.
Effect of the Electric Spark on the Resistance of Bad Conductors, 350.
ELECTRIC LIGHTING IN THE CITY OF LONDON, 454.
Electric Lighting of London, Mr. F. Bailey on, 159.
ELECTRIC SHOCKS, 788.
Electrical Oscillations, Mr. Lecher on, 318.
ELECTRICAL STANDARDS, 574.
Electrical Standards' Committee, 223, 443
Electromagnetic Radiation, Prof. Kimball on, 27.
Electromagnetic Solution of Equations, 285.
Electromagnetic Radiation, Measurement of, 286.
Electropathic Quacks, 2.
Electrostatic Wattmeters, 561.
Employment of Choking Coils and Condensers in connection with Constant Current Work, 750.
Energy Efficiency of Glow Lamps, 502.
ENGINEERING AT CAMBRIDGE, 668.
Ether as a Source of Motion, 750.
ETHER, TRANSFER OF ENERGY BY THE, 74.
"EXACT" SCIENCE, 606.
FERRANTI EFFECT, 204.
Ferranti Effect, 349, 561.
Fires, Electrical, 286.
Frankfort Exhibition, 286.
French Electrical Industry, 128.
German Electric Lighting Bill, 629.
Globular Discharge, 2.
GLOW LAMPS, ECONOMY IN THE USE OF, 700.
Glow Lamps, Energy Efficiency of, 502.
Glow Lamps, Legal Status of the Candle Power of, 252.
Glow Lamps, Life and Efficiency of, 128.
Glow Lamps, Reduced Price of, in the United States, 28.
Grosvenor Gallery, The Breakdown at, 160.
Houses of Parliament, Electric Light in, 686.
Human Body, Electricity in Relation to the, 594.
Impedance and Self-Induction, Methods of Measuring, 62.
Inauguration of the City Lighting, 411.
Indoor Illumination, 501.
Institution Dinner and Conversazione, 95.
Institution of Civil Engineers, 317.
INSTITUTION OF ELECTRICAL ENGINEERS, 172.
INTERCHANGE OF CENTRAL STATION STATISTICS, 106.
Journal of the Institution of Electrical Engineers, 384.
Lamp Revenue, 777.
Lane-Fox Claims, 27, 777.
Lieb Ball Bearing for Lifts, 2.
LIGHTHOUSES, OUR ISOLATED, 696.
Lightning in Harness, 350.
LLOYD'S RULES FOR ELECTRIC LIGHTING, 38.
Local Bye-laws relating to Overhead Wires, 285. [482.
LONDON COUNTY COUNCIL AND TECHNICAL EDUCATION,
London County Council's Overhead Wires Bill, 62, 594.
London Electric Supply Corporation, 286, 593.
London-Paris Telephone Line, 561, 593.
Lord Rayleigh on the Sensitiveness of the Bridge Method when used with Periodic Currents, 777.
Magnetic Leakage of Transformers and Power Measurements, 561.
Magnetic Materials in Laboratories, 96.
Magnetism, A Pretty Experiment in Illustration of Prof. Ewing's Theory of, 128.
Magneto-Optic Generation of Electricity, 192.
MECHANICAL EQUIVALENTS IN PATENT LAW, 362.
Meters of the Future, 317.
Mines, Electricity in, 471.
Model Bye-laws, 285.
MORE BOARD OF TRADE RULES, 424.
Motion of Atoms in Electric Discharges, A Novel Method of Investigating the, 251.
National Telephone Company, 383.
New Tesla Motor, 472.
Nomenclature, 529.
Novel Distinction between Paramagnetic and Diamagnetic Bodies, 444.
Oliver Heaviside's Researches, 251.
Permanent Electrical Museum, 384.
Photo-Electricity, 350.
Portable Electric Plants for Military Purposes, 472.
Postal Telegraph Administration, 749.
Presidential Address, Prof. Crookes', 317.



Digitized by Google

## Leading Articles and Editorial Notes (*continued*).


Press Visit to the Elmore Company's Works, 412.
Proof Plate for use in Accumulator Tests, 61.
Regulation of Motors for Electric Traction, 2.
Results of Electric Traction, 444.
Royal Society, Election of Sir William Thomson to the Presidency of, 127.
Rules for Wiring, 749.
SCIENTIFIC PAPERS OF JAMES CLERK MAXWELL, 40.
Secondary Batteries, Discussion on, at the Institution of Electrical Engineers, 127, 191.
Selenium Cells, and Seeing by Electricity, 192.
Sewage, Electrical Treatment of, 128.
Société Internationale des Electriciens, 657.
South Kensington, Proposed Railway under, 224, 251.
Sparking Distances of High Pressure, 502.
Specific Inductive Capacity of Liquid Dielectrics, 657.
Spherical Harmonics, 96.
Sprague (Mr.) and the Electro Magnetic Theory, 443.
Steinmetz's Formula for Hysteresis Loss, 251.
Study of the Alternating Electric Arc between a Ball and a Point, 412.
SUPPLY OF ELECTRICITY, 542.
Telegraphing Without Wires, 685.
Telephone and the Law, 252.
TELEPHONE PATENT, LAPSE OF THE, 234.
Telephony, Inductive Disturbances in, 685.
Tesla (Mr.) on the Losses which occur in Transformers, 62.
Thermo-Electric Thermometer, 224.
Thomson (Prof. Elihu) on the Electric Arc, 562.
Transformer Core Losses, 529.
TRANSFORMER DISTRIBUTION, 512.
Transformer Indicator Diagrams, 594.
Transformers at the Grosvenor Gallery, Breakdown of the, 127.
UNITED STATES AND THE TELEGRAPHS, 640.
Uniformity in the Use of Symbols, 530.
University College and King's College, 383.
VAN OF PROGRESS, IN THE, 328
Variation of Voltage allowed by the Board of Trade, 159.
Velocity of the Electric Discharge through Rarefied Gases, 657
Ventilating Power of Gas, 192.
Watt *v.* Maxim Electric Company, 160.
Wenstrom Hydraulic Gear for Electrical Traction, 1.
Wesley as an Electrician, 530.
Wheatstone Bridge Measurements with the Aid of the Telephone, 1.
Wiener's Experiments on the Direction of Vibration in a Beam of Polarised Light, 629, 686.
Willans Engines and Dynamos, Tests of, 28.


## Letters to the Editor.


| | |
|---|---|
| Air Space of Dynamos, A New Empirical Formula for | ANDERSEN, F. V., 53. |
| | RAVENSHAW, H., 90. |
| Armature Cores, Analysis of Losses in | HOUSMAN, R. H., 740. |
| Barking Road Cars | FRAZER, T., 554, 619. |
| | KAPP, GISBERT, 520. |
| | KING, FRANK, 587. |
| | MACKENZIE, W. G. M., 520 586. |
| Bath Electric Light Circuits, Insulation of the | FORBES, GEO., 520. |
| Boult's Wire Table | BOULT, W. S., 406. |
| Bye-Laws of Urban Authorities | CURTIS-HAYWARD, A. C., 339. |
| Callan Induction Coil | LENNON, FRANCIS, 554. |
| Capacity Measurement of Cables | ANSELL, HAROLD W., 654. |
| | DEARLOVE, ARTHUR, 741. |
| | YOUNG, JULIAN E., 654. |
| Chelsea Electricity Supply Company, Mr. Richard Chamberlain and the | COURTENAY, J. IRVING, 181. |
| Chelmsford Lighting | CROMPTON AND CO., 496. |
| City and South London Railway | WILLBOND, A., 340. |
| Cologne Electric Light Cables | SOCIETE D'EXPLORATION DES CABLES ELECTRIQUES, 90. |
| Compound Dynamos | BREW, WM., 280. |
| Contractors' Grievances | W. H., 769. |
| Control Magnets for Galvanometers | OBACH, EUG., 680. |
| | WALMSLEY, DR. R. M., 740. |
| Deptford, Experiment with a Condenser at | THOMSON, SIR WILLIAM, 216. |
| Drum Winding | PARSONS, C. A., 281. |
| Eccentric Stations | A. K. C., 21. |
| Edinburgh Exhibition | BENNETT, A. R., 20. |
| Electric and Magnetic Theories | BURNS, GAVIN J., 465. |
| | COLE, R. S., 433. |
| | GRAY, J., 520. |
| | HEAVISIDE, OLIVER, 374, 553. |
| | LODGE, OLIVER J., 375. |
| | SPRAGUE, J. T., 340, 374, 405, 434, 463, 495, 533. |
| | THOMPSON, SILVANUS P., 375, 404, 520. |
| Electric Arc, An Experiment with | ANDREWS, J. D. F., 681. |
| Electric Lighting Statistics | DENNY LANE, 555. |
| Electricity for Heating Purposes | FLEMING, E. L., 218. |
| Electricity in relation to the Human Body | LAWRENCE, H. NEWMAN, 652. |
| Electrolytic Preparation of Bleaching Agents | ANDREOLI, E., 90. |
| Electrostatic Forces *versus* Gravitation | LODGE, OLIVER J., 553. |
| Forces between Electric Currents | LODGE, OLIVER J., 180. |
| | MURRAY, J. E., 217. |
| Gas and Electric Lighting and Ventilation | FLETCHER, GEO., 246. |
| Glow Lamps on the Series System, Life of | LOTT, FRANK, 53. |
| Illumination, Indoor | B. P., 521. |
| | J. B. V., 521. |
| | PROGRESS, 521. |
| Inductance, The Determination of | STEINMETZ, CHAS., 279. |
| Induction Coil and Dr. Callan, of Maynooth College | MOLLOY, DR. GERALD, 465. |
| Insulation, Oil | SWINTON, A. A. C., 118. |
| Kimball (Prof.) and Electricity | JOHNSTONE, JAMES, 90. |
| Lane-Fox Claims | ERSKINE, R. S., 21. |
| | ST. G. LANE-FOX, 799. |
| Local Authorities and Electric Tramways | HIGGENS, T. W. E., 21. |
| Magnetics and Nomenclature | EVERSHED, SYDNEY, 554. |
| More Board of Trade Rules | IN STATU PUPILLARI, 465, 496. |
| Mullingar Asylum, Tenders for | O'BRIEN, ARTHUR, 218. |
| Physical Laboratory for a College, An Ideal | LODGE, OLIVER J., 117. |
| Physics *v.* Metaphysics | J. F., 118. |
| Resistance Coils | ADAMSON, ED. W., 465. |
| | CUFF, J. CLEMENT, 435. |
| Secondary Batteries, Positive and Negative Plates | MOLLOY, GERALD, 246. |
| Secondary Cell, The Chemistry of the | FITZGERALD, DESMOND G., 246. |
| Selenium | BIDWELL, SHELFORD, 246. |
| Sewage, Electrical Treatment of | SEGUNDO, E. C. DE, 218. |
| | WORTH, F. G., 280. |
| "Shaking the Foundation of Science" | WEBBER, MAJOR-GENERAL, 280. |
| Sparking Distances | SHAND, ROBERT, 709. |
| Split Dynamometer for Determining Differences of Phase between Two Alternating Currents of Equal Period | STEINMETZ, CHAS., 767. |
| Stranded Wire, The Conductivity of | CONOLLY, JAS., 435. |
| Telephone, Bourseul's Speculations on the | LOCKWOOD, THOS. D., 118. |
| Telephone Circuits, Inductive Disturbances in | BENNETT, A. R., 768. |
| Telephone Patent, Lapse of the | STUART, OTIS K., 405. |
| Transformers, Losses in | TESLA, NIKOLA, 88. |
| Transmission of Energy | LODGE, OLIVER J., 88. |
| Tommassi Multitubular Accumulator | SHIPPEY, ARTHUR, 182. |
| Twisted Telephone Lines | BENNETT, A. R., 798. |
| Visual Signalling in Foggy Weather | BROWN, G., 742. |
| Voltage and Electromotive Force | SUMPNER, W. E., 680. |
| Voltmeters, Permanent Magnet | COLBY, ED. F., 279. |
| Westminster Electric Supply Corporation | KENNEDY, A. H. W., 53. |
| Wiring of Calico Print Works | M. & Co., 769. |


## Scientific Societies, Papers, &c., read before.


| | |
|---|---|
| **Aldershot Military Society.** | |
| Electricity and its Tactical Value for Military Operations, 489. | HIPPISLEY, Major R. L. |
| **American Academy of Arts and Sciences.** | |
| Magneto Telephone Receiver, On the Influence of the Strength of a Magnet in a, 486. | HAYES, H. E., and CROSS, C. R. |
| **American Institute of Electrical Engineers.** | |
| High Speed Railway Work, 765. | CROSBY, O. T. |
| Inductance and its Proposed Unit, the Henry, 267, 305. | KENNELLY, A. E. |
| Inductive Disturbances in Telephone Circuits, 705. | CARTY, J. J. |
| **Civil and Mechanical Engineers' Society.** | |
| Electric Cranes, 490. | BOLTON, REGINALD. |
| **Electric Light Convention. (Providence, U.S.A.)** | |
| Electric Arc and its Use in Lighting, 577. | THOMSON, Prof. ELIHU. |
| **Institution of Civil Engineers.** | |
| Cost of Generation and Distribution of Electrical Energy, 708. | CROMPTON, R. E. B. |
| **Institution of Electrical Engineers.** | |
| Distribution of Electricity, with Special Reference to the Chelsea System, 399, 420, 491. | WEBBER, Major-General. |
| Electricity in Transitu: From Plenum to Vacuum, 323, 354, 389. | CROOKES, Prof. W. |
| Multipolar Dynamos, Notes on the Design of, 702, 733, 793. | ESSON, W. B. |
| Notes on the Chemistry of Secondary Cells, 102, 140, 176, 215. | AYRTON, Prof. W. E., LAMB, C. G., and SMITH, E. W. |
| Transformer Distribution, 514, 545, 613. | SWINBURNE, J. |
| **Junior Engineering Society.** | |
| Electro-magnetic Mechanisms, 238, 269, 293. | THOMPSON, Prof. S. P. |
| **Liverpool Engineering Society.** | |
| Liverpool Electric Supply Stations, 401. | HOLMES, A. B. |
| **Montefiore Institute Old Students' Association.** | |
| Note on the Design of Dynamos, 646. | MELOTTE, FELIX. |
| **New York Electric Club.** | |
| Artificial Light of the Future, 147. | NICHOLS, Prof. ED. L |
| Notes on the Electric Railway, 455. | POPE, F. L. |
| **Physical Society.** | |
| Alternate Current Condensers, 214. | SWINBURNE, JAS. |
| Alternating Current Influence Machine, 764. | WIMSHURST, JAS. |
| Electrolysis, Some Points in, 678. | SWINBURNE, JAS. |
| Electrostatic Wattmeters, 571. | SWINBURNE, JAS. |
| Ewing's Theory of Induced Magnetism, An Illustration of, 170. | THOMPSON, Prof. S. P. |
| Experiments in Photo-Electricity, 360, 492. | MINCHIN, Prof. G. M. |
| Further Contributions to Dynamometry, 541. | BLAKESLEY, T. H. |
| Generality of certain Formulæ published for a special case, by Mr. Blakesley, Tests of a Transformer, 540. | AYRTON, Prof. W. E., and TAYLOR, J. F. |
| Magnetic Proof Pieces and Proof Planes, 679. | THOMPSON, Prof. S. P. |
| Magnetism, The Solution of a Geometrical Problem in, 170. | BLAKESLEY, T. H. |
| Measurement of Electro-magnetic Radiation, 302, 335. | BOYS, C. V. BRISCOE, A. E. WATSON, W. |
| Property of Magnetic Shunts, 764. | THOMPSON, Prof. S. P. |
| Selenium Cells, Some Experiments with, 213. | SHELFORD-BIDWELL. |
| Theory of Dissociation into Ions and its Consequences, 678. | PICKERING, Prof. S. U. |
| **Royal Institution.** | |
| Electric and Magnetic Screening, 722. | THOMSON, Sir WILLIAM. |
| Electro-Magnetic Repulsion, 567, 601. | FLEMING, Prof. J. A. |
| **Royal Society.** | |
| Electrostatic Screening by Gratings, Nets, or Perforated Sheets of Conducting Material, 692. | THOMSON, Sir W. |
| Measurement of the Power given any Electric Current to any Circuit, 736. | AYRTON, W. E., and SUMPNER, Dr. W. E. |
| Sensitiveness of the Bridge Method in its application to Periodic Electric Currents, 791. | Lord RAYLEIGH. |
| Variational Electric and Magnetic Screening, 694. | THOMSON, Sir WM. |
| **Society of Arts.** | |
| Electricity in Relation to the Human Body. Its Dangers and its Uses, 582. | LAWRENCE, H. N., and HARRIS, Dr. A. |
| Electric Lighting Progress in London, 206. | BAILEY, F. |
| Electro-Magnet, The, 17, 47, 82, 109, 151, 177, 200. | THOMPSON, Prof. S. P. |
| **Society of Chemical Industry.** | |
| Electrical Treatment of Sewage, 146. | WEBSTER, W. |
| Tanning by the Aid of Electricity, 763. | RIDEAL, Dr. S., and TROTTER, A. P. |




Digitized by Google

# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 651.—Vol. XXVI. FRIDAY, NOVEMBER 7, 1890. Price Fourpence.

## NOTES.

Some useful suggestions with regard to the measurement of resistance have recently been made by M. Chaperon, who, in three short Papers appearing in the October number of the *Journal de Physique*, discusses the capabilities of the Wheatstone's bridge method when a telephone and alternate currents are used in place of the ordinary galvanometer and battery. In spite of the great delicacy of the telephone, measurements made with it are much less accurate than those obtained with a reflecting galvanometer, because the adjustment for minimum sound is never sharply defined. This is, to a great extent, due to the fact that all resistance coils obtainable have a certain amount of self-induction, and produce a considerable inductive effect with alternating currents of the high frequency occurring in the telephone. If this disadvantage could be overcome, the telephone would, in many cases, be a more sensitive and convenient instrument to employ than the galvanometer; and it is in this connection that M. Chaperon's suggestions are of value. The experiments have been more particularly directed to the improvement of the Kohlrausch method of measuring liquid resistances. To reduce the polarisation effects to a minimum, and to render heating negligible, M. Chaperon arranges each branch of the bridge so as to have a high resistance of about a thousand ohms. The stretched platinum iridium wire is very thin, only about ·02 millimetres in diameter, and, in order that the fixed resistance may have no great inductive effect, a special system of winding has been adopted.

The ordinary method of double-winding used in resistance coils serves very well for most direct current measurements; but the compensation for induction effects is not nearly perfect enough when rapidly alternating-currents are used, and according to M. Chaperon, the results obtained under such circumstances are "detestable." The new coils have been wound singly, but so that successive layers are wound in opposite directions, the operation being effected by a specially constructed machine. The current in adjacent conductors thus flows in opposite directions, and self-induction is practically eliminated, while the capacity effect is rendered negligible since contiguous portions of the wire are at nearly the same potential.

This method has already been used by Mr. Swinburne in the construction of non-inductive resistances for wattmeters. The chief object in view in this case was to secure good insulation by keeping the ends of the coil well apart; and the mode of winding, which is described in the Paper on "Testing Iron" in our issue of October 10th, consisted simply of reversing the bobbin in the lathe on the completion of each layer. This method is stated to yield as good non-inductive coils as the ordinary method of double winding, while the strength of the insulation is much increased.

An interesting instance of the way in which the advancement of practical knowledge contributes to the progress of theory is afforded by an artifice adopted by M. Chaperon, and which appears to have been attended with excellent results. The telephone used had a resistance lying between 150 and 200 ohms, and was thus unsuited to a Wheatstone bridge, the resistances in which were many thousands of ohms. This difficulty was, however, entirely overcome by using a small transformer, the primary circuit of which had a resistance of 5,000 ohms, and placing the telephone in the secondary circuit.

The Wenstrom hydraulic gear for electrical traction, which is alluded to by our New York correspondent, is an ingenious clutch for gradually starting a car while the armature is running at full speed. The device consists of a rotary pump full of oil, the intake and delivery ports being connected by a short passage, in which there is a plug valve. The pump is of the well-known Beale's exhauster type, which is, perhaps, better known to our readers in the modification to be found in the air blower of the Thomson-Houston dynamo. It consists of a cylindrical block placed eccentrically in a chamber, which is divided into two parts by a pair of shutters sliding in a groove in the block. When the valve is open the armature runs idle, the oil merely circulating. When the passage is closed the pump is locked, since the oil is incompressible. By partially closing the valve the speed of the car may be controlled without proportionally reducing the velocity of the armature. It seems that this invention —which aims at being nothing more than a friction clutch, and, as far as it goes, achieves a very useful purpose—just misses a far more important result, namely that of a variable speed gear. The idea occurred to us, when the Rigg hydraulic engine was first described, that two such engines coupled together in series hydraulically would form such a gear. The eccentricity of this engine, it will be remembered, is variable. A short stroke hydraulic motor pumping into a long stroke motor is what is wanted for electrical purposes. When running idle the stroke of the hydraulic motor should be nil, at starting

Digitized by Google

it should be small, and at full speed of the car it should be a maximum. Now then, inventors, there is the idea! In Reauleaux's "Kinematics of Machinery" there are between fifty and sixty "chamber crank trains," from which hints may be gathered for putting it into practice.

The regulation of motors for electric traction is a problem which seems to offer a fascinating field for the efforts of inventors. Some would use a single motor, pointing out, with good reason, that large machines are obviously more efficient than those of smaller dimensions. To this it is answered that when the two are fully loaded, the actual amount wasted electrically on account of this decreased efficiency; and mechanically, by reason of the more numerous bearings—not to say economically, in view of the multiplication of parts—is trifling compared with the facilities which are offered when an extra pull is required at starting, or when a comparatively small amount of power is needed when the car is lightly loaded, or when it is running down a gradient. A common practice is to interpose a resistance on starting, to prevent the rush of current through the stationary armature; and when, for the sake of claiming an advantage over a rival system rather than for obtaining any economic advantage, the necessary coils are wound round the magnet bars which are presumably furnished already with their proper windings, the system is said to offer a peculiar superiority, in that it employs no rheostat. Others will boldly put their resistance coils on slate frames and use asbestos without any apology, and great ingenuity has been expended in utilising a minimum number of coils in a maximum number of combinations.

If there be a form of lift which offers absolute safety it is probably to be found in that kind which is provided with a long vertical screw, the cage being attached to a massive nut. The friction which such a device entails has allowed the hydraulic lift to put this mechanical arrangement into the background. But with the application of electric motors in view, Mr. C. A. Lieb has invented a most extraordinary ball bearing. According to a sectional view of this bearing in the *Electrical World* of New York of Nov. 1st, the nut, for a length of nine threads, does not bear directly on the screw, but a continuous row of steel balls is interposed. As the screw turns the balls must evidently travel along relatively to the nut at half the velocity of the helix of contact; but whither can they travel? Mr. Lieb, in reply, provides a tunnel through the nut parallel to its axis, and through this a procession of balls makes its way from one end back to the starting point. Whether this remarkable application of the ball-bearing principle, which has done so much for the bicycle, will extend the field of usefulness of the electric motor, remains to be seen; the ingenuity of the idea is most remarkable.

Amongst the disputed points in the subject of electrical discharges is the phenomenon of globular lightning. Many treat this as an optical illusion due to the excessively minute duration of the spark discharge, just as, when we have for an instant gazed upon the noonday sun and turn away, we see a reddish globe of fire float slowly straight before our eyes. So singularly do the descriptions of globular lightning tally with this well-known phenomenon, that this explanation would be irresistible were it not for the fact that these portentous spheres are alleged to terminate their alarming promenades by a deafening explosion. On the other hand, it is impossible to explain away the many records of persons who have seen the slowly-moving globes of fire. Amongst these persons was the electrician Cavallo, who saw a luminous ball slowly ascend the stem of a Leyden jar, then slowly descend and burst with a loud report. At a recent meeting of the *Académie des Sciences*, at the conclusion of a Paper on this topic by M. Faye, the meteorologist, the ex-Emperor of Brazil, narrated how, nearly forty years ago, when travelling on horseback in the southern province of Rio Grande, he saw a globe of lightning fall, traverse the fields for some instants, and then burst with a loud sound. Will none of the votaries of the camera at least attempt to fix a globular discharge whilst it is perambulating across the landscape?

In the absence of further information, we are disposed to take the charitable view that Count Mattei is ignorant enough of electrical science to imagine that he can permanently electrify his drugs, and we need not necessarily compare him with vendors of magnetic belts and other impudent impostors. But there can be no excuse for the unblushing incapacity in electrical matters of the Public Analyst of Paddington, F.C.S., F.I.C., who describes his tests of Count Mattei's blue, green, and white electricities as follows:—"To find if they possessed any special electrical properties they were placed singly in thin glass tubes; these tubes were suspended by silk filaments. Under such circumstances an electrical body would point one end to the north and the other end to the south. Not one of these came to rest in such a position; neither were any of them attracted by a magnet, as an electrical body would be. Hence, they certainly are not electrical."

In this connection we are sorry to notice that the *St. James's Gazette*, an otherwise respectably-conducted journal, has lately taken to inserting conspicuous paragraphs as original matter, which, when read, turn out to be advertisements of an electropathic quack. This is a clear case of imposture, and, if possible, is, journalistically, more disreputable than that of the advertiser.

**Harrogate.**—The Town Council have decided to apply for powers to light the town by electricity.

**Interurban Telephony.**—The trunk wire between Cologne and Coblenz is now completed.

**Chemnitz.**—The tramway at Chemnitz has been acquired by the Allgemeine Elektricitäts Gesellschaft, who intend to work the line by electricity.

**Paris.**—A fire broke out on Saturday evening at the Grand Café, Boulevard des Capucines, owing to a short circuit of the electric light mains.

**Brighton.**—The foundation-stone of the Brighton Municipal electric light station was laid on Tuesday afternoon by the Mayor.

Digitized by Google

**Bale.**—A company has been formed by the firms Escher and Wys, Geigy, and the Oerlikon Maschinenfabrik for the electric lighting of Bâle by means of power derived from the Rhine.

**Bromley Local Board.**—This Board has decided to take the necessary steps to obtain a Provisional Order, and to request Prof. Kennedy to advise the Clerk on details.

**The Elmore Companies.**—It is announced that M. Secrétan, late of the Société des Métaux, has accepted the position of manager of Elmore's French Patent Copper Depositing Company.

**North Shields.**—In accordance with a recent decision of the Tynemouth Town Council, a notice has been published intimating that the Corporation of Tynemouth intend to apply for a Provisional Order.

**Electric Lighting Statistics.**—According to a table prepared by Dr. Bersillon the number of arc lamps used in Paris in 1885 was only 68; last year the number had risen to 393 arcs and 6,188 incandescents. The fires officially stated to have been caused by electricity had risen in the same period from 1 to 33.

**Appointments Vacant.**—The Gravesend School of Science and Art is in want of a teacher in "Electricity and Magnetism," and of a teacher in "Mathematics and Theoretical Mechanics." Further particulars will be found in our advertisement columns.

**Finsbury Technical College.**—A course of six lectures on the chemical and physical properties of india-rubber and gutta-percha will be delivered at the above institution by Mr. Thomas Bolas, on Wednesday evenings, beginning next week. For further particulars, see our advertisement columns.

**Newcastle-on-Tyne.**—One afternoon last week the lid of an electric-light main junction box was blown into the air. Three or four people are stated to have been knocked down by the force of the explosion, but no one was hurt seriously. The cause of the explosion is believed to have been an accumulation of gas in the box from neighbouring tenements.

**Antwerp.**—The military telephonic system connecting the various points of the Antwerp fortifications, installed in 1881 and partly maintained by the Compagnie Belge du Téléphone Bell, has been since August 1, 1890, in the hands of the military authorities, who have entirely reconstructed the network, employing Dejongh transmitters and Goffart receivers.

**The Frankfort Exhibition.**—We learn from the *Elektrotechinsche Rundschau* that Messrs. Seimen and Halske, besides an extensive exhibit of continous current plant, are also building a 400 horse-power alternator for the Frankfort Exhibition. Transformers of all sizes are being made, including one for a tension of 40,000 volts, to be used for testing cables.

**The Electric Light and the Defence of the Thames.**—The operations that took place last week on the Thames below Gravesend with the object of testing the efficiency of the electric light for defence purposes were much interfered with by a dense fog that hung about the river. Further operations will take place at a future period.

**Kingston-on-Thames.**—At a special meeting of the Town Council last week it was decided to apply for a Provisional Order. Last year the Council made a similar application in conjunction with the Surbiton Improvement Commissioners and the Hampton Wick Local Board, but met with a refusal on the ground that the Board of Trade had no power to grant a Provisional Order to combined authorities.

**Edinburgh Exhibition.**—The Edinburgh Exhibition, which was opened by the Duke of Edinburgh on May 1st, was closed on Saturday evening last. The total number of visitors to the exhibition has been 2,414,129. The number of visitors to the Edinburgh Exhibition of 1886 was 2,769,779. On Saturday night the number of persons admitted to the exhibition was 25,204.

**Royal Institution.**—At the general monthly meeting of this Institution, Professor Viriamu Jones, M.A., Mr. C. N. Nicholson, M.A., Mr. John Hartley Perks, and Sir James Stirling were elected members of the Royal Institution. The special thanks of the members were returned to Dr. J. A. Fleming for the presentation, on behalf of Professor Elihu Thomson, of the apparatus employed by Professor Thomson in his experiments on electro-magnetic repulsion.

**London Chamber of Commerce.**—At the meeting of the Electrical Trades' Section Committee, announced for Monday next, at 4 p.m., the following subjects are on Agenda paper:—(1.) Board of Trade rules; (2.) Proposals in regards to Correspondent's duties; (3.) Mr. Crompton's scheme for the interchange of useful information; the approaching expiration of European Commercial Treaties; American Tariff; other matters.

**The Junior Engineering Society.**—On Friday afternoon last a very numerous party of members of this Society visited the Royal Arsenal, Woolwich, by special facilities afforded through the kindness of the Director General of Ordnance Factories. The Inaugural Meeting of the Society's tenth session takes place on the 21st inst., when Professor S. P. Thompson, President-elect, delivers an address on "Electro-Magnetic Mechanisms."

**"St. Martin's-le-Grand."**—We have pleasure in noticing the advent of *St. Martin's-le-Grand, the Magazine of the Post Office*. This magazine takes the place of the now defunct *Blackfriars*, and is the same size as that journal. We think the change of title a great improvement. The first number contains Mr. Preece's Paper on "Sanitary Aspects of Electric Lighting," and a quantity of other matter of an interesting character. The magazine is well got up, and we hope will prove a success.

**Subways for Supply Mains.**—At the last meeting of the Strand Board of Works Mr. Emden's proposal respecting a subway to be made for the storing of the pipes and wires of the gas, water, and electric light companies was discussed, and the matter referred to the Works and Parliamentary Committee with a view to united action being taken. A memorial will be promoted by all the districts in London to induce the County Council to bring a Bill into Parliament dealing with the subject.

**New York Subway Rentals.**—The Consolidated Subway Company has notified to the New York electric light companies that they must pay the rentals already due and overdue for duct space in the New York subways; and that in the event of their failure to pay these rentals or a portion of them, the Subway Company will either cut their wires and cables or remove them, or both. The Companies have in the meantime protected themselves by an injunction of the New York State Supreme Court.

**Personal.**—Mr. Magnus Volk having fulfilled his engagement with the General Electric Power and Traction Company, his connection with that Company has ceased, and he is now completing some new types of electrical measuring instruments.—Mr. A. J. Lawson, A.I.E.E., late Canadian agent of the Brush Electrical Company, Montreal, has recently been appointed superintending electrical engineer to the Siam Electric Light Company, and left for Bangkok on Monday last to instal and run a Mordey Alternate Current Plant of 10,000 lights.—Mr. A. W. Jones has resigned the post of chief electrician to the Exeter Central Station, and has joined the Laing, Wharton, and Down Construction Syndicate.

**The Coffin Electric Welding System.**—We learn that in a few weeks this system will be in actual work in this country. It is proposed to erect a small plant to demonstrate the efficiency of the process in London, the power being taken from an existing public lighting installation. It is claimed by the Syndicate who hold the British patents, that a single arc-light circuit will weld bars of metal, and an incandescent circuit is all that is required for the smaller weldings, thus saving the expense of laying down a separate installation on the transformer principle.

**Chemically Pure Zinc.**—According to *l'Electricien*, M Cahaigne, of Paris, has succeeded in producing chemically pure zinc on a commercial scale and at a price but little higher than that of ordinary zinc. MM. Pouchard, Mathioux et Cie., makers of electric clocks, have used Cahaigne zinc rods in the Leclanché cells employed by them. The cells in question furnished current for about 90 hours, and the consumption of the chemically pure zinc amounted to 28 grms. per cell, while the

Digitized by Google

consumption of ordinary well-amalgamated zincs amounted to 36 to 38 grms. The Cahaigne zinc was, moreover, uniformally consumed, while the amalgamated rods were very irregularly attacked.

**Telephonic Communication between London and Paris.**—The work in connection with the establishment of telephonic communication between London and Paris is being pushed forward very rapidly on this side of the Channel, and has made such satisfactory progress during the last few weeks that it is stated communication will be established early in the new year. Some alterations, however, have been decided upon in reference to the route to be taken by the cable. Instead of crossing the Channel and touching the English coast near Hythe, it has been decided to land it at St. Margaret's Bay, where it will be connected with the special wire running from this point *viâ* Dover, Folkestone, Ashford, and Maidstone to London.

**The Boston Street Railway Power Station.**—The work on the foundations of this, the largest electric power station in the world, was, says the *Electrical Engineer* of New York, begun about the 1st of October, 1889. The foundation work is now completed, about 8,000 piles having been driven, and about 35,000 tons of concrete and masonry used in its construction. The dimensions of the boiler-house are 158ft. by 79ft. 6in., and six 500 horse-power Babcock and Wilcox boilers will be put in. The chimney rests on a base 56ft. square, tapering to 30ft. at the top of the foundation; it is now 192ft. high, and will ultimately have a height of 252ft. Power will be furnished, to start with, by six 1,000 horse-power engines installed in an engine-room 176ft. long by 150ft. broad. By the 1st December the erection of the boilers and engines will be actively commenced; and it is expected that by May, 1891, some of the engines will be ready for work.

**West Metropolitan Tramway Company.**—Referring to the fine imposed on the West Metropolitan Tramway Company, at the instance of the Hammersmith vestry, for the bad state of repair of the roadway in Uxbridge-road, the secretary of the company states that the decision will be appealed against, and that evidence will be produced showing that the alleged defects were chiefly in the part of the roadway which the vestry has to maintain. He adds: For the past two years the tramway company has been urgently pressing the Hammersmith vestry for its sanction to adopt electricity on their lines, which would necessarily involve an entire relaying of the roadway with new material. Parliament has already sanctioned the proposal, and the local boards, with the exception of those of Hammersmith and Acton, have also given their consents. It would be pure waste of money to do extensive repairs now which would all have to be done a second time.

**St. Pancras.**—The first stone of the St. Pancras municipal electric light station was laid on Wednesday afternoon. Prof. Henry Robinson (the electrical engineer to the Vestry) stated that the installation, which was now being carried out by the Vestry under his direction, would serve the south-western part of the parish, and was intended to be followed by further stations to serve the rest of the district if the result proved as satisfactory from a commercial standpoint as was anticipated. The "three-wire system" had been adopted, and the plant would be capable of supplying current to 10,000 16 candle-power incandescent lamps simultaneously. High-tension current would be provided on a separate set of mains to the 90 public lights in the streets. There would further be six sets of accumulators capable of supplying 800 to 900 lights during the period of minimum demand. Provision had been made at the outset for five miles of distributing mains, designed to carry current for 25,000 lamps burning simultaneously.

**Heavy Telegraph Work.**—The interest in the political demonstrations recently made in Newcastle was evinced in the heavy call by the Press upon the telegraph, the demand made upon it exceeding anything that had before been experienced there. There were 17 Wheatstone circuits arranged. To reach the long distances across to Ireland from Newcastle 10 repeaters had to be inserted at different parts of the lines. These were put in on the English side at Nevin, in South Wales, Haverford West, and Llanfair, and there was another at Edinburgh to reach Belfast. The longest wire run was worked from Nevin to Cork, 600 miles. Seventeen offices were supplied direct with a verbatim report and 52 with a column summary. The number of words despatched over these circuits on Friday, October 17th, was 121,000. On Saturday, the 18th, 79,000 words were telegraphed. On Monday, the 20th, the number of words signalled was 99,000; the total number of words transmitted during the three days' demonstration being 299,000.

**Vibrations of an Incandescent Platinum Wire when traversed by an Intermittent Current.**—In a recent number of the *Comptes Rendus* M. Argyropoulos describes the following experiment:—Take a platinum wire about ·7m. long and a fraction of a millimetre in diameter, and pass a current through it until it becomes incandescent; then, if the wire is stretched in a horizontal position and Foucault interrupter is inserted in its circuit, the wire immediately vibrates and becomes subdivided into a series of waves having well-marked ventral segments and nodes. The number of segments is augmented by very slowly decreasing the tension of the wire. On increasing the tension the number is diminished until the incandescent wire vibrates transversely with a single ventral segment at the middle. M. Argyropoulos employed a battery of from 45 to 50 Bunsen cells, and screwed down the commutator until the wire became white hot; then, if the commutator was released, the stretched wire immediately commenced to vibrate.

**Aluminium in the Electric Arts.**—In an article under this title the *Electrical Engineer* of New York remarks that the considerable reduction in the price of aluminium may result in its extended use in the electric arts. Its great lightness and strength make it eminently adapted for overhead line work, its specific gravity being but 2·6 as compared with copper, which has a specific gravity of 8·9. Its resistance, it is true, is nearly twice that of copper; but on account of its low specific gravity, its weight would only be about four-sevenths that now required in copper for the same conductivity. Looking still further, there are many of the parts which go to make up an electric car that could be made of aluminium, and which would tend materially to reduce the car weight without affecting its strength or efficiency. Thus, among other details, the trolley wheel and trolley pole might be made of aluminium to considerable advantage. If to this were added the substitution of aluminium for iron and brass now employed on the truck and motors, outside of the magnetic circuit, the reduction in weight would be an important factor tending to economy.

**Obituary.**—We regret to record the death at Corinth, on 19th ult., of Chevalier Edward Rosenbusch, at the age of 53. The deceased was born at Einbeck, in Hanover, and first landed in Malta as an *employé* of the Mediterranean Extension Telegraph Company. On the resignation by Mr. Andrews of the post of Superintendent, the Directors appointed Mr. Rosenbusch his successor in 1869. He introduced the electric light and the telephone into Malta, to a considerable extent at his own expense. When the Eastern Telegraph Company acquired the plant of the Mediterranean Extension Company, Mr. Rosenbusch was tranferred, first to Patras and afterwards to Corinth, where he continued to reside until his death. Mr. Rosenbusch was appointed Member of the Institution Civil Engineers in 1871, was decorated with the Order of the Crown of Prussia in 1876 for services rendered to the Royal Astronomical Society of Berlin. The Italian Government conferred upon him the Orders of the Corona d'Italia and of SS. Maurizio e Lazzaro for services rendered to the Italian refugees in Malta; and the Sublime Porte, that of the 3rd Class of the Medjidie. He leaves a widow and six children.

**Silver Refining by Electricity.**—The following method of refining silver electrically is described in the *Engineering and Mining Journal*:—The method is most suitable for the refining of auriferous silver containing about 11 per cent. of gold, the cost in this case being only about 14 cents per pound. The principle upon which the process is based consists in using in an ordinary electrolytic bath anodes of an argentiferous matte, and a thin plate of pure silver as the cathode. The bath consists of a very weak solution of nitric acid containing about one per cent. of the acid. The anodes, which are about

Digitized by Google

one-half inch thick, with a surface of about 13·5 square inches, are placed in muslin bags, which retain the gold, platinum, peroxide of lead, and similar foreign materials contained in the matte. The current used is 150 amperes, and the potential difference between the plates one volt. During the whole period of work brushes are kept moving up and down the silver plates, sweeping off the silver deposited into troughs put for the purpose at the bottom of the bath. These troughs are removed from time to time, and the silver taken out and sent to the furnace. If the matte contains copper, this is dissolved by the nitric acid, but is not deposited on the cathode.

**International Telegraph Statistics.**—The following figures for the year 1888 may be of interest:—

| Country. | Population per office open. | Square miles per office open. | Telegrams per head. | Miles of wire per office open. |
|---|---|---|---|---|
| United Kingdom | 5,300 | 17 | 1·4 | 26 |
| France | 4,125 | 22 | 1·36 | 16 |
| Germany | 3,000 | 13 | ·35 | 13 |
| Austro-Hungary | 7,520 | 46 | ·15 | 14 |
| Russia | 27,280 | 2,250 | ·08 | 37 |
| Italy | 8,200 | 30 | ·2 | 16 |
| India | 72,555 | 241 | ·01 | 36 |

It is curious to note that while such diverse countries as England, France, and India obtain about the same number of messages per employé, viz., respectively, 482, 500, and 475; in Italy they require only 6,897 employés to deal with 7,061,131 telegrams, or over 1,000 messages per employé.

**Globular Lightning.**—In a recent communication to the Académie des Sciences, M. H. Faye gives a long list of globular lightning phenomena witnessed during a storm at Saint Claude in August last. The list was collected by M. Cadenat Professor of Physics, at the Saint Claude College, and the following is a sample story. M. Mermet stated that he saw three fireballs fall into a courtyard at the back of his house. Two of them moved slowly along at some little height above the ground. The third struck against an iron bar resting on a wall, rebounded, and then travelled along at a distance of some few metres above the soil: suddenly changing direction, it entered a passage and descended a staircase at the end. It then passed between the wall and an open door, destroying the lock and ironwork, into the street, where it burst, making a big hole in the door and splitting it from top to bottom. M. Mascart remarked at the end of this communication, that it would be prudent to "make some reserves" as to the actual existence of globular lightning, at least in certain cases where it appeared to have altogether extraordinary properties. On the other hand, the ex-Emperor of Brazil testified to having seen a case of globular lightning in the Province of Rio Grande forty years ago.

**Electric Lighting (Transmission of Power) in Switzerland.**—The following figures with regard to the position of the electric light in Switzerland may be gathered from a recently published table. The total number of installations at the end of 1889 was 351, of which 11 only were central stations. Of the 340 isolated plants no less than 182, or 51 per cent., were in mills or factories of various descriptions. The number of dynamos running at the end of last year was 408, having a total output of 5,150 kilowatts, or an average of 12·6 kilowatts each; these machines supplied 51,155 incandescent and 845 arc lamps. The eleven central stations are those at Aussersihl, Brunnen, Faido, Geneva, Interlaken, Lausanne, Leukbad, Lucerne, Martigny, Meyringen, and Vevey-Montreux. The stations at Brunnen, Lucerne, and Vevey-Montreux are on the alternate-current transformer system, the others employing the continuous-current system. Power is derived in 177 cases from turbines, in 138 cases from steam engines, in 32 cases from gas engines, in 4 cases from electric motors. Besides these installations there are 24 transmission of power installations, 7 electro-motor stations, and 41 accumulator installations. The power transmitted varies from 2 to 280 horse-power, and the distance from ·05 to 10 kilometres. The number of machines is 76 and their capacity 1,714 kilowatts. The electric tramway at Vevey-Montreux, 10·6 kilometres long with 7 motor cars, and the electric rope railway on the Bürgenstock are included.

**Indurated Fibre Conduits.**—According to the *Electrical Engineer* of New York, some indurated fibre pipes used for underground telephone work in Philadelphia have stood severe tests during a period of over eighteen months. This material is made from long wood fibres, separated, washed free from all saps and gums, moulded while in a pulpy state into the requisite size and shape, and then subjected to great hydraulic pressure. After this it is treated and hardened by a special chemical process and rendered impervious to moisture, acids, or gas. It is extremely tough and durable, and will withstand great crushing strains. The tensile strength is about 1,100lb. to the square inch. Its weight is about one-fifth that of iron for equivalent service in pipe form, and it will resist over 200 degrees of heat. For electric light subway work the manholes have a bottom of asphalt concrete, upon which is placed a flooring of indurated fibre an inch or more in thickness. The walls of the chamber are similarly treated. The wires are carried through these manholes in rubber tubing to the pipes, which are generally 1½in. inside diameter with ½in. shell, and are joined together with collars, in which they are fastened by means of screw threads. This system is, as already mentioned, in successful use in Philadelphia, where 40 miles are laid. In Detroit, the Detroit Electric Light Company have about 20,000ft., and the local Edison Company have some also. Specimens that have been underground for four years have been recently exhumed and tested, and showed no change whatever.

**The Electric Storage Battery Company's Accumulator.**—The storage battery now being manufactured by the Electric Storage Battery Company of Philadelphia bears a striking resemblance to the Laurent-Cely accumulator described in *The Electrician* of May 30, 1890. The conclusion arrived at by this Company is that the lead reduced from the chloride possesses the best properties for battery purposes. To obtain the chloride, commercial lead is melted and converted into a finely divided powder. The finely divided lead is then dissolved in nitric acid and precipitated as chloride of lead by the addition of hydrochloric acid. The white chloride of lead so obtained, after being thoroughly washed and dried, is mixed with a certain proportion of chloride of zinc, and the mixture brought to a molten state in a furnace. The fused mixture is then poured into square moulds and allowed to cool. The square blocks of chloride so formed, and which are destined as the active matter in the plates, are then placed in a mould prepared for their reception and a grid of lead cast around them under pressure. The grids are then packed between zinc plates and placed in a tank containing dilute chloride of zinc. There is thus formed a voltaic couple, the action of which is to dissolve the zinc chloride and to extract the chlorine from the lead chloride contained in the blocks. The last trace of chlorine is removed from the plates by washing and then placing them in a tank containing nitric acid, and passing a current. This action also opens the pores and leaves a pure lead sponge in the grid. The plates intended for positives are then packed tightly between perforated ebonite boards, and formed into peroxide in dilute sulphuric acid. The standard cell consists of 9 positive and 10 negative plates, having a capacity of 230 ampere hours, and weighing complete 34lb. This gives a capacity of 9·9 ampere hours per lb. of plate and 18 ampere hours per lb. of total active material. In size the plate is 5¾ × 6in. In the traction cell the weight of active material and of the grids is, respectively, 12¼ and 10⅝lb. Four cars on the Lehigh Avenue Street Railroad, Philadelphia, have, says the *Electrical Engineer*, of New York, been operated continuously during the last four months with cells of this type. This road has numerous curves, and gradients as heavy as 5¼ per cent. These have taxed the cells to their utmost, the 100 cells on each car frequently being discharged at the rate of 45 electrical horse-power. During the month of August, these cars alone carried 59,000 passengers, with frequent loads of 100 passengers on a car. The batteries have frequently made runs of 63 miles with a single charge under these conditions. A storage battery station on this system has also been for some time in operation at Germantown, Pa. The plant consists of 512 cells, in eight series of 64 each, and has a capacity of 1,600 ampere hours.

Digitized by Google

## MAGNETISM IN IRON AND OTHER METALS.*—XXXIV.

BY PROF. J. A. EWING, F.R.S.

(*Continued from page 733.*)

§ 124. **Effects of Longitudinal Pull in Iron.**—Turning now to iron, we find that much more complex variations of magnetic quality are produced by longitudinal stress. We have to distinguish between two cases, that of soft annealed iron, and that of iron which has been hardened by a mechanical operation such as stretching, which has given it a permanent set. With hard metal the effects of stress are in general much greater than with annealed metal. Both cases have this in common, that the presence of any moderate amount of longitudinal pull increases the susceptibility when the magnetisation is weak, but reduces the susceptibility when the magnetisation is strong. We have here the phenomenon of the Villari reversal to which allusion has already been made. But in the case of hard metal, where it is possible to apply a stronger pull without permanently altering the characteristics or structure of the piece, it appears that the presence of a sufficiently great amount of stress may be unfavourable to magnetisation, even in the earliest stages of the magnetising process. These, as well as other effects of stress will be best appreciated by means of a careful study of curves which exhibit the process of magnetisation in iron wires pulled by various amounts of hanging load. The wires, in the experiments to be described, were of such a size that each kilogramme of load corresponded to a stress of about 2·2 kilometres per square mm.

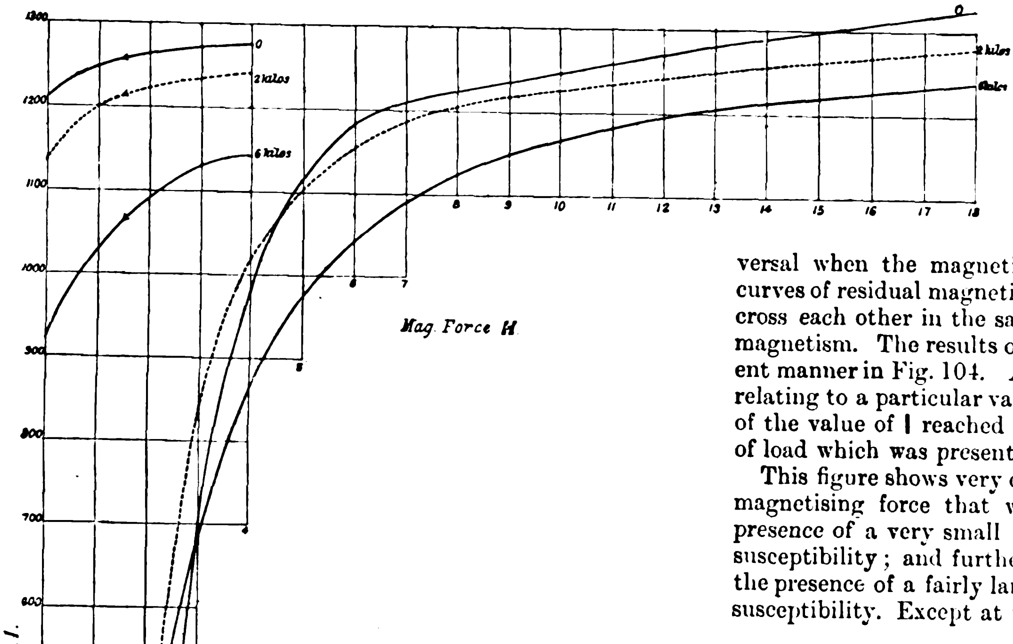
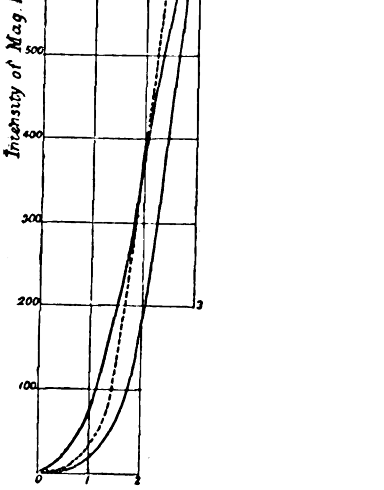




Fig. 103.—Magnetisation of Annealed Iron under Various Amounts of Longitudinal Pull.

§ 125. **Annealed Iron under Pulling Stress.**—Fig. 103 shows, by curves of I and H, the magnetisation of a wire of soft annealed iron under various amounts of longitudinal pull (no load, 2 kilos, and 6 kilos).* The curve for no load lies at first lowest, and finally highest. Each curve, in fact, lies at first lower, and afterwards higher, than a curve for any greater amount of load. Thus, the presence of load is favourable to magnetisation when I is small, but unfavourable when I is great. And the curves obtained by removing the magnetising force (which are shown to the left in the figure) preserve throughout their whole course the relative places with which they start, the differences between them becoming only accentuated as the magnetising force is reduced to zero. Thus, the presence of pulling load is unfavourable to the residual magnetism left after a strong field has been applied; though, as another experiment has shown, it is favourable to the residual magnetism that is left after magnetisation by a weak field Its influence on the residual magnetism is, in fact, of the same kind as its influence on the induced magnetism; both suffer reversal when the magnetisation is sufficiently increased. The curves of residual magnetism (which are not drawn in the figure) cross each other in the same manner as the curves of induced magnetism. The results of this experiment are shown in a different manner in Fig. 104. A series of curves are drawn there, each relating to a particular value of the force H, to show the relation of the value of I reached by applying that force to the amount of load which was present when the force was applied.

This figure shows very clearly that except under the strongest magnetising force that was applied in the experiment, the presence of a very small amount of pulling load increases the susceptibility; and further, that except in the weakest fields, the presence of a fairly large amount of pulling load reduces the susceptibility. Except at very low and again at high magnetisation, there is maximum of a susceptibility occurring with a particular load; and the value of this load becomes smaller as the magnetisation is increased. This maximum disappears in the lowest fields, no doubt only because the load is insufficiently great to show it.

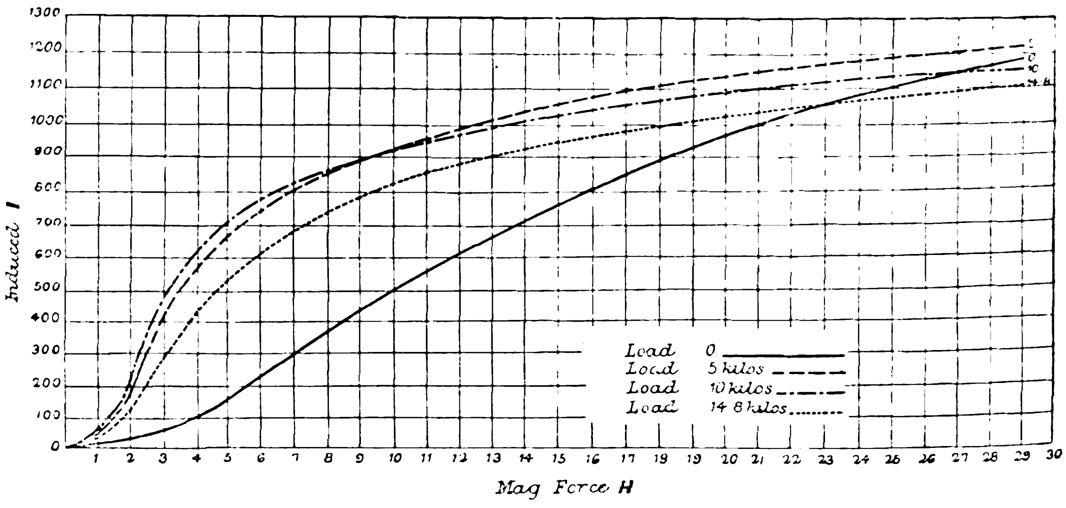



Fig. 105.—Magnetisation of Hardened Iron under Various Amounts of Longitudinal Pull.

§ 126. **Hardened Iron under Pulling Stress.**—Figs. 105 and 106 show the effects of various amounts of longitudinal pull on iron wire which had been hardened by stretching beyond the an elastic limit. Fig. 105 gives the induced magnetism, and Fig. 106 gives the residual magnetism, both in relation to H, the process of magnetising being performed, as in previous examples, while a constant load hung from the wire.

The first thing to observe here is the immense effect which a moderate amount of pull has in augmenting the susceptibility with respect to feeble magnetising forces. On the other hand, when a condition approaching saturation is reached, the presence

* All rights are reserved.

* *Phil. Trans.*, 1885, plate 64.

Digitized by Google

of load is unfavourable to magnetisation; in other words, we have, as before, the Villari reversal. But it is now to be noticed that even in the weakest fields the susceptibility is increased only when the amount of the load is moderate: to apply stress

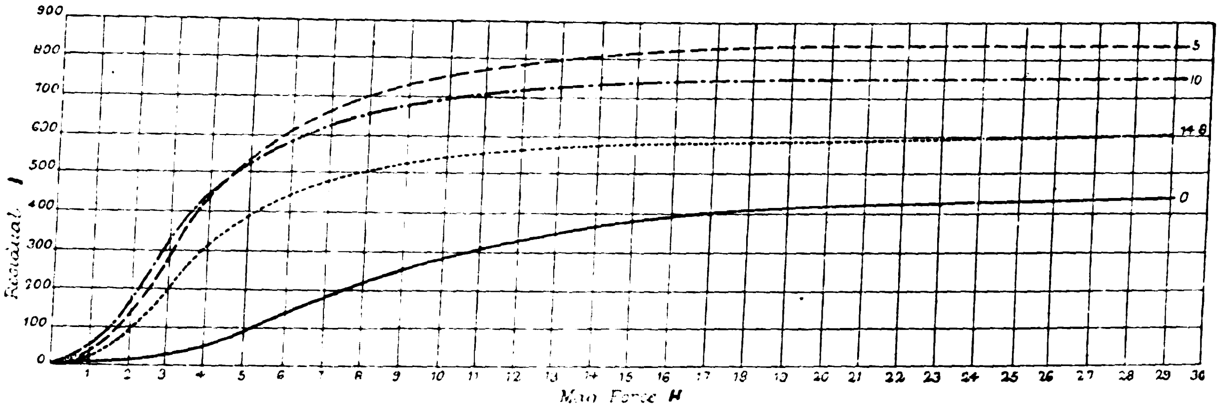



Fig. 106.—Residual Magnetisation of Hardened Iron under Various Amounts of Longitudinal Pull.

beyond a certain amount is prejudicial, whether the magnetisation be strong or weak. This is shown by the fact that the curve for 14·8 kilos. lies below the curves for 5 and 10 kilos. thoughout its whole course.

The same remarks apply to the residual magnetism (shown in Fig. 106). The influence of stress on it is even greater.

Fig. 107 shows, in the same way as Fig. 104, the results of another experiment of the same kind, in which a piece of the same iron wire, also hardened by stretching, was magnetised under

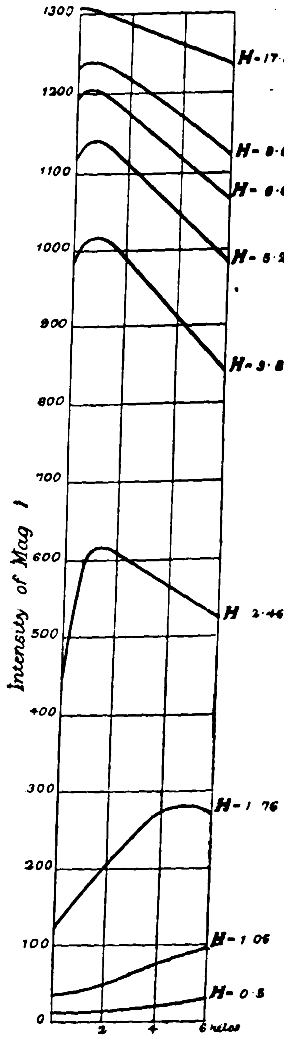



Fig. 104.—Magnetisation of Annealed Iron under Various Amounts of Longitudinal Pull.

a series of loads which in this case ranged up to about 19 kilos. This figure shows very clearly that a moderate amount of load is more favourable to magnetisation than either less load or more; the exact amount which is most favourable depends on the degree of magnetisation, being less in strong fields than in weak ones. It varies, in this example, from about 10 to 5 kilos, for the range of magnetic forces with which the experiment deals.

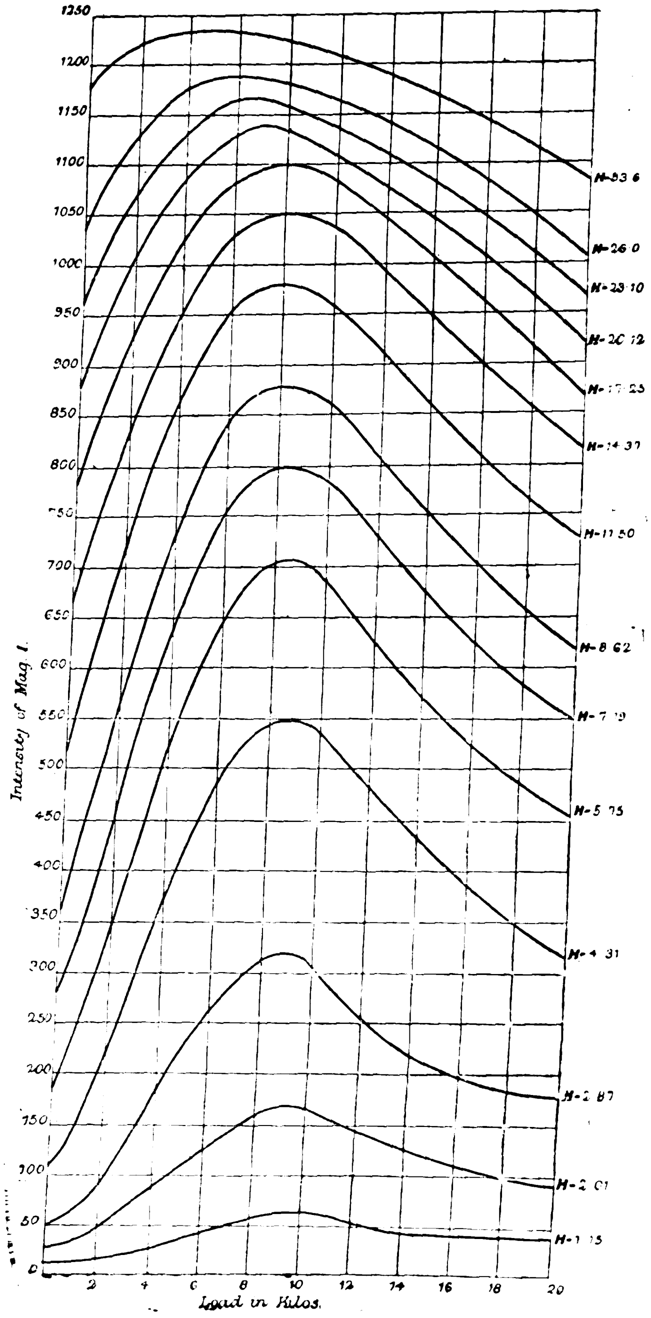



Fig. 107.—Magnetisation of Hardened Iron under Various Amounts of Longitudinal Pull.

The effects of pulling stress on the susceptibility of steel are generally similar to the effects in iron.

*(To be continued.)*

Digitized by Google

## DRUM ARMATURE WINDING.

BY F. M. WEYMOUTH.

*Introductory.*

It frequently happens that men who have served their apprenticeship in mechanical engineering, and, perhaps, had considerable experience in that line, ultimately drift into electrical work. If of an inquiring turn of mind, such as, indeed, may be taken to be generally the case, they will find a variety of problems arise before them in connection with their new sphere of occupation, for which to them there is no immediate solution. Many books abound; but some of these are expensive, or else cover so much ground that much detail is necessarily omitted. The drum armature in itself involves a host of problems; taking its theory alone it is very puzzling to the new comer, and mechanical considerations also of all sorts demand attention. It is the object of these articles to put some of these mechanical considerations before younger readers. As to the theory that was treated much at large in another Article (on the Generation of Current and Potential in Drum Winding, see *The Electrician* of July 16th, 1889).

Various methods have been adopted from time to time by different inventors and makers to put this type of winding into a practical form. Among the many points for consideration that occur, perhaps the most prominent is that involving the question as to how to take the cross-connections at the end of the armature round the spindle. It is thus of interest to observe for one thing in what different ways this particular

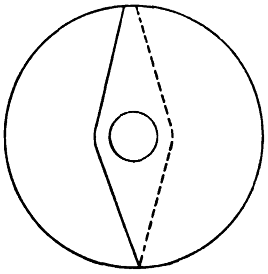


Fig. 1.

difficulty has been surmounted, and the "end-winding," as it is termed, arranged. It may be true that in the case of armatures for small currents, and wound with flexible wire, this difficulty may not be very great. But in dealing with heavy currents and conductors of large section, it is different, and many points of mechanical construction arise for consideration; and it is with these we shall be mostly concerned in the course of our remarks. We may state here, parenthetically, that though some of the sketches that will accompany this article will be taken from designs actually carried out, all will not, but will merely illustrate principles of design without pretending to be actual representations of any particular machines. Further, it may be added that we shall confine ourselves almost exclusively to armatures for two-pole machines.

Dealing for the present with wire-winding for light currents, we meet with the most simple and crude of all armature winding in Siemens' wire wrapping. This winding consists fundamentally as shown in Fig. 1, and supposing a single turn per section, in merely carrying the wire from one commutator segment, say, along the periphery of the drum parallel with the axis, across the further end, giving it a slight bend to one side to get past the spindle, and so back again on the other side, repassing the spindle, and then joining it to the next commutator lug from whence it started, or in irregular winding to some other lug. In practice, however, the wire may be carried round many times before being joined up to the lug of the next commutator segment. Each "section" of the winding is thus said to be composed of so many "turns;" and while there may thus be any number (within reason) of "turns per section," there are as many "sections" as there are segments in the commutator, neither more nor less. All the turns in a section may lie in approximately the same plane, carefully insulated from each other, and each section likewise from neighbouring sections, and from the core. There may hence be in a winding of this sort a large total number of turns of the single wire; and as the volts depend for one factor on the aggregate of the areas enclosed severally within half the number of these single coils or turns, it will be seen that this form of winding is particularly suitable for small currents and a high pressure, for few amperes but many volts.

It will now become obvious that in a fully wound armature of this sort, especially when the wires lie in two or more layers on the periphery of the drum, there will be a great accumulation of wire at each end, giving the ends of the armature a more or less hemispherical shape, where the coils overlie each other, as shown in Fig. 2. The current courses round the armature in one section as many times as there are turns in it, thence to a commutator segment, whence again, supposing the segment not to be in contact with a brush, to another section. Now, as each turn round the armature means virtually the opportunity of acquiring potential, a considerable difference of pressure accumulates between each section as a whole, and so between each commutator segment, rendering special care necessary as to their insulation.

But now, instead of each section of the winding being composed of one long length of wire carried round many times, the several turns being "in series" with one another, let us suppose that each "turn" consists of a separate wire, and the "section" a group of wires all carried round together, with all their ends at one end of the section connected to one commutator lug, and all the other ends to another lug. The several "turns" would now be connected "in parallel." The current, instead of being able only to flow through the turns one after

Fig. 2.

the other, would now flow through them all at once as they lie side by side, and thus would go only *once* round the core lengthways between any two segments of the commutator. The effect will hence be noted. The aggregate of the areas enclosed within the several coils, as we may now term the sections, being considerably reduced, other things being equal, the volts will be proportionately reduced; and as the current is able to flow through all the wires in a coil at once, it meets with less resistance—the resistance depending for one thing on the sectional area of the conductor—and there will be a large current; in a similar manner there would be a greater flow of water under a given head through a large pipe than a small one. We thus find, in fact, that the conditions as compared with the former case are reversed, and we have many amperes, but few volts. It will be necessary to provide a larger commutator; for while the number of segments remains unaltered, these must be of a section sufficiently large to carry the now heavy current, and of a length sufficient to afford room for a suitable number of brushes to take it off.

But to return once more to the former case of many turns per section, we may consider briefly some of the merits and demerits of this particular form of winding apart from its adaptability for heavy currents. As is well known, and fully explained in our last article, the current in its course through the armature winding, pursues two paths from brush to brush; in fact, as it might, supposing it were possible to remove the core, and pull the wire all out into one large circular loop with the brushes on the opposite ends of a diameter, when the current would be able to flow along both sides of the loop from one brush to the other. Now, with too great a density of current, the conductors are liable to heat. Let us briefly consider this point. Take the case of two pipes conveying

Digitized by Google

water, one, say, 4in. diameter bore and the other 2in., and let us imagine the same delivery through each. Now, as the sectional areas of the two bores—or, in other words, of the fluid cylinders in each—will vary with the square of their diameters, it follows that the velocity of the water in the small pipe will be $2^2=4$ times the velocity in the large pipe. Now, confining ourselves to slow velocities (as with high velocities the analogy will not hold good for hydraulic reasons), and imagining a long length of piping, we now find that besides there being in the first place the necessity of four times the head or pressure to produce the higher velocity in the small pipe, there will be a still further increase of head necessary in the case of the small pipe, on account of the increased friction between the water and the internal skin of the pipe due to the higher pressure. Thus the point to be noted is, that in this small pipe as compared with the large, we find there is a waste of energy incurred due to this friction. If this be carried to an extreme, and an attempt be made to still further increase the delivery, the small pipe may end by bursting. Now to return to our electric conductors, we find this analogy to hold good. If it is attempted to force more than a certain quantity of electricity per unit of time through a given size of conductor, there will be similar waste of energy; only in the case of the electric current, this will show itself by the rise of temperature of the conductor; and this waste energy, in the form of heat, will be dissipated by radiation or convection. As the heating of the conductor will decrease its conductivity, there will likewise need to be a corresponding increase of pressure or potential. Similarly, also, if matters be carried to an extreme, and it be attempted to make the wire carry an undue amount of current, the wire will simply melt, or even burst, with a sudden increase of current, owing to the inside of the wire melting before the outside, and thus expanding quicker.

*(To be continued.)*

## THE CENTRAL STATIONS OF THE METROPOLITAN ELECTRIC SUPPLY COMPANY.

BY DR. J. A. FLEMING, M.A.

*(Continued from page 739.)*

The underground conductor system of this Company consists of iron conduits into which are drawn highly insulated mains, mostly Silvertown electric light cable (Class L), the size chiefly in use being $\frac{19}{16}$. The pipes are of iron, cast vertical and in nine foot lengths. These iron conduits are laid under the footways and split T pipes are inserted for the customers' "take off," but no junction or jointing boxes are used. The general system of main laying as devised by the engineer of the Company, Mr. Frank Bailey, is to lay the mains in "rings," drawing in the cable in short lengths, and taking both ends of each such length into the consumers' premises.

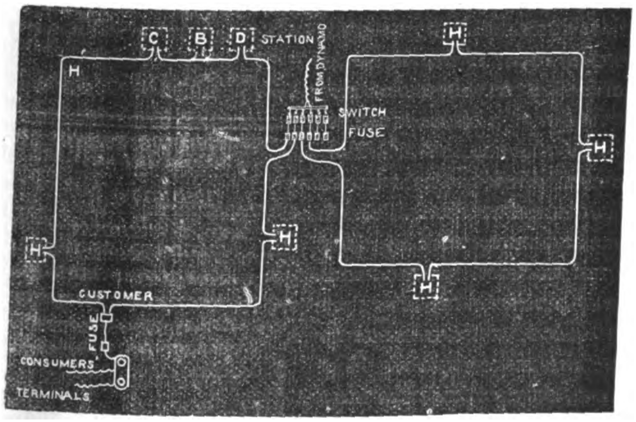



FIG. 10.—The Metropolitan Company's System of Ring Mains.

The diagram in Fig. 10 will make clear the arrangement followed. This arrangement in "rings" ensures that each customer gets his supply in duplicate, and the "ring" can be cut anywhere without interfering with the continuity of the supply of any consumer; and any section can be cut out and tested or replaced at any time. As the present price of coal necessitates working at a current density of about 600 amperes per square inch, it is clear that even if the "ring" is cut anywhere the cable will not become overloaded. Each of the sections or lengths from customer to customer is without joint*, and no making of T joints (always a difficult matter) is required. If a house at B Fig. 10 requires a supply the main from C to D can be disconnected from the cut-outs even with the current on, and one or both the halves of that section of the cable drawn out of the conduit and replaced by new lengths, the old lengths being returned to stores and used for other similar work; or one of the lengths may be drawn through with a new short length of the proper dimension attached to the end.

*(To be continued.)*

## THE CITY AND SOUTH LONDON RAILWAY.

The City and South London Railway was opened by the Prince of Wales on Tuesday last, and in a few weeks' time it may be expected that a regular passenger traffic will commence. The "royal train" having brought a number of guests from the City terminus, an inspection was made of the engine-room and other parts of the depôt at Clapham-road. Luncheon was afterwards served to a party of 250 visitors, among whom were many well-known engineers.

The railway is of the subway type, passing from King William-street, in the City, under the Thames, to Stockwell. The line has been constructed on a method, designed by Mr. Greathead, in the form of two circular iron tunnels 10ft. in diameter, driven throughout the London clay, and about 60ft. below the surface. The method of working resembles the sinking of a caisson. A steel shield was forced forward while material was excavated. When a sufficient advance had been made, a ring of cast-iron plates was built up, and a lime grout was forced into the space left by the sides of the shield between the lining plates and the soil. A speed of 16ft. per day was attained, and since the tunnels were commenced several other important works have been constructed, or are in progress, on the same plan. Near the Stockwell terminus an old water-course, consisting of gravel, with a considerable quantity of water, was encountered. The air-lock principle, for which this system is excellently adapted, was employed, and after some delay in providing the necessary machinery which it was hoped might have been unnecessary, the tunnels were satisfactorily completed. It was originally intended to work the railway by cable, but tenders were invited for running it by electricity, and eventually plans were submitted to the Company by Messrs. Mather and Platt, and the Company accepted this firm's scheme, which is based upon the experience obtained by Dr. Edward Hopkinson in the construction of the Bessbrook-Newry Narrow-Gauge Electrical Railway. The contractors employed Messrs. John Fowler and Co., of Leeds, to supply the boilers and engines, and Messrs. Beyer, Peacock and Company to construct the framework of the electrical locomotives. All the electrical plant has been carried out under the special superintendence of Dr. Edward Hopkinson, of Messrs. Mather and Platt. Dr. John Hopkinson, F.R.S., has acted throughout as consulting engineer, and Mr. G. A. Grindle as resident engineer.

The whole of the generating plant is situated at Stockwell, the suburban terminus of the line. It consists of three large Edison-Hopkinson dynamos, each worked independently by a vertical compound Fowler engine. The engines work at a steam pressure of 140lb. per square inch, and have been built of exceptionally massive proportions. They run at 100 revolu-

* In a former part of this article (see *The Electrician*, Oct. 31, 1890, p. 739) it was stated erroneously that the joints were made and vulcanised in place. On this method of Mr. Bailey's there are no joints in the mains at all.

Digitized by Google

## DRUM ARMATURE WINDING.

BY F. M. WEYMOUTH.

*Introductory.*

It frequently happens that men who have served their apprenticeship in mechanical engineering, and, perhaps, had considerable experience in that line, ultimately drift into electrical work. If of an inquiring turn of mind, such as, indeed, may be taken to be generally the case, they will find a variety of problems arise before them in connection with their new sphere of occupation, for which to them there is no immediate solution. Many books abound; but some of these are expensive, or else cover so much ground that much detail is necessarily omitted. The drum armature in itself involves a host of problems; taking its theory alone it is very puzzling to the new comer, and mechanical considerations also of all sorts demand attention. It is the object of these articles to put some of these mechanical considerations before younger readers. As to the theory that was treated much at large in another Article (on the Generation of Current and Potential in Drum Winding, see *The Electrician* of July 16th, 1889).

Various methods have been adopted from time to time by different inventors and makers to put this type of winding into a practical form. Among the many points for consideration that occur, perhaps the most prominent is that involving the question as to how to take the cross-connections at the end of the armature round the spindle. It is thus of interest to observe for one thing in what different ways this particular difficulty has been surmounted, and the "end-winding," as it is termed, arranged. It may be true that in the case of armatures for small currents, and wound with flexible wire, this difficulty may not be very great. But in dealing with heavy currents and conductors of large section, it is different, and many points of mechanical construction arise for consideration; and it is with these we shall be mostly concerned in the course of our remarks. We may state here, parenthetically, that though some of the sketches that will accompany this article will be taken from designs actually carried out, all will not, but will merely illustrate principles of design without pretending to be actual representations of any particular machines. Further, it may be added that we shall confine ourselves almost exclusively to armatures for two-pole machines.

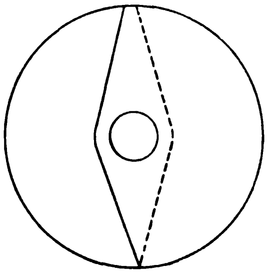


Fig. 1.

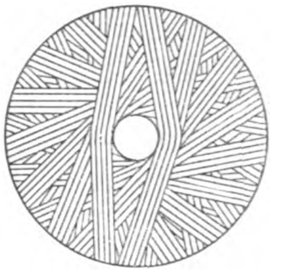


Fig. 2.

Dealing for the present with wire-winding for light currents, we meet with the most simple and crude of all armature winding in Siemens' wire wrapping. This winding consists fundamentally as shown in Fig. 1, and supposing a single turn per section, in merely carrying the wire from one commutator segment, say, along the periphery of the drum parallel with the axis, across the further end, giving it a slight bend to one side to get past the spindle, and so back again on the other side, repassing the spindle, and then joining it to the next commutator lug from whence it started, or in irregular winding to some other lug. In practice, however, the wire may be carried round many times before being joined up to the lug of the next commutator segment. Each "section" of the winding is thus said to be composed of so many "turns;" and while there may thus be any number (within reason) of "turns per section," there are as many "sections" as there are segments in the commutator, neither more nor less. All the turns in a section may lie in approximately the same plane, carefully insulated from each other, and each section likewise from neighbouring sections, and from the core. There may hence be in a winding of this sort a large total number of turns of the single wire; and as the volts depend for one factor on the aggregate of the areas enclosed severally within half the number of these single coils or turns, it will be seen that this form of winding is particularly suitable for small currents and a high pressure, for few amperes but many volts.

It will now become obvious that in a fully wound armature of this sort, especially when the wires lie in two or more layers on the periphery of the drum, there will be a great accumulation of wire at each end, giving the ends of the armature a more or less hemispherical shape, where the coils overlie each other, as shown in Fig. 2. The current courses round the armature in one section as many times as there are turns in it, thence to a commutator segment, whence again, supposing the segment not to be in contact with a brush, to another section. Now, as each turn round the armature means virtually the opportunity of acquiring potential, a considerable difference of pressure accumulates between each section as a whole, and so between each commutator segment, rendering special care necessary as to their insulation.

But now, instead of each section of the winding being composed of one long length of wire carried round many times, the several turns being "in series" with one another, let us suppose that each "turn" consists of a separate wire, and the "section" a group of wires all carried round together, with all their ends at one end of the section connected to one commutator lug, and all the other ends to another lug. The several "turns" would now be connected "in parallel." The current, instead of being able only to flow through the turns one after the other, would now flow through them all at once as they lie side by side, and thus would go only *once* round the core lengthways between any two segments of the commutator. The effect will hence be noted. The aggregate of the areas enclosed within the several coils, as we may now term the sections, being considerably reduced, other things being equal, the volts will be proportionately reduced; and as the current is able to flow through all the wires in a coil at once, it meets with less resistance—the resistance depending for one thing on the sectional area of the conductor—and there will be a large current; in a similar manner there would be a greater flow of water under a given head through a large pipe than a small one. We thus find, in fact, that the conditions as compared with the former case are reversed, and we have many amperes, but few volts. It will be necessary to provide a larger commutator; for while the number of segments remains unaltered, these must be of a section sufficiently large to carry the now heavy current, and of a length sufficient to afford room for a suitable number of brushes to take it off.

But to return once more to the former case of many turns per section, we may consider briefly some of the merits and demerits of this particular form of winding apart from its adaptability for heavy currents. As is well known, and fully explained in our last article, the current in its course through the armature winding, pursues two paths from brush to brush; in fact, as it might, supposing it were possible to remove the core, and pull the wire all out into one large circular loop with the brushes on the opposite ends of a diameter, when the current would be able to flow along both sides of the loop from one brush to the other. Now, with too great a density of current, the conductors are liable to heat. Let us briefly consider this point. Take the case of two pipes conveying

Digitized by Google

water, one, say, 4in. diameter bore and the other 2in., and let us imagine the same delivery through each. Now, as the sectional areas of the two bores—or, in other words, of the fluid cylinders in each—will vary with the square of their diameters, it follows that the velocity of the water in the small pipe will be $2^2 = 4$ times the velocity in the large pipe. Now, confining ourselves to slow velocities (as with high velocities the analogy will not hold good for hydraulic reasons), and imagining a long length of piping, we now find that besides there being in the first place the necessity of four times the head or pressure to produce the higher velocity in the small pipe, there will be a still further increase of head necessary in the case of the small pipe, on account of the increased friction between the water and the internal skin of the pipe due to the higher pressure. Thus the point to be noted is, that in this small pipe as compared with the large, we find there is a waste of energy incurred due to this friction. If this be carried to an extreme, and an attempt be made to still further increase the delivery, the small pipe may end by bursting. Now to return to our electric conductors, we find this analogy to hold good. If it is attempted to force more than a certain quantity of electricity per unit of time through a given size of conductor, there will be similar waste of energy; only in the case of the electric current, this will show itself by the rise of temperature of the conductor; and this waste energy, in the form of heat, will be dissipated by radiation or convection. As the heating of the conductor will decrease its conductivity, there will likewise need to be a corresponding increase of pressure or potential. Similarly, also, if matters be carried to an extreme, and it be attempted to make the wire carry an undue amount of current, the wire will simply melt, or even burst, with a sudden increase of current, owing to the inside of the wire melting before the outside, and thus expanding quicker.

*(To be continued.)*

## THE CENTRAL STATIONS OF THE METROPOLITAN ELECTRIC SUPPLY COMPANY.

BY DR. J. A. FLEMING, M.A.

*(Continued from page 739.)*

The underground conductor system of this Company consists of iron conduits into which are drawn highly insulated mains, mostly Silvertown electric light cable (Class L), the size chiefly in use being $\frac{19}{16}$. The pipes are of iron, cast vertical and in nine foot lengths. These iron conduits are laid under the foot-

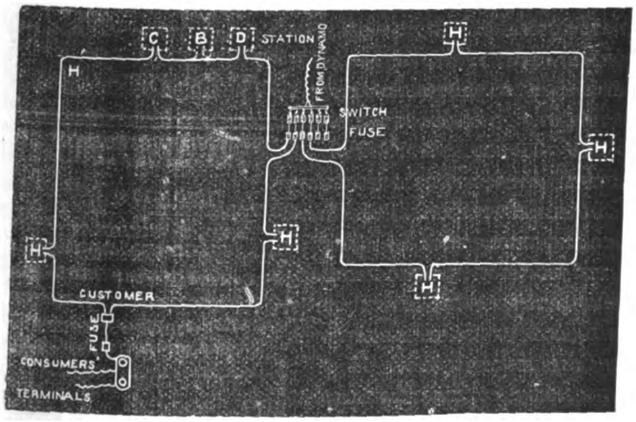



FIG. 10.—The Metropolitan Company's System of Ring Mains.

ways and split T pipes are inserted for the customers' "take off," but no junction or jointing boxes are used. The general system of main laying as devised by the engineer of the Company, Mr. Frank Bailey, is to lay the mains in "rings," drawing in the cable in short lengths, and taking both ends of each such length into the consumers' premises. The diagram in Fig. 10 will make clear the arrangement followed. This arrangement in "rings" ensures that each customer gets his supply in duplicate, and the "ring" can be cut anywhere without interfering with the continuity of the supply of any consumer; and any section can be cut out and tested or replaced at any time. As the present price of coal necessitates working at a current density of about 600 amperes per square inch, it is clear that even if the "ring" is cut anywhere the cable will not become overloaded. Each of the sections or lengths from customer to customer is without joint*, and no making of T joints (always a difficult matter) is required. If a house at B Fig. 10 requires a supply the main from C to D can be disconnected from the cut-outs even with the current on, and one or both the halves of that section of the cable drawn out of the conduit and replaced by new lengths, the old lengths being returned to stores and used for other similar work; or one of the lengths may be drawn through with a new short length of the proper dimension attached to the end.

*(To be continued.)*

## THE CITY AND SOUTH LONDON RAILWAY.

The City and South London Railway was opened by the Prince of Wales on Tuesday last, and in a few weeks' time it may be expected that a regular passenger traffic will commence. The "royal train" having brought a number of guests from the City terminus, an inspection was made of the engine-room and other parts of the depôt at Clapham-road. Luncheon was afterwards served to a party of 250 visitors, among whom were many well-known engineers.

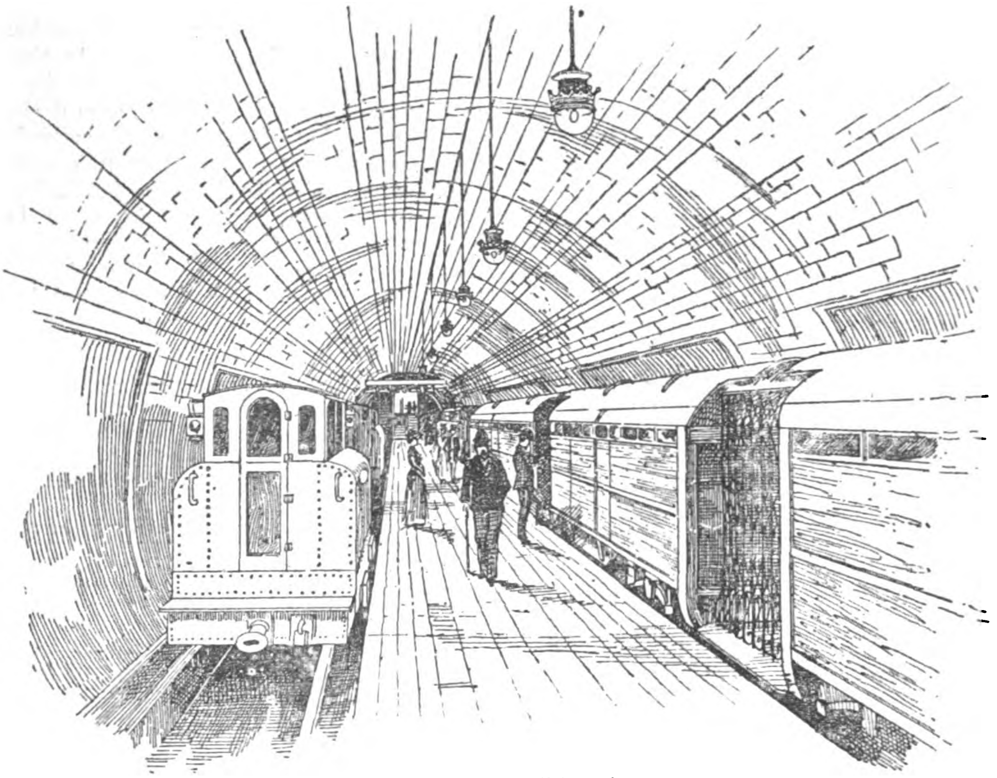
The railway is of the subway type, passing from King William-street, in the City, under the Thames, to Stockwell. The line has been constructed on a method, designed by Mr. Greathead, in the form of two circular iron tunnels 10ft. in diameter, driven throughout the London clay, and about 60ft. below the surface. The method of working resembles the sinking of a caisson. A steel shield was forced forward while material was excavated. When a sufficient advance had been made, a ring of cast-iron plates was built up, and a lime grout was forced into the space left by the sides of the shield between the lining plates and the soil. A speed of 16ft. per day was attained, and since the tunnels were commenced several other important works have been constructed, or are in progress, on the same plan. Near the Stockwell terminus an old water-course, consisting of gravel, with a considerable quantity of water, was encountered. The air-lock principle, for which this system is excellently adapted, was employed, and after some delay in providing the necessary machinery which it was hoped might have been unnecessary, the tunnels were satisfactorily completed. It was originally intended to work the railway by cable, but tenders were invited for running it by electricity, and eventually plans were submitted to the Company by Messrs. Mather and Platt, and the Company accepted this firm's scheme, which is based upon the experience obtained by Dr. Edward Hopkinson in the construction of the Bessbrook - Newry Narrow - Gauge Electrical Railway. The contractors employed Messrs. John Fowler and Co., of Leeds, to supply the boilers and engines, and Messrs. Beyer, Peacock and Company to construct the framework of the electrical locomotives. All the electrical plant has been carried out under the special superintendence of Dr. Edward Hopkinson, of Messrs. Mather and Platt. Dr. John Hopkinson, F.R.S., has acted throughout as consulting engineer, and Mr. G. A. Grindle as resident engineer.

The whole of the generating plant is situated at Stockwell, the suburban terminus of the line. It consists of three large Edison-Hopkinson dynamos, each worked independently by a vertical compound Fowler engine. The engines work at a steam pressure of 140lb. per square inch, and have been built of exceptionally massive proportions. They run at 100 revolu-

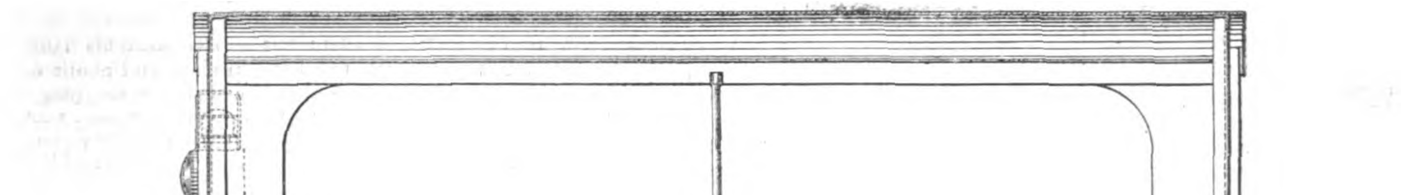
* In a former part of this article (see *The Electrician*, Oct. 31, 1890, p. 739) it was stated erroneously that the joints were made and vulcanised in place. On this method of Mr. Bailey's there are no joints in the mains at all.

Digitized by Google

tions per minute, giving a piston speed of 450ft. per minute. They are fitted with automatic expansion gear of improved ropes. The automatic gear, being so arranged as to cut off the steam, if necessary, in both cylinders from dead cut-off to $\frac{3}{4}$



The Platform, Stockwell Terminus.



Section of 100-h.p. Electric Locomotive.

Scale of Feet.

1 0 1 2 3 4 5

type on both the high-pressure and low-pressure cylinders, and are controlled by a powerful governor having a capacity of 750ft. lb., which is driven direct from the crank shaft by cotton stroke. The engines will indicate up to 375 horse-power each. The cylinders are steam jacketed, the high pressure is 17in. diameter and the low pressure 27in., stroke 27in. The pistons

Digitized by Google

are fitted with Mather and Platt's rings and springs, and the valves are specially arranged with multiple parts which reduces their movement considerably and still allows a very prompt action; as the ports are as close as possible to the end of each cylinder the loss of pressure by wire drawing is very small. Large and slow speed engines were selected on account of the very irregular nature of the work, it being considered that the high speed engines which are so largely and economically used for electric lighting could not so well cope with the sudden variations of load as the type which has been selected. The fly wheels are 14ft. diameter and 28in. broad, and drive the dynamos direct by means of leather chain belts 26in. wide.

It is a pity that the engine-room does not permit of a greater distance than 24ft. between the centres of the engines and that of the dynamos, since jockey pullies are rendered necessary. These are all very well as an expedient, but are not often to be met with in an important station of this kind. The engines are supplied with steam from six Lancashire boilers 7ft. diameter by 28ft. long, which are fitted with Vicar's mechanical stokers.

Livet's boiler setting is used, which provides flues of a varying area, and which, in conjunction with the mechanical stoker, is said to effect a saving of fuel, and certainly succeeded on the occasion of our visits to the depôt in preventing smoke. Two large feed water heaters are also supplied with brass tubes of ample surface for receiving the whole of the exhaust steam from the engine without back pressure.

The 202 kilowatt dynamos are fitted with all the latest improvements. The weight of the armature alone, which is drum wound with spiral ends, being about two tons, the weight of the entire machine being something over 17 tons. Each machine is capable of generating 450 volts and 450 amperes. There are three brushes on each rocking arm, each separately adjustable with a forward thrust and hold-off catch. The magnet limbs are exceedingly massive, each limb with its pole piece being over four tons, and the yoke of the machine weighs about three tons. The machines can be run either as shunt or compound as required. The total weight of copper wire on the magnet of each machine is nearly one and a-half tons. The present machines have an electrical efficiency of slightly over 96 per cent., and the commercial efficiency of the engine and dynamo, *i.e.*, ratio of the electric power available outside the dynamo to the indicated horse-power of the engine is over 75 per cent. Two dynamos are capable of working the trains on the line at any time.

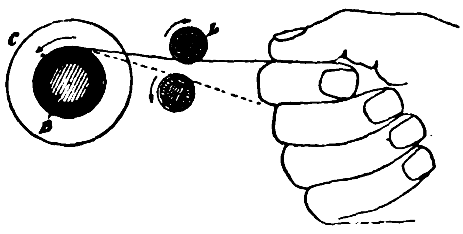
The current is conveyed from the dynamos to a general distributing and testing switch-board, fixed in a recess of the engine-house. From this board, which resembles in some respects the Westinghouse switch-board described in our last issue, the main circuits are taken to various parts of the line, and the current passing through each circuit is measured, suitable arrangements being provided for switching over from one circuit to another. The main cables have been manufactured by the Fowler-Waring Company, and consist of a copper core of $\frac{61}{14}$ B. W. G., insulated with Fowler-Waring insulating material and then lead-sheathed.

The working conductor is of channel steel carried on glass insulators, the joints being fished, and also connected with copper strips. The steel employed is of very high conductivity, and has been rolled specially for the purpose by the Shelton Iron and Steel Company, of Stoke-on-Trent. The working conductor is divided into sections for convenience of testing and carrying out repairs on the permanent way. The insulation obtained is thought by the contractors to be extraordinarily high. When the full pressure of 500 volts is on the complete system of working and feeding conductors, the leakage current does not exceed one ampere, so that the total loss by leakage is less than 1 horse-power; this is a small fraction of 1 per cent. of the total power required for working the line to its full capacity. The current is collected from the working conductor by sliding shoes of iron or steel arranged in a very similar way to that employed on the Bessbrook line.

Fourteen electric locomotives have been supplied by Messrs. Mather and Platt for working the line, each capable of developing 100 effective horse-power, and of running at from 25 or 26 miles per hour. The locomotives are constructed so that the shafts of the armatures are the axles of the locomotives. The driving wheels run at about 240 revolutions per minute when the locomotive is travelling at 20 miles per hour. The locomotives have a fixed wheel base and a motor is fitted to each axle, the axles not being coupled, but working independently. The current is conveyed from the collecting shoes through an ammeter to a regulating switch, then to a reversing switch, thence to the magnets and back through the frame-work of the locomotive to the rails. The locomotives are fitted with Westinghouse Automatic Air Brakes, and also a screw hand-brake, and they and the carriages are lighted from the working conductor by lamps in series. The compressed air for the brakes is stored in two cylinders, twelve inches in diameter, and the capacity is sufficient for three times as many stoppages as are likely to occur in any double journey. The trains, when loaded, will weigh 30 tons, and it is intended that ten trains shall be worked on the line at one time.

## WOOD'S MAGNET WINDER.

A clever little device is described in the *Electrical Engineer* of New York, by which a wire may be easily guided to and fro in winding magnet coils. Two guide spindles, L, are geared together and to the sleeve B on which the bobbin C is carried. The spindles have screw threads cut on them, and as they revolve in opposite directions, a wire guided by any thread is carried laterally in one




direction or in the other. The operator has only to move his hand up or down to engage the wire in one screw-thread or in the other. The speed of the guide spindles must be proportioned to the gauge of the wire. The difficulty in winding a magnet chiefly is met with at the ends rather than in guiding the wire, as every young electrician knows, but this method may sometimes prove to be useful.

## MEETINGS OF SCIENTIFIC SOCIETIES, &c.

**FRIDAY, November 7th.**

INSTITUTION OF ELECTRICAL ENGINEERS.

*7.30 p.m.* Students' Meeting.

ELECTRO HARMONIC SOCIETY.

*8 p.m.* Smoking Concert at St. James's Hall.

**MONDAY, November 10th.**

LONDON CHAMBER OF COMMERCE.

*4 p.m.* Meeting of Electrical and Allied Trades Section Committee.

**TUESDAY, November 11th.**

INSTITUTION OF CIVIL ENGINEERS.

*8 p.m.* Ordinary Meeting. Paper to be read: "Steam on Common Roads," by JOHN MCLAREN, A.M.I.C.E. Presentation of Medals, Premiums, and Prizes awarded at the end of last Session.

ROYAL VICTORIA HALL.

*8.30 p.m.* Lecture: "Columbus," by A. H. GILKES.

**THURSDAY, November 13th.**

INSTITUTION OF ELECTRICAL ENGINEERS.

*7 p.m.* Council Meeting.

*8 p.m.* Ordinary General Meeting. Paper to be read: "On the Chemistry of Secondary Cells," by Prof. W. E. AYRTON, F.R.S., C. G. LAMB, B.Sc., and E. W. SMITH.

The above Paper will be discussed together with that on "The Working Efficiency of Secondary Cells," by the same Authors, which was read at the Edinburgh Meeting on July 16th.

**FRIDAY, November 14th.**

PHYSICAL SOCIETY.

*5 p.m.* Papers to be read: "On Certain Relations existing among the Refraction Indices of some of the Chemical Elements," by Rev. T. PELHAM DALE, M.A.; "Tables of Spherical Harmonics with examples of their practical use," by Prof. J. PERRY, F.R.S.

Digitized by Google

# The Electrician.

**Published every Friday, Price Fourpence; Post Free, Fourpence Halfpenny.**
**Editorial, Publishing, and Printing Offices:**
**SALISBURY COURT, FLEET ST., LONDON, E.C.**
*Telephone No.* 2714. *Telegrams:* "ELECTRICIAN NEWSPAPER, LONDON."

*All Letters relating to Subscriptions, Advertisements and other business matters should be addressed to the Publisher,* "THE ELECTRICIAN," *Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to* "THE ELECTRICIAN" *Printing and Publishing Company, Limited, and be crossed* "*Coutts and Co.*" *All other letters to be addressed to the Editor.*

*All letters intended for insertion in* "THE ELECTRICIAN," *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

"THE ELECTRICIAN" *is published every Friday morning, in time for the morning mails. Subscribers should receive their copies by the first post on Friday morning.*

"THE ELECTRICIAN" *is on sale at the railway bookstalls throughout the Kingdom on Friday morning, and can be obtained of all Booksellers and Newsvendors; or direct from the Publishing Offices as above.*

*New Volumes of* "THE ELECTRICIAN" *commence in May and November.*

## SUBSCRIPTION RATES.

The rates for Subscriptions to "THE ELECTRICIAN" are as follows:—

| | 3 months. s. d. | 6 months. s. d. | 12 months. s. d. |
|---|---|---|---|
| For the United Kingdom | 5 0 | 10 0 | 19 6 |
| For Foreign Parts and Colonies:— Within Postal Union | 6 6 | 12 6 | 24 0 |
| Aden, Borneo, Ceylon, China, India, Japan, Java, Labuan, Mozambique, New Caledonia, Persia, Philippine Islands, Siam, Transvaal, and Zanzibar | 7 6 | 14 6 | 28 0 |

## TO ADVERTISERS.

"THE ELECTRICIAN" *offers exceptional advantages to Advertisers.* **It has by far the largest circulation of any English Electrical paper, and circulates all over the World.**

*Particulars relating to Advertisements will be promptly forwarded on application to the Offices as above.*

TRADE ADVERTISEMENTS *intended for the current issue must reach the Offices not later than First Post on Thursday morning. Renewals of expiring advertisement orders and alterations to standing advertisements should be in the Publisher's hands by Wednesday at latest. No alteration can be made in Wrapper advertisements after Wednesday evening.*

SMALL PREPAID ADVERTISEMENTS *(for Rates see page xvii.) are accepted up to 4 p.m. on Thursday.*

## TECHNICAL PRINTING.

"THE ELECTRICIAN" PRINTING AND PUBLISHING COMPANY (LIMITED) *inform Electricians, Electric Light Engineers, &c., that they make a specialty of Technical Printing, and have a large Staff thoroughly acquainted with Electro-Technology. They can, therefore, promise Accuracy and Despatch in the Printing of Electro-Technical Literature, &c.*

## "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. (Royal 8vo.)

*Early in each year is issued* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. *The* DIRECTORY *was established in 1883, and the 1890 Edition consisted of about 850 pages of printed matter. The names and addresses of all persons engaged in the Electrical Industries at home and abroad may be relied upon as accurate. Useful Tables and Electrical Formulæ, and information specially compiled for this work are given, together with popularly-written Biographical Notices of the leading Electricians, Electrical Engineers, &c., accompanied in many cases by Portraits.*

*Orders for the 1890 issue should be forwarded* AT ONCE *to the Publishing Offices, Salisbury-court, Fleet-street, London, E.C.*

*The 1891 Edition is now preparing, and New Names, &c., can now be received.*

## ELECTRICAL BOOKS AND PUBLICATIONS.

*All Books, Newspapers, and other publications, dealing with Electrical and kindred subjects, can be ordered direct of* "THE ELECTRICIAN" *Printing and Publishing Company, who are proprietors of the well-known* "ELECTRICIAN" *Series of Standard Electrical Works, and are agents for all the leading publishing houses at home and abroad.*

## CONTENTS OF THE CURRENT NUMBER.

NOTES ... 1
Magnetism in Iron and other Metals. XXXIV. By Prof. J. A. Ewing, F.R.S. Illus. Con. ... 
Drum Armature Winding. By F. M. Weymouth. Illustrated ... 8
The Central Stations of the Metropolitan Electric Supply Company. By Dr. J. A. Fleming. Illustrated ... 9
The City and South London Railway. Illustrated ... 9
Wood's Magnet Winder. Illustrated ... 11
Meetings of Scientific Societies ... 11
THE CITY AND SOUTH LONDON RAILWAY ... 12
Electrical Distribution by Transformers from Central and Eccentric Stations. By Dr. J. A. Fleming, M.A. Illustrated. Continued ... 13
The Electrolytic Preparation of Bleaching Agents. By A. Rigaut. Illustrated ... 16
The Electro-Magnet. By Prof. Silvanus P. Thompson, D.Sc., B.A., M.I.E.E. Illustrated. Continued ... 17
American Notes ... 20
CORRESPONDENCE—
The Edinburgh Exhibition—A. R. Bennett ... 20
Local Authorities and Electric Tramways—T. W. Higgens ... 21
Eccentric Stations—A. K. C. ... 21
Lane Fox Claims—R. S. Erskine ... 21
Trade Notes and Notices ... 21
LEGAL INTELLIGENCE—
The Halifax and Bermuda Cable Company v. Magniac ... 22
The Edison and Swan Electric Light Co. v. Robertson ... 22
Douse's Patent Fire-Check Co. ... 22
COMPANIES' MEETINGS, &c.—
The Monte Video Telephone Company (Limited) ... 22
Westminster Electric Supply Corporation (Limited) ... 22
The West India and Panama Telegraph Company (Ltd.) ... 24
The Western and Brazilian Telegraph Company (Ltd.) ... 24
Metropolitan Electric Supply Company (Limited) ... 24
New Companies Registered ... 25
City Notes, &c. ... 25

## SPECIAL NOTICE.

**With this Number of "THE ELECTRICIAN" is issued (gratis) the Index to Volume XXV. Complaints of non-receipt should be promptly addressed to the Publisher.**

**NOW READY.**

**Volume XXV. of "THE ELECTRICIAN," price 12/6, post free, 13/6.**

**ALSO NOW READY.**

**Cases for binding Volume XXV., price 2/0, post free, 2/3.**

## THE CITY AND SOUTH LONDON RAILWAY.

The construction and equipment of the first electrical railway in this country, which was opened on Tuesday last, naturally divides itself into two portions—the mechanical work of driving the tunnels and making the lifts, and the electrical work of providing for the transmission of the power generated by the engines to the motors which propel the trains. These two portions differ from each other to a somewhat remarkable degree, inasmuch as the former is full of novelties, while the latter is as simple a piece of electrical engineering as can be found. The tunnels were driven on the ingenious GREATHEAD system, which, while it reminds one strongly of the "shield" with which BRUNEL drove the first Thames tunnel, is a bold and skilfully-arranged departure from ordinary practice. The new idea of running one tunnel below another in order to save space, the working of a connected system of immense lifts from one pumping station, the abolition of the ticket system, are among the more important innovations, together with many minor devices, such as the ejector hydrants for draining the tunnel. On the other hand, the electrical engineer, while he cannot but welcome the direct driving of the armatures, a desideratum often talked of but never before realised, will find little, if any, other novelty, either great or small; even the direct driving being an obvious method which is only a novelty, because an opportunity for its use has not previously presented itself. At all events, no ingenious devices are apparent, and on this account but little chance is offered for a

Digitized by Google

breakdown. To achieve an undertaking on such a scale with appliances so simple reflects the highest credit on the engineers concerned. This, the most extensive and important application of the transmission of power, has been carried out with three dynamos of a very well-known type; a switch-board of the utmost simplicity, and one which in this respect may be envied by many an owner of an electric light plant; a steel channel rail on glass insulators, a most unpretentious pair of collectors, a pair of series motors, and a resistance switch; and there you have the whole apparatus. We are not aware that there is any newly patented invention in use, though a large amount of work of a far higher order has been expended, both on the design of the whole scheme and the elaboration of the details. But this absence of elaborate invention is a most satisfactory indication of the state to which electrical engineering has advanced. It is an industry which is scarcely ten years old, and it is no great exaggeration to say that all the electrical apparatus required for this railway might but for its size have been bought from stock, so great is the adaptability of electricity and of electrical machinery. We recently ventured to criticise in a friendly way a system of electric traction, which merits the term "system" since it is an aggregation of ingenious and original inventions, and, as in many "systems" one new departure entails another, the outsider has a difficulty in discovering which features are essential and which are adventitious. The electrical details of the City and South London Railway are so simple that even the *Daily Telegraph* cannot go wrong, though it is unable to put forth an article on the subject without going out of its way to introduce the fairy Electra who "bravely submits to be accumulated, and leaps into the crystal vacuum and glows with cheerful splendour as she circles round the tiny *film* of *platinum*."

It is, we think, highly satisfactory that the first electric railway is no adaptation, but embodies an absolutely fresh departure. Many firms engaged in electric traction and several companies, have from time to time asserted with more or less confidence that they were on the point of entering or had entered into an arrangement with the Metropolitan or with the District Railway Company for running trains, or for working a portion of the lines. In the majority of these cases, it is probable that the proposers were not acquainted with the magnitude of their offers, and modestly withdrew after they had ascertained the real facts. There would be a strong temptation to use the present carriages, and to run—or, at all events, to talk about running—trains of the ordinary length. Electric traction has a much better chance at the South London line. Here the trains will carry a hundred passengers; and 20 trains can run in the hour, even if the two-minute service, which is being talked about, is not feasible. In speed, they can easily outrun the ponderous trains on the Inner Circle; and probably the system of filling and emptying the cars of passengers will give the new line a greater advantage. The earliest railways were sadly fettered by the traditions of the stage-coach; and until these were shaken off, and it was realised that the change was something more than the exchange of horses for a steam locomotive, not much progress was made. Should the new railway prove to be a success, the projected line under Oxford-street is sure to be constructed. When that in its turn has given satisfactory evidence that the right system has been adopted, the alteration of the Metropolitan and possibly of the District Railway must be only a matter of time.

But a work of this kind, though it be all that an engineer can ask for, and on this very account incapable of any fundamental improvement, may for all that fail to be a financial success. The first Thames tunnel was practically a failure as a footway, though a triumph as a work of engineering. *The Times* of Tuesday discusses the probabilities of a 5 per cent. dividend, and does not do so in the prospectus writer's style. The one fare of twopence is, fortunately, a matter which can at any time be altered. It is not improbable that it will reduce the traffic at the intermediate stations, but it may make the calculation of the cost of running rather difficult to compare with other railways. We very much regret to hear that Messrs. Mather and Platt have contracted to run the trains at 3½d. per train mile for two years. This system has proved disastrous in both electrical and other mechanical tramway work, it has led to all sorts of complications and disputes, and has created antagonism where co-operation is essential. The local authorities themselves have not done as much harm to the development of electric traction as have tramway companies, who have tempted inexperienced inventors to make what they call demonstrations of their systems under this method of contracting at so many pence per car mile.

The selection of the standard gauge of 4ft. 8½in. is very satisfactory. It is impossible to tell how our railway systems may develop, and in the event of a serious strike, or a siege, internal communication by means of railways such as this, and the others which may be expected to follow, would be of incalculable value if they could on such emergencies be connected with the main lines. The adoption of the Westinghouse brake is another sensible feature. No doubt an electrical brake would pull up the train quite as promptly, but the failure of the current in the conductor is remotely possible, and the air brake entails a very small expense in working. There is one point only which we wish to criticise, and that is, the insulation resistance of the line. We could hardly believe it when we learned that a leakage of one ampere was calmly contemplated from the point of view of the horse-power lost. In closed iron tubes, and with continuous currents, the effect on telephones and telegraphs is not likely to be serious. The flat glass insulators and the proximity of the conductor to the return rails will easily account for this low insulation, but it seems to be scarcely in keeping with the high-class execution and admirable design of the rest of the undertaking.

## ELECTRICAL DISTRIBUTION BY TRANSFORMERS FROM CENTRAL AND ECCENTRIC STATIONS.*

BY DR. J. A. FLEMING, M.A.

*(Continued from page 711.)*

§ 18. **The Lowrie-Hall System.**—The various elements in the Transformer system of the House-to-House Electric Lighting Company have been brought to their present perfection by the inventive skill of Mr. W. Lowrie and Mr. C. J. Hall. The Alternator built by Messrs. Elwell-Parker, of Wolverhampton, is of a somewhat similar type to the Alternator of Messrs. Zipernowsky Déri and Blathy, employed in the Ganz system. In this machine the stationary portion is the armature in which the current is generated, and the revolving portion constitutes the field magnets. Fig. 51 shows the general external appearance of the 100-unit size machine having a safe out-put of 100,000 watts, or 130 horse-power. The circular iron frame is composed of thin sheets of charcoal iron ring-shaped, insulated from each other by paper and bolted together. This armature ring is parted on the central horizontal line so that the upper part can be lifted off to insert or remove the field magnets. This ring-frame is carried on the cast-iron frame work of the machine, but is insulated from it. On the inner cylindrical surface of this ring-shaped iron core are fixed the armature coils. These coils are formed of copper tape, each wound on a former so as

* All rights are reserved.

Digitized by Google

to form a coil of flat or link shape, and yet slightly curved so as to fit closely to the inner surface of the armature core. The edges of the tape winding are thus exposed. The centre of the flat coil is occupied by a piece of insulating material. These flat coils are placed close together upon the cylindrical inner surface of the divided iron armature ring so that the axis of each coil is radial to the ring, and the coils are secured in their places by strips of wood screwed to the cheeks and extended over the ends of the coils outside the line of travel of the magnets.

These armature coils are then joined up in series, and the terminal wires brought to insulated terminals on a sheet of ebonite contained in a lock-up box. There are 28 armature coils thus joined in series, each coil producing about 70 volts, or 2,000 in all.

The armature coils can be easily individually removed for examination or for repair. The field magnet or revolving portion of the machine consists of a solid soft wrought-iron ring, with wrought-iron radial pole pieces securely attached thereto; and these pole pieces are of solid wrought iron.

The exciting coils are wound on shells, which are slipped on to which is secured the wrought iron ring with the magnet poles. The shaft carries two gun-metal rings insulated from each other and from the shaft to which are attached the ends of the field-magnet circuits, and by means of which the exciting current is passed into the field circuit. Each ring is provided with two sets of brushes, each set being ample for collecting the exciting current, and the brushes and their holders are carried by a support from the base plate. Suitable adjustable springs control the pressure of these brushes, and their holders are carried against their contact rings. The shaft carries two pulleys of cast iron, one, the driving pulley, turned with seven grooves for seven $1\frac{1}{2}$in. ropes, and the other turned with four grooves for four $\frac{3}{4}$in. ropes for driving the exciter dynamo. The exciter is a series-wound machine, with drum armature, running a speed of 800 revolutions per minute. Each alternator has its own exciter, and for the 100 unit alternators the exciters furnish a current of 25 to 28 amperes at 120 volts.

The speed of the alternators is 350 revolutions per minute, giving an alternating current having about 10,000 alternations per minute, or a "frequency" of 83.

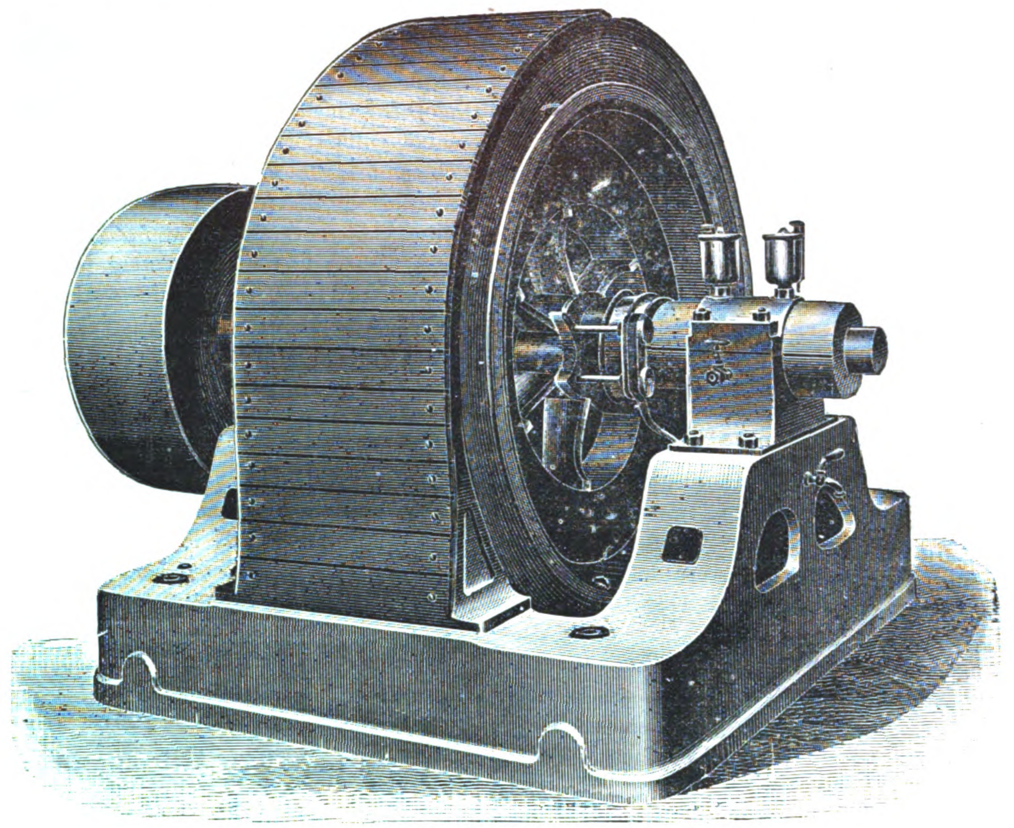


FIG. 51.—100-Unit Lowrie-Hall-Parker Alternator.

these pole pieces, and secured by bolts from being displaced by centrifugal action. There are 28 such radial magnetic poles, alternately N and S polarity.

The coils of the field magnets are joined up in series, and the terminal wires are brought to two insulated gun metal rings on the steel shaft of the dynamo.

The current density in both armature coils and field magnet coils is not allowed to exceed 2,000 amperes per square inch of section.

The base plate of the dynamo is of strong box pattern, ribbed and flanged. The frame for supporting the laminated iron armature core is cast separate, and securely bolted to planed facings. The plummer blocks for the bearings are cast separate from the base plate, and secured thereto by bolts and lugs and wrought iron wedge keys. The bearings of the magnet shaft are each 20in. long and fitted with brasses of phosphor bronze. The bottom brass is so arranged that it can be removed without lifting the shaft and yet well secured sideways. The bearings are provided at each end with oil catchers, by which used oil is caught and drained away to a tank in the base plate, from which it can be drawn off and filtered for re-use. The steel shaft carried by these bearings is 6in. in diameter. It carries a cast iron hub to

The output of each alternator is 50 amperes at 2,000 volts. The over-all height of this alternator is 8ft. 6in., and the weight 10 tons. A separate pair of wires are taken off one coil of the armature for the purpose of regulation of electromotive force in a way to be presently described.

The commercial efficiency of this alternator at full load is stated to be about 85 or 87 per cent. These alternators work well in parallel. If two alternators driven by separate engines are thrown in parallel and the steam is shut off one engine, it still continues to be taken round by its dynamo acting as a motor and driven by the fellow-dynamo acting as a generator.

Alternators of this type are made in the following sizes:—

| Safe output in kilowatts. | Load in 60-watt lamps. | Revolutions per minute. | Revolutions of exciter per minute. |
|---|---|---|---|
| 30 | 500 | 600 | 1,000 |
| 45 | 750 | 550 | 1,000 |
| 60 | 1,000 | 500 | 1,000 |
| 90 | 1,500 | 400 | 800 |
| 120 | 2,000 | 350 | 700 |
| 150 | 2,500 | 300 | 600 |
| 200 | 3,300 | 250 | 500 |

Digitized by Google

All these machines are arranged to give an alternating current having 10,000 to 12,000 reversals of current per minute, and electromotive force of 1,000, 2,000, or 3,000 volts, as required.

§ 19. **Lowrie-Hall Transformers.**—The transformers are of the closed magnetic-circuit core type. Two iron cores are formed of piles of thin iron plates (*see* Fig. 52), each plate being separated by thin paper from the next. On each of these cores is wound a primary and a secondary coil one over the other, part of the iron core projecting beyond the coils at both ends. The two coil-covered cores are then placed side by side, and the plates of the cores projecting beyond the coils are turned over alternately, each pair of plates forming a closed magnetic circuit. The whole of the plates are then clamped tightly together at both ends to ensure good magnetic contact. The completed converter shown in Fig. 53 thus seems to form a closed laminated iron ring of rectangular shape, and having a primary and secondary coil wound on each side of the ring. The transformers are placed in iron-converter cases (Fig. 54). The pairs of primary and secondary coils are respectively joined up in series, and the terminals brought to insulated terminals outside the case. The usual primary and secondary double-pole fuses are placed in porcelain boxes on the case. The converter cases have lugs and rings so as to suspend or fix them in place. These transformers are said to take about ·02 ampere-current in the primary when on open secondary circuit. The various sizes used are for out-puts of 1, 2, 4, 6, 8, 10, 16, 20, 30, 40 E.H.P., and are wound to convert from 2,000, 1,500, and 1,000 volts to 100 or 50 volts.

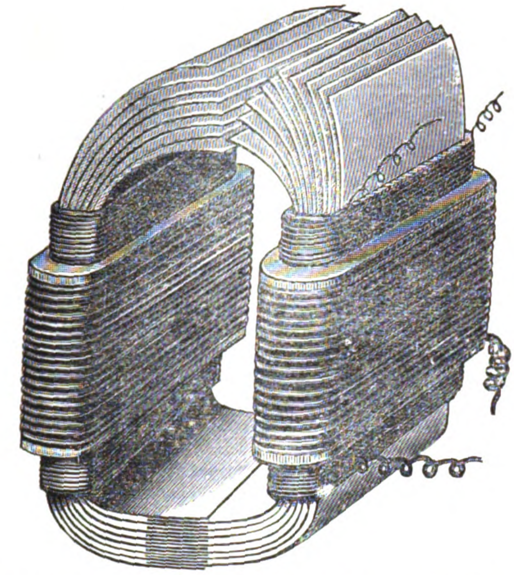


Fig. 52.– Diagram showing Method of building up the Lowrie-Hall Transformer.

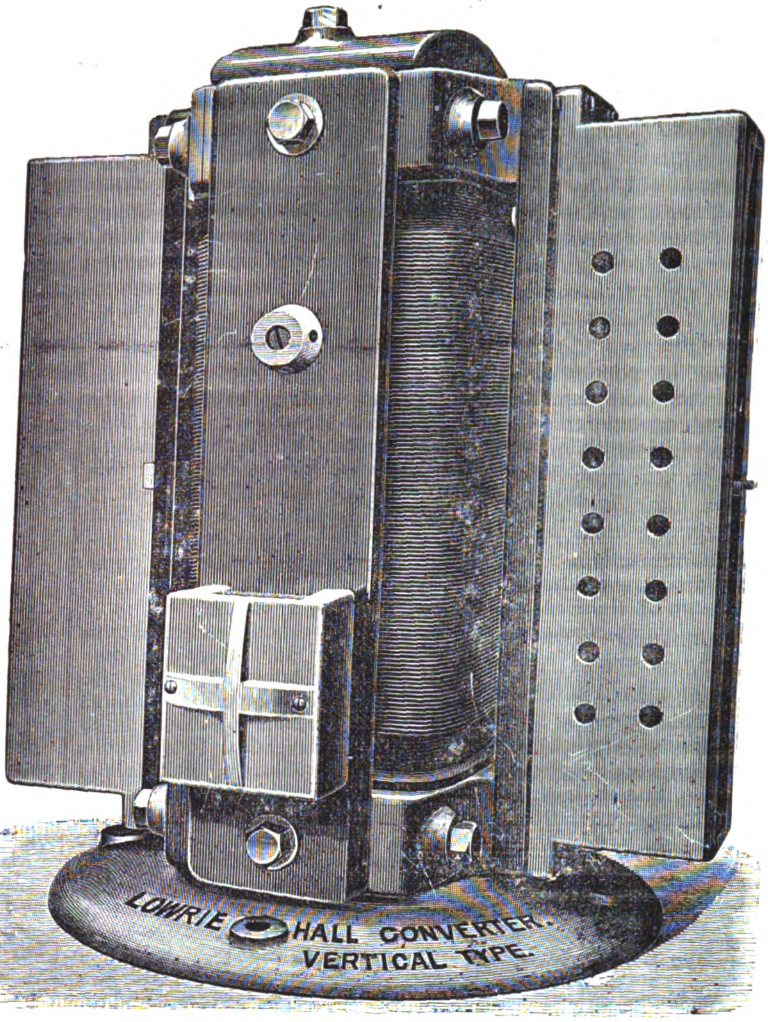



Fig. 54.—Lowrie-Hall Transformer.

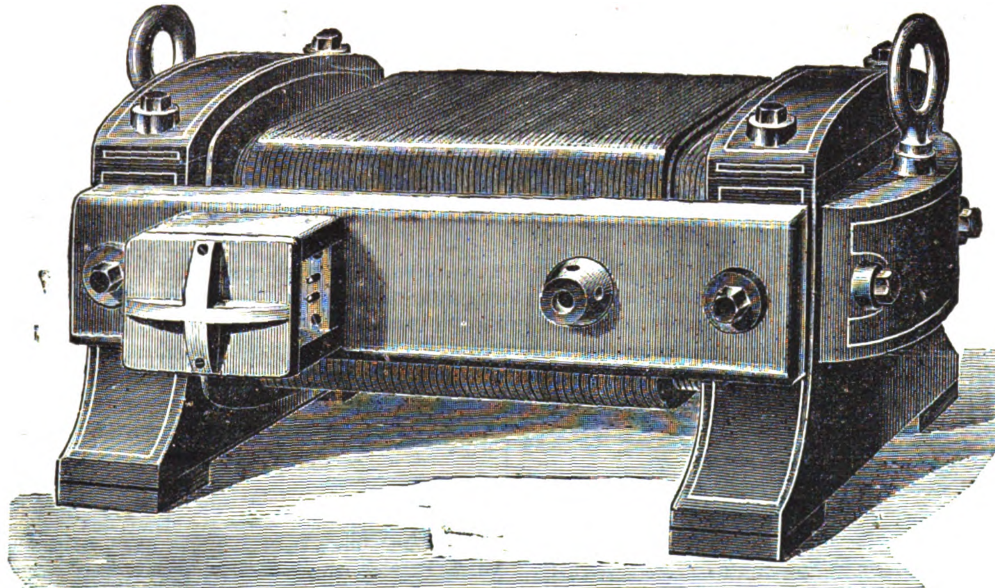


Fig. 53.—Lowrie-Hall Transformer.

*(To be continued.)*

## THE ELECTROLYTIC PREPARATION OF BLEACHING AGENTS.*

BY A. RIGAUT.

The fact that bleaching agents could be obtained by electrolysis of the chlorides has been known for some time. Becquerel[1] calls attention to the fact that chlorine and sodium are products of the decomposition of sodium chloride by the current from a battery of 30 cells. Brand[2] asserts that in 1820 he had suggested the idea of bleaching by the electrolysis of a solution of sea salt, and the experiment which he described is a very curious one. He applied a small disc of platinum, which had been rendered electro-positive to a piece of coloured calico, impregnated with a solution of sodium chloride, and which was stretched upon a second disc, rendered electro-negative. White patches resulted at the parts electrolysed. Brand added that this application had been patented by Bagg. In 1849 Bouis,[3] taking up the experiments of Kolb, who had succeeded in transforming by electrolysis a solution of potassium chloride into chlorate discovered that with the same number of cells the resulting reactions were different, according to the temperature at which he worked, and that if matters were arranged so that the temperature was not raised, hypochlorite of potassium and not chlorate was obtained. This experiment, however, he repeated with more or less concentrated solutions and with different currents the action of which was prolonged for 48 hours, and he always obtained hypochlorite of potassium. The mechanism of its formation is due to the action of the chlorine liberated at the anode upon the nascent potassium at the cathode, the latter arising from the reaction of liberated potassium upon the water of the solution. Since then C. Watt[4] (1851), Hunter (1857), De Gemini[5] (1858) have described electrolytic processes for the production of alkaline hypo-chlorites. In 1859 Lardenois patented a product "electro-chlorygen" obtained by the electrolysis of salt in a lead vat, which formed the negative pole, the positive pole being a sheet of platinum. It is still the electrolysis of the chlorides, with a view of obtaining sodium and chlorine, that Dickson, in 1862, was working at. At the time that these various processes were patented electrolytic methods were practically inapplicable, and we doubt if they were even tried by the chemical industry.

In more recent times we have the patent of Fitzgerald and Molloy (1862). These gentlemen also obtained hypochlorites from chlorides, and pointed out a method of regenerating by electrolysis the hypochlorite exhausted in a bleaching process. The next patent we come to is that of Fournier (1879). A little later (1882) Ostersetzer investigated the electrolysis of a solution of sodium chloride, and showed that when dilute it only gave hydrogen and oxygen, while after a certain degree of concentration had been reached, sodium hypochlorite[6] was obtained. Upon this work, Dobbies and Hutchinson based a method of bleaching by electricity.[7] In 1883 MM. Naudin and Bidet took up the question of electro-chemical bleaching,[8] and endeavoured with the aid of M. Schneider to apply it commercially. These gentlemen showed that in the electrolysis of sodium chloride, taking into consideration the losses inherent to any commercial process, one ought to be able to make the same quantity of chlorine serve indefinitely, "the chlorine on coming into contact with organic matter being transformed into a compound substance containing an exactly equivalent amount of chlorine, and capable of yielding it up." In short, they showed that the chlorine could be regenerated after having acted upon the coloured substance. The laboratory experiments of MM. Naudin and Bidet were very successful, but the inventors, badly informed perhaps, as to the efficiency of the modern dynamo-electric machine, did not devote themselves to the solution of the many difficulties which crop up when a process is made use of commercially, and on a large scale, and they soon gave up the research. In 1883, when M. Naudin published his results, electric bleaching was, it is asserted, well known in Russia,[9] where Lidoff and Tikcomiroff[10], seeking to find the liquid possessing the maximum bleaching power, electrolysed various chlorides. These investigators gave the preference to chloride of potassium. Representing the bleaching properties of an electrolysed solution of potassium chloride by 100, that of sodium chloride was found to be 73, and that of calcium chloride 24. Lidoff and Tikhomiroff also, it seems[11], carried out electric bleaching at the Vienna Electrical Exhibition. According to M. Gimé[12], the production of hypochlorites by electrolysis has, for some time past, been carried out in America, and a concentrated solution of sea-salt is there generally employed. In France, however, we think we are not wrong in stating that, with the exception of M. Hermite, who generates bleaching agents for a special purpose, all the users of hypochlorites still employ chemical processes. In fact, at the Centenary Exhibition, the electro-chemical industry was only represented by the Hermite process and by that of MM. Gall and de Montlaur for manufacturing potassium chlorate.

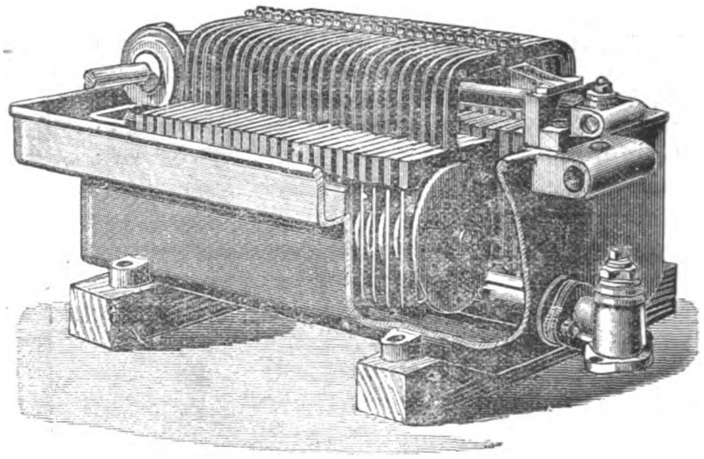


FIG. 1.—Hermite Electrolyser.

It was in 1883, after the failures of M. Naudin, that M. Hermite was led to take up the subject of the electrolysis of the chlorides. After prolonged experiments on sodium chloride, he relinquished this substance, firstly, for calcium chloride, and then for magnesium chloride, the latter salt, in his opinion, lending itself best to transformation into a bleaching agent.

In the Hermite process, the "electrolyser" (Fig. 1) is of galvanised cast iron. Along the bottom runs a pipe, pierced with numerous holes, by means of which the solution enters the vat. A channel runs along the upper edge of the "electrolyser," into which the electrolysed solution overflows and finds its way to the bleaching vats. The cathodes consist of a series of zinc discs mounted on two slowly rotating spindles. Between each pair of discs is an anode plate (Fig. 2) consisting of platinum gauze fixed in an ebonite frame and connected by a leaden lug to a copper bar. In order to keep the zinc discs perfectly clean, flexible ebonite scrapers, such as the one shown in Fig. 2, are fixed to the anodes. As the zinc discs revolve, these ebonite pieces bear against their surfaces and clear off any deposit. In carrying out operations on a large scale, several "electrolysers" are connected in series. Generally speaking, a current of from 1,000 to 1,200 amperes at a pressure of five volts is employed.

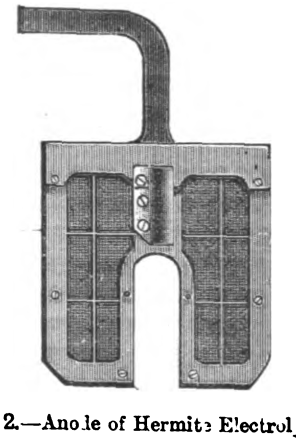


FIG. 2.—Anode of Hermite Electrolyser.

From the point of view of economy the anode should be a good conductor, cheap, and unattacked by the products of electrolysis. Carbon seems, therefore, to be the most suitable substance for this purpose, and in many processes it has been and is employed. M.

* From *La Lumière Électrique.*

[1] *Electro-chimie.* 1843, p. 130.

[2] *Manual of Chemistry.* 1848, Vol. I., p. 222.

[3] *Comptes Rendus.* Vol. XXIX., p. 403.

[4] *Rev. Int. de l'Électricité,* August, 1890.

[5] *Génie Industrielle,* Vol. VIII., p. 219.

[6] *Journal* of the Society of Chemical Industry, 1882.

[7] *La Nature,* 1882.

[8] *Société Chimique,* Vol. XL.

[9] *La Nature,* 1883.

[10] *Journal de la Société Chimique Russe,* 1882, p. 342.

[11] *Rev. Int. de l'Électricité* (August, 1890).

[12] *La Lumière Electrique,* Vol. XIX., p. 164.

Digitized by Google

Hermite, however, after lengthy experiments, failed to obtain a grade of carbon proving sufficiently unattackable by electrolysed chlorides. He found that carbon oxidised and disintegrated. The classical researches of Bartoli and Pasogli (1882) showed that whenever in electrolysis oxygen was liberated at the anode, carbon is attacked, and we have as a result carbonic oxide, carbonic acid, and a black substance "mellogen," etc., and, in the case of graphite, graphitic acid. According to the same investigators, when chloride solutions are electrolysed the disintegration of the retort carbon employed is the more rapid the more dilute the solutions. Since, therefore, in the Hermite process the magnesium chloride solution is extremely weak, platinum anodes become absolutely necessary, and this renders the "electrolysers" costly, and tends to prevent the general adoption of the process in "*la petite industrie.*" M. Hermite has endeavoured to make use of platinised copper and porcelain, but the platinum was rapidly attacked by the electrolysed solution.

Up to the present M. Hermite has employed a 5 per cent. solution of magnesium chloride, but he now proposes to use a more economical bath. After having tried with some success a solution of Strassfurt "camallite," which is a double chloride of magnesium and potassium, he now makes use of a solution containing 5 per cent. of magnesium chloride and 5 per cent. of sea salt, a small quantity of recently precipitated magnesia being added to the bath. When this solution is electrolysed, only the water and the magnesium chloride appear to be decomposed; the solution, in fact, remains perfectly clear, and if the sodium chloride were electrolysed, soda would be formed and magnesia precipitated, and the liquid would be clouded.

The interpretation of the various chemical reactions which take place during the electrolysis of the chlorides is difficult, though the formation of hypochlorites by the action of the chlorine liberated at the + pole upon the alkali generated at the − pole seems a probable explanation. This does not, however, explain the great bleaching power of the solution, which bears no relation to the amount of chlorine it contains. This apparently abnormal property may be explained, if not proved, somewhat as follows:—The water is decomposed at the same time as the chloride, ozonised oxygen being formed. Now, ozone, as Dr. Graf pointed out some few months ago, is fairly soluble in the alkaline chlorides, and especially so in magnesium chloride. Again, electrolytic ozone is a well-known bleaching agent, and H. N. Warren[13] tried to make use of it in his method of bleaching by the electrolysis of water. Among the products which might be formed is oxygenated water, whose absence, however, in the electrolysed solutions of the chlorides has been noted, but which would, if present, be able to act as a bleaching agent; indeed, quite recently a method of bleaching cotton based on its properties has been described.[14] But oxygenated water being absent, we can predict the presence of other bleaching agents in the liquid. M. Dutet[15] has, in fact, observed that in the electrolysis of alkaline solutions the volume of the oxygen which is liberated is much less than one-half of that of the hydrogen. The properties of the liquid obtained were investigated by M. Dutet, who came to the conclusion that alkaline peroxides, endowed with oxidising powers, are formed, whose instability has, up to the present, prevented their isolation. Now these unstable peroxides may be bleaching agents, and we note that one of the conditions of the electrolysis of the chlorides is the alkalinity of the liquid, potash or soda for the alkaline chlorides, magnesia in the case of the Hermite process. Let us add to this hypothesis the far more probable one of the formation of unknown oxygen chlorine compounds, for the chemistry of these compounds is still very obscure. It is, indeed, possible that there may be some sort of incompatibility between the formation of all these products by electrolysis of the chlorides. For instance, it is well known that ozone is rapidly destroyed in the presence of chlorine; but what is the resultant body, and what are its bleaching qualities? MM. Hautefeuille and Chappins endeavoured to obtain it by means of high-tension electric discharges in a mixture of oxygen and chlorine[16]. In 1887 the brothers Brin proposed to use the bleaching properties of this mixture after its passage through their "ozoniser" to bleach paper pulp[17]. Mailfert asserts that chlorine and ozone combine to form chloric acid[18]. E. Becquerel[19] made an experiment which showed that an oxygen compound of chlorine should result from the electrolysis of the chlorides, even without the presence of alkalies. Becquerel placed in the same circuit some acidulated water and an aqueous solution of chlorine, and found that while 7·25 volumes of oxygen were liberated from the water, only 6·25 were liberated from the chlorine solution. The same experiment with bromium and iodine gave respectively 4·5 and 4 volumes. Electrolytic oxygen is, therefore, capable of combining with chlorine. M. Riche, who has also studied this question, has shown that the final product of the electrolysis of an aqueous solution of chlorine is perchloric acid.[20]

(*To be continued.*)

[13] *Chemical News*, Vol. LX., p. 103.
[14] *Bulletin de la Société Industrielle* de Rouen. July-August, 1889.
[15] *La Lumière Electrique.* (Vol. XXIII., p. 376.)
[16] *Comptes Rendus.* Vol. LXXXXI., p. 762; Vol. LXXXXVIII., p. 626.
[17] *La Lumiere Electrique.* Vol. XXXV., p. 608.
[18] Tommasi. *Electrochimie* (1889), p. 117.
[19] Becquerel. *Electrochimie* (1843), p. 173.
[20] *Comptes Rendus*, Vol. XLVI., p. 348.

## THE ELECTRO-MAGNET.*

BY PROF. SILVANUS P. THOMPSON.

(*Continued from page 751.*)

### APPENDIX TO LECTURE II.

CALCULATION OF EXCITATION, LEAKAGE, &c.

*Symbols used.*

$N$ = whole number of magnetic lines (C.G.S., definition of magnetic lines, being 1 line per square centimetre to represent intensity of a magnetic field, such that there is 1 dyne on unit magnetic pole) that pass through the magnetic circuit. Also called the *magnetic flux*.
$B$ = the number of magnetic lines per square centimetre, in the iron; also called the *induction*, or the internal magnetisation.
$B''$ = the number of magnetic lines per square inch in the iron.
$H$ = the magnetic force or intensity of the magnetic field, in terms of the number of magnetic lines to the square centimetre that there would be in air.
$H''$ = the magnetic force, in terms of the number of magnetic lines that there would be to the square inch, in air.
$\mu$ = the *permeability* of the iron, &c.; that is, its magnetic conductivity or multiplying power for magnetic lines.
$A$ = area of cross section, in square centimetres.
$A''$ = area of cross section, in square inches.
$l$ = length in centimetres.
$l'$ = length, in inches.
$S$ = number of spirals or turns in the magnetising coil.
$i$ = electric current, expressed in amperes.
$v$ = coefficient of allowance for leakage; being the ratio of the whole magnetic flux to that part of it which is usefully applied. (It is always greater than unity.)

RELATIONS OF UNITS.

1 inch = 2·54 centimetres;
1 centimetre = 0·3937 inch.
1 square inch = 6·45 square centimetres;
1 square centimetre = 0·1550 square inch;
1 cubic inch = 16·39 cubic centimetres;
1 cubic centimetre = 0·0610 cubic inch.

TO CALCULATE THE VALUE OF B OR OF B″ FROM THE TRACTION.

If P denote the pull, and A the area over which it is exerted, the following formulæ (derived from Maxwell's law), may be used:—

$$B = 4{,}965 \sqrt{\frac{P \text{ kilos.}}{A \text{ sq. cm.}}};$$

$$B = 1{,}316{\cdot}6 \sqrt{\frac{P \text{ lb.}}{A \text{ sq. in.}}}; \text{ or}$$

$$B'' = 8{,}494 \sqrt{\frac{P \text{ lb.}}{A \text{ sq. in.}}}.$$

TO CALCULATE THE REQUISITE CROSS-SECTION OF IRON FOR A GIVEN TRACTION.

It is not expedient to attempt to employ tractive forces exceeding 150lb. per square inch in magnets whose cores are of soft wrought iron, or exceeding 28lb. per square inch in cast iron. Dividing the given load that is to be sustained by the electro-magnet by one or other of these numbers, gives the corresponding requisite sectional area of wrought or cast iron respectively.

TO CALCULATE THE PERMEABILITY FROM B OR FROM B″.

This can only be satisfactorily done by referring to a numerical Table (such as Table II. or IV.), or to graphic curves (such as Fig. 18), in which are set down the result of measurements made on actual samples of iron of the quality that is to be used. The

* A series of four Cantor Lectures delivered before the Society of Arts, January—February, 1890.

Digitized by Google

values of $\mu$ for the two specimens of iron to which Table II. refers may be *approximately* calculated as follows :—

$$\text{For annealed wrought iron, } \mu = \frac{17{,}000 - B}{3 \cdot 5};$$

$$\text{For grey cast iron, } \mu = \frac{7{,}000 - B}{3 \cdot 2}.$$

These formulæ must not be used for the wrought iron for tractions that are less than 28lb. per square inch, nor for cast iron for tractions less than $2\frac{1}{4}$lb. per square inch.

### To Calculate the Total Magnetic Flux which a Core of given Sectional Area can conveniently carry.

It has been shown that it is not expedient to push the magnetisation of wrought iron beyond 100,000 lines to the square inch, nor that of cast iron beyond 42,000. These are the highest values that ought to be assumed in designing electro-magnets. The total magnetic flux is calculated by multiplying the figure thus assumed by the number of square inches of sectional area.

### To Calculate the Magnetising Power requisite to force a given Number of Magnetic Lines through a definite Magnetic Reluctance.

Multiply the number which represents the magnetic reluctance by the total number of magnetic lines that are to be forced through it. The product will be the amount of magnetomotive force. If the magnetic reluctance has been expressed on the basis of centimetre measurements, the magneto-motive force, calculated as above, will need to be divided by 1·2566 $\left(i.e., \text{by } \frac{4\pi}{10}\right)$ to give the number of ampere-turns of requisite magnetising power. If, however, the magnetic reluctance has been expressed in the units explained below, based upon inch measures, the magnetising power, calculated by the rule given above, will already be expressed directly in ampere-turns.

### To Calculate the Magnetic Reluctance of an Iron Core.

(*a*) *If Dimensions are given in Centimetres.*—Magnetic reluctance being directly proportional to length, and inversely proportional to sectional area and to permeability, the following is the formula :—

$$\text{Magnetic reluctance} = \frac{l}{A\mu};$$

but the value of $\mu$ cannot be inserted until one knows how great B is going to be ; when reference to Table II. gives $\mu$.

(*b*) *If Dimensions are given in Inches.*—In this case we can apply a numerical co-efficient, which takes into account the change of units (2·54), and also, at the same time, includes the operation of dividing the magneto-motive force by four-tenths of $\pi$ (=1·2566) to reduce it to ampere turns. So the rule becomes

$$\text{Magnetic reluctance} = \frac{l''}{A''\mu} \times 0 \cdot 3132.$$

*Example.*—Find the magnetic reluctance from end to end of a bar of wrought-iron 10in. long, with a cross section of four square inches, on the supposition that the magnetic flux through it will amount to 440,000.

### To Calculate the Total Magnetic Reluctance of a Magnetic Circuit.

This is done by calculating the magnetic reluctances of the separate parts, and adding them together. Account must, however, be taken of leakage ; for when the flux divides, part going through an armature, part through a leakage path, the law of shunts comes in, and the net reluctance of the joint paths is the reciprocal of the sum of their reciprocals. In the simplest case the magnetic circuit consists of three parts (1) armature, (2) air in the two gaps, (3) core of the magnet. These three reluctances may be separately written, as in the table in following table.

If the iron used in armature and core is of the same quality, and magnetised up to the same degree of saturation, $\mu$ and $\mu_3$, will be alike. For the air-gaps $\mu = 1$, and therefore is not written in.

If there were no leakage, the total reluctance would simply be the sum of these three terms. But when there is leakage, the total reluctance is reduced.

| — | For Centimetre Measure. | For Inch Measure. |
|---|---|---|
| 1. Armature ............... | $\frac{l}{A_1 \mu_1}$ | $\frac{l''_1}{A''_1 \mu_1} \times 0 \cdot 3132$ |
| 2. The Gaps ............... | $2\frac{l_2}{A_2}$ | $2\frac{l''_2}{A''_2} \times 0 \cdot 3132$ |
| 3. Magnet Core............ | $\frac{l_3}{A_3 \mu_3}$ | $\frac{l''_3}{A''_3 \mu_3} \times 0 \cdot 3132$ |

### To Calculate the Ampere-Turns of Magnetising Power Requisite to Force the Desired Magnetic Flux through the Reluctances of the Magnetic Circuit.

(*a.*) *If Dimensions are given in Centimetres* the rule is :—

Ampere-turns = the magnetic flux, multiplied by the magnetic reluctance of the circuit, divided by $\frac{4}{10}$ of $\pi$ (=1·2566).

Or, in detail, the three separate amounts of ampere-turns required for three principal magnetic reluctances are explained as follows :—

$$\left.\begin{array}{l}\text{Ampere-turns required to drive N lines}\\ \text{through iron of armature} \ldots\ldots\end{array}\right\} = N \times \frac{l_1}{A_1 \mu_1} \div \frac{4\pi}{10},$$

$$\left.\begin{array}{l}\text{Ampere-turns required to drive N lines}\\ \text{through the two gaps} \ldots\ldots\end{array}\right\} = N \times \frac{2l_2}{A_2} \div \frac{4\pi}{10},$$

$$\left.\begin{array}{l}\text{Ampere turns required to drive } v\text{N lines}\\ \text{though the iron of magnet core} \ldots\ldots\end{array}\right\} = vN \times \frac{l_3}{A_3 \mu_3} \div \frac{4\pi}{10},$$

And, adding up : —

$$\text{Total ampere-turns required} \ldots\ldots = \frac{10}{4\pi} N \left\{ \frac{l_1}{A_1 \mu_1} + \frac{2l_2}{A_2} + \frac{v\, l_3}{A_3 \mu_3} \right\}.$$

(*b.*) *If Dimensions are given in Inches*, the rule is :—Ampere-turns = magnetic flux multiplied by the magnetic reluctance of the circuit. Or, in detail :—

$$\left.\begin{array}{l}\text{Ampere-turns required to drive N lines}\\ \text{through iron of armature} \ldots\ldots\end{array}\right\} = N \times \frac{l''_1}{A''_1 \mu_1} \times 0 \cdot 3132,$$

$$\left.\begin{array}{l}\text{Ampere-turns required to drive N lines}\\ \text{through two gaps} \ldots\ldots\end{array}\right\} = N \times \frac{2\, l''_2}{A''_2} \times 0 \cdot 3132,$$

$$\left.\begin{array}{l}\text{Ampere-turns required to drive } v\text{N lines}\\ \text{through iron core of magnet} \ldots\ldots\end{array}\right\} = vN \times \frac{l''_3}{A''_3 \mu_3} \times 0 \cdot 3132;$$

And, adding up :—

$$\text{Total ampere turns required} = 0 \cdot 3132\, N \left\{ \frac{l''_1}{A''_1 \mu_1} + \frac{2\, l''_2}{A''_2} + \frac{v\, l''_3}{A''_3 \mu_3} \right\}.$$

It will be noted that here $v$, the coefficient of allowance for leakage, has been introduced. This has to be calculated as shown later. In the meantime it may be pointed out that, in designing electro-magnets for any case where $v$ is approximately known beforehand, the calculation may be simplified by taking the sectional area of the magnet core greater than that of the armature in the same proportion. For example, if it were known that the waste lines that leak were going to be equal in number to those that are usefully employed in the armature (here $v = 2$), the iron of the cross might be made of double the section of that of the armature. In this case $\mu_3$ will approximately equal $\mu_1$.

### To Calculate the Coefficient of Allowance for Leakage, $v$.

$v$ = total magnetic flux generated in magnet core ÷ useful magnetic flux through armature. The respective useful and waste magnetic fluxes are proportional to the permeances along their respective paths. *Permeance*, or magnetic conductance, is the reciprocal of the *reluctance*, or magnetic resistance. Call useful permeance through armature and gaps $u$; and the waste permeance in the stray field $w$; then

$$v = \frac{u + w}{u},$$

$w$ may be estimated by the Table VIII. given above, or other leakage rules, but should be divided by two, as the average difference of magnetic potential over the leakage surface is only about half that at the ends of the poles.

### Rules for Estimating Magnetic Leakage.

(I. to III. Adapted from Prof. Forbes' rules.)

*Prop. I. Permeance between two parallel areas facing one another.*—Let areas be $A_1''$ and $A_2''$ square inches, and distance apart $d''$ inches, then :—

$$\text{Permeance} = 3 \cdot 193 \times \tfrac{1}{2} (A''_1 + A''_2) \div d''.$$

*Prop. II. Permeance between two equal adjacent rectangular areas lying in one plane.*—Assuming lines of flow to be semicircles, and that distances $d''_1$ and $d''_2$ between their nearest and furthest edges respectively are given, also $a''$ their width along the parallel edge :—

$$\text{Permeance} = 2 \cdot 274 \times a'' \times \log_{10} \frac{d_2''}{d_1}.$$

*Prop. III. Permeance between two equal parallel rectangular areas lying in one plane at some distance apart.*—Assume lines of leakage to be quadrants joined by straight lines.

$$\text{Permeance} = 2 \cdot 274 \times a'' \times \log_{10} \left\{ 1 + \frac{\pi (d'_2 - d_1)}{d''_1} \right\}.$$

Digitized by Google

*Prop. IV. Permeance between two equal areas at right angles to one another.*—Permeance (if air angle is 90°) = double the respective value calculated by II. or III.

Permeance (if air angle is 270°) = $1\frac{2}{3}$ times the respective value calculated by II.

If measures are given in centimetres these rules become the following:—

$$\text{I. } \tfrac{1}{2}(A_1 + A_2) \div d;$$

$$\text{II. } \frac{a}{\pi} \log_e \frac{d_2}{d_1};$$

$$\text{III. } \frac{a}{\pi} \log_e \left(1 + \frac{\pi(d_2 - d_1)}{d_1}\right).$$

*Prop. V. Permeance between two parallel cylinders of indefinite length.*—The formula for the reluctance is given above: the permeance is the reciprocal of it. Calculations are simplified by reference to Table VIII.

---

I have now to make a few remarks before entering upon the consideration of special forms of magnets. I have already pointed out that where you require a magnet simply for holding on to its armature, common-sense (in the form of our simplest formula) dictated that the circuit of iron should be as short as was compatible with getting the required amount of winding upon it. That at once brings us to the question of the difference in performance of long magnets and short ones. Last week we treated that topic so far as this, that if you require your magnet to attract over any range across an air space, you required a sufficient amount of exciting power in the circulation of electric current to force the magnetic lines across that resisting space, and therefore you required length of core in order to get the required coil wound upon the magnetic circuit. But there is one other way in which the difference of behaviour between long and short magnets—I am speaking of horse-shoe shapes—comes into play. So far back as 1840, Ritchie found that it was more difficult to magnetise steel magnets (using for that purpose electro-magnets to stroke them with) if these electro-magnets were short than if they were long. He was, of course, comparing magnets which had the same tractive power, that is to say, presumably had the same section of iron magnetised up to the same degree of magnetisation. This difference between long and short cores is obviously to be explained on the same principle as the greater projecting power of the long-legged magnets. In order to force magnetism not only through an iron arch but through whatever is beyond, which has a lesser permeability for magnetism, whether it be an air gap or an arch of hard steel destined to retain some of its magnetism, you require magneto-motive force enough to drive the magnetism through that resisting medium; and, therefore, you must have turns of wire; that implies that you must have length of leg on which to wind those turns. Ritchie also found that the amount of magnetism remaining behind in the soft iron arch after turning off the current, at the first removal of the armature, was a little greater with long than with short magnets; and, indeed, it is what we should expect now, knowing the properties of iron, that long pieces, however soft, retain a little more—have a little more memory, as it were, of having been magnetised—than short pieces. Later on I shall have specially to draw your attention to the behaviour of short pieces of iron which have no magnetic memory.

WINDING OF THE COPPER.

I now take up the question of winding the copper wire upon the electro-magnet. How are we to determine beforehand the amount of wire required, and the proper gauge of wire to employ?

The first stage of such a determination is already accomplished; we are already in possession of the formulæ for reckoning out the number of ampere-turns of excitation required in any given case. It remains to show how from this to calculate the amount of bobbin-space, and the quantity of wire to fill it. Bear in mind that a current of 10 amperes (*i.e.*, as strong as that used for a big arc light) flowing once around the iron, produces exactly the same effect magnetically as a current of one ampere flowing around 10 times, or as a current of only one-hundredth part of an ampere flowing around a thousand times. In telegraphic work the currents ordinarily used in the lines are quite small, usually from five to twenty thousandths of an ampere; hence in such cases the wire that is wound on need only be a thin one, but it must have a great many turns. Because it is thin and has a great many turns, and is consequently a long wire, it will offer a considerable resistance. That is no advantage, but does not necessarily imply any greater waste of energy than if a thicker coil of fewer turns were used with a correspondingly larger current. Consider a very simple case. Suppose a bobbin is already filled with a certain number of turns of wire, say 100, of a size large enough to carry one ampere without over-heating. It will offer a certain resistance, it will waste a certain amount of the energy of the current, and it will have a certain magnetising power. Now suppose this bobbin to be re-wound with a wire of half the diameter, what will the result be? If the wire is half the diameter it will have one quarter the sectional area, and the bobbin will hold four times as many turns (assuming insulating materials to occupy the same percentage of the available volume). The current which such a wire will carry will be one-fourth as great. The coil will offer sixteen times as much resistance, being four times as long and of one-fourth the cross-section as the other wire. But the waste of energy will be the same, being proportional to the resistance and to the square of the current, for $16 \times \frac{1}{16} = 1$. Consequently the heating effect will be the same. Also the magnetising power will be the same, for though the current is only one-quarter of an ampere, it flows around 400 turns; the ampere-turns are one hundred, the same as before. The same argument would hold good with any other numerical instance that might be given. It therefore does not matter in the least to the magnetic behaviour of the electro-magnet whether it is wound with thick wire or thin wire, provided the thickness of the wire corresponds to the current it has to carry, so that the same number of watts of power are spent in heating it. For a coil wound on a bobbin of given volume the magnetising power is the same for the same heat waste. But the heat waste increases in a greater ratio than the magnetising power, if the current in a given coil is increased; for the heat is proportional to the square of the current, and the magnetising power is simply proportional to the current. Hence it is the heating effect which in reality determines the winding of the wire. We must—assuming that the current will have a certain strength—allow enough volume to admit of our getting the requisite number of ampere-turns without overheating. A good way is to assume a current of one ampere while one calculates out the coil. Having done this, the same volume holds good for any other gauge of wire appropriate to any other current. The terms "long-coil" magnet and "short-coil" magnet are appropriate for those electro-magnets which have, respectively, many turns of thin wire and few turns of thick wire. These terms are preferable to "high-resistance" and "low-resistance," sometimes used to designate the two classes of windings, because, as I have just shown, the resistance of a coil has in itself nothing to do with its magnetising power. Given the volume occupied by the copper, then for any current-density (say, for example, a current density of 2,000 amperes per square inch of cross-section of the copper), the magnetising power of the coil will be the same for all different gauges of wire. The specific conductivity of the copper itself is of importance; for the better the conductivity, the less the heat-waste per cubic inch of winding. High conductivity copper is, therefore, to be preferred in every case.

Now the heat which is thus generated by the current of electricity raises the temperature of the coil (and of the core), and it begins to emit heat from its surface. It may be taken as a sufficient approximation that a single square inch of surface, warmed 1°Fahr. above the surrounding air, will steadily emit heat at the rate of $\frac{1}{225}$ of a watt. Or, if there is provided only enough surface to allow of a steady emission of heat at the rate of 1 watt* per square inch of surface, the temperature of that surface will rise to about 225° Fahr. above the temperature of the surrounding air. This number is determined by the average emissivity of such substances as cotton, silk, varnish, and other materials of which the surfaces of coils are usually composed.

In the specifications for dynamo machines it is usual to lay down a condition that the coils shall not heat more than a certain number of degrees warmer than the air. With electro-magnets it is a safe rule to say that no electro-magnet ought ever to heat up to a temperature of more than 100°Fahr. above the surrounding air. In many cases it is quite safe to exceed this limit.

The resistance of the insulated copper wire on a bobbin may be approximately calculated by the following rule. If $d$ is the diameter of the naked wire, in mils., and D is the diameter, in mils., of the wire when covered, then the resistance per cubic inch of the coil will be:—

$$\text{Ohms per cub. inch} = \frac{960{,}700}{D^2 \times d^2}.$$

We are, therefore, able to construct a wire-gauge and amperage table which will enable us to calculate readily the degree to which a given coil will warm when traversed by a given current, or conversely, what volume of coil will be needed to provide the requisite

* The *watt* is the unit of rate of expenditure of energy, and is equal to ten million ergs per second, or to 1-746th of a horse-power. A current of one ampere, flowing through a resistance of one ohm, spends energy in heating at the rate of one watt. One watt is equivalent to 0·24 calories per second of heat. That is to say, the heat developed in one second, by expenditure of energy at the rate of one watt would suffice to warm one gramme of water through 4·2 (Centigrade) degrees. As 252 calories are equal to one British (lb. Fahrenheit) unit of heat, it follows that heat emitted at the rate of one watt would suffice to warm 3·4lb. of water one degree Fahrenheit in one hour; or one British unit of heat equals 1,058 watt-seconds.

Digitized by Google

circulation of current without warming beyond any prescribed excess.

Accordingly, I shall give a Wire-Gauge and Amperage Table which we have been using for some time at the Finsbury Technical College. It was calculated out under my instructions by one of the Demonstrators of the College, Mr. Eustace Thomas, to whom I am indebted for the great care bestowed upon the calculations.

For many purposes, such as for use in telegraphs and electric bells, smaller wires than any of those mentioned in the table are required. The table is, in fact, intended for use in calculating magnets in larger engineering work.

*(To be continued.)*

## AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *October* 21, 1890.

**The Street Railway Convention.**—The event of the past week has been the American Street Railway Convention, at Buffalo, N.Y. To electricians it was particularly interesting, for the reason that every branch of electrical industry was there represented, its representatives outnumbering the Street Railway delegates proper by at least two to one. The Westinghouse Electric Railway Company, which has been working very quietly up to the present time, appeared with one of its motor cars, a particularly elegant specimen, built at the Pullman works, and the new motor was the subject of a great deal of attention on the part of both street railway men and electricians. Little need be added to what has already been published of its peculiarities. In practice it runs admirably, the cast-in gearing somewhat deadening the noise which is only too noticeable in most electric cars. This was not as completely obviated, however, as early reports indicated—the unpleasant whirring was somewhat muffled, but by no means absent. Another interesting electrical exhibit was that of the Wenstrom electric railway system which is now being vigorously exploited. The Wenstrom system uses a four-pole motor of the well-known Wenstrom type, geared but once instead of through an intermediate shaft, as is now usual. The gearing is not rigid, but through the medium of a hydraulic coupling, practically a small rotary pump forcing oil through a closed circuit. The circulation can be regulated or entirely stopped by a valve, so that when the valve is opened, the motor may run free without driving the car axle; but when it is closed, and the oil can no longer circulate, the whole turns as if it were rigidly connected, as indeed it is, through the medium of an incompressible mass of oil. The arrangement is highly ingenious, and is said to work admirably in practice. The first Wenstrom road will be started ere long, and then some further details will be forthcoming. The Edison Company, which is now operating the Sprague apparatus, showed a complete motor truck, equipped with two interesting additions to the Sprague apparatus. The first of these is what is euphemistically known as a starting coil. It is nothing more nor less than a resistance momentarily thrown into series with the motors at the start in order to obviate the initial rush of current. The Edison managers are careful not to call it a resistance coil or rheostat. It is not in any proper sense of the term a rheostat: but it certainly is a resistance coil, although only for temporary use. The second Edison edition to the Sprague system is the equaliser. This is intended to obviate any unequal distribution of current between the two motors, which, as is well known, are placed in parallel. Experience has shown that the load, under certain circumstances, may be very unequally distributed between the pair of motors, and equalising coils have been devised to prevent this. Their action is virtually a sort of compound winding, so that when one motor tends to get more than its share of the work, the increase of current would pass around the field magnets and the other motor, and equalise the load again. It is really a species of cross-compounding between two machines. There seems to be no limit to the number of electric cars to be tried at present. On October 15th, a new Eickemeyer railroad-motor was tested, with a considerable degree of success, which is intended to obviate the necessity for the present gearing, which constitutes a serious objection to our present street-car systems.

NEW YORK, *October* 28, 1890.

**The Westinghouse Arc Light Alternators.**—At the meeting of the Institute of Electrical Engineers, October 21st, a very interesting Paper was read by Messrs. Tobey and Walbridge, dealing with a series of remarkable tests made by them on the alternating arc light dynamo of the Westinghouse Company. This machine, like much of the Westinghouse apparatus, is the invention of Mr. William Stanley, jun., one of our best known and most accomplished experts in alternating current matters. It possesses the very remarkable property of being almost exactly self-regulating, the current of a 40-light arc machine remaining very nearly constant from no load to full lead. This noteworthy result is obtained by the peculiar construction of the armature. This is provided with wide and deep teeth, flaring at the ends so as to partly shut in the space between them. The coils consist of a large number of turns, and are wound around these teeth. The action of the armature as a regulator is accomplished by virtue of its very powerful magnetic reaction. Any tendency to increase the current immediately lowers the potential. So perfectly is this regulation carried out, that the terminals can be short-circuited without the slightest danger; in fact, an automatic short-circuiting switch is provided to avoid the dangerous rise in potential that might be caused by breaking a circuit. The efficiency of this alternator is said to be remarkably high, reaching 90 per cent. on half load, and somewhat higher on full load. Taken altogether, it is a type of dynamo that possesses a very large number of valuable qualities.

**Electrical Execution.**—Another effort is being made to have the electrical execution law repealed, this time in behalf of the miserable Japanese wretch sentenced a few months ago. The present plea is that the execution of Kemmler furnished evidence that death by electricity was a cruel form of capital punishment, and, as such, prohibited by the Constitution of the United States. It is hardly probable, however, that the Supreme Court, before whom this question will come, will take the view of the case desired by the prisoner's attorneys.

**A Substitute for Platinum Wire in Incandescent Lamps.**—The report is current that a chemist near this city has discovered a practical method of dispensing with platinum wire in the manufacture of incandescent lamps. On investigation it appears that this rumour has some substantial foundation. In view of the rapid rise in the price of platinum such a discovery is certainly much to be desired by the public; and it is to be hoped that the inventor will secure the substantial reward that such a discovery merits.

## CORRESPONDENCE.

### THE EDINBURGH EXHIBITION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Your remarks of last week are calculated to convey an erroneous impression as to the origin and conduct of the Exhibition, a result which I am sure you by no means intend.

No "professional Exhibition promoter" had anything to do with its initiation; in fact, none of the originators had had any connection with previous Exhibitions in any capacity whatever. Mr. Bapty was appointed manager by the Executive Council several months after the start, with which he had absolutely nothing to do. He is the only person favoured with a "dinner and cheque," for which tokens of appreciation he is indebted to the exhibitors alone.

It is clearly inexact to state that "the two representative bodies of the electrical trades and professions gave it no encouragement whatever." On the contrary, the Institution of Electrical Engineers, at a special and full meeting of

Digitized by Google

Council, decided to support the Exhibition, and did so, as a fact, in every way possible. The junior body took a different view, and endeavoured through the three or four members who are reported to have attended the meetings at which the matter was discussed to stop the Exhibition, but in that they altogether failed. Not only was the Exhibition, as a whole, the largest and most varied ever seen in Scotland, but as an electrical Exhibition it was by far the best ever held in the United Kingdom, and is entitled to rank second only to the Paris show of 1881. That the Electrical Section of the London Chamber of Commerce were not unanimous in opposing is shown by the fact that the names of some of its prominent members figure on the London Committee and as exhibitors in the catalogue.

The statement that the chief electrical exhibitors were from the North is also wide of the mark. The great majority of electrical exhibits were from London and France; very few came from Scotland itself. Neither were medals awarded to any electrical exhibits as the paragraph might be read to imply.

The financial results are no doubt disappointing, but are not likely to prove nearly so much so as some of the published statements indicate. The Exhibition was promoted, not to make a profit, but to instruct, educate, and amuse, and in these respects the intentions of the originators have been fully realised.

The almost continuous wet weather experienced during the run of the Exhibition militated much against its financial success, but the chief adverse circumstance, against which it was impossible to contend, was the utter breakdown of the train service on the North British Railway, on which easy access to the Exhibition principally depended. Had this been foreseen or deemed within the bounds of probability, or even possibility, another site would have been chosen or the Exhibition abandoned altogether.—Yours, &c. A. R. BENNETT.

Edinburgh, November 3rd, 1890.

## LOCAL AUTHORITIES AND ELECTRIC TRAMWAYS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR:—No doubt there are Vestries *and* Vestries, but there also are various kinds of schemes for electric tramways submitted to them.

Last week the Chelsea Vestry had submitted to them a scheme by which it was proposed to lay an electric tramway down the main business thoroughfare, and to run cars about 6ft. wide down the centre of a 19ft. 6in. roadway, with shops on each side, where at the present time blocks are constantly occurring during the summer season.

Is it astonishing that the Vestry objected to such a scheme? It is absurd to talk about bribery and bad motives. The ordinary traffic must be given facilities for getting about, and a body of business men know this and must act accordingly.—Yours truly, T. W. E. HIGGENS.

Town Hall, Chelsea, S.W., Nov. 3, 1890.

[We are glad to note that Mr. Higgens, the Surveyor to the Chelsea Vestry, agrees with the opinion expressed in our leader of last week regarding bribery. Considering the present state of the King's-road and of the Fulham-road, the opposition of the Vestry appears to be reasonable.—ED. *E.*]

## ECCENTRIC STATIONS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: When a word already in use has a new meaning assigned to it in scientific language, it is of great importance that that meaning should be carefully defined at the time of its introduction; otherwise the word, instead of saving time, causes confusion.

In the absence of the slightest hint from the author, I concluded—I think, fairly enough—that by central stations he meant generating centres, and by eccentric stations, distributing banks of converters fed from those centres. Thus Deptford would be a central station and the Grosvenor an eccentric; but in one of your Editorial notes to-day I see Deptford described as an "eccentric" station. Might I ask for an authoritative statement as to what is the correct meaning?

While speaking of accuracy, I may mention that the famous lighthouse experiments were conducted at the South and not the North Foreland.—Yours, &c., A. K. C.

[The meaning attached by Dr. Fleming to the term "eccentric station" is, we are authoritatively given to understand, the meaning one would naturally attach to it—viz., *a station which is not at the centre of the area of distribution.* The Deptford Station *is*, therefore, according to Dr. Fleming's use of the term, an "eccentric station."—ED. *E.*]

## LANE FOX CLAIMS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: At a meeting of the Defence Association formed to resist the claims being made by the Lane Fox Electrical Company in respect of the Lane Fox patents, held at the offices of the Kensington and Knightsbridge Electric Lighting Company (Limited), at 148, Brompton-road, S.W., the following resolution was passed:—

"That the list of members of this Association be closed on Saturday fortnight, November 22nd, and after that date members of the electrical trade who, being attacked by the Lane Fox Electrical Company, are desirous of availing themselves of the benefits of this Association, will be required to pay the double fee of £50." Under these circumstances, any members of the trade who wish to join the Association should communicate with me before the above-mentioned date.

I may mention, for the benefit of those who are not fully acquainted with the steps that have been taken in the matter, that several opinions have been obtained and submitted to counsel by different members of the Association, all of which agree in advising that the claims of the Lane Fox Electrical Company cannot be sustained.

Trusting you will be able to insert this in your next issue, as it is most important that it should reach all your readers.—Yours, &c., for the Defence Association,

R. S. ERSKINE, Hon. Sec.

148, Brompton-road, London, S.W., Nov. 4, 1890.

## BOOKS, &c., RECEIVED.

"Proceedings of the American Association for the Advancement of Science, August, 1889." (Salem.)

"Impianti Illuminazione Elettrica." Manuale Praticao di Emilio Piazzoli. (Milano: Ulrico Hoepli.)

"A Treatise on Electro-Metallurgy." By WALTER G. MCMILLAN, (London: Charles Griffin & Co.)

"Electric Light." By John W. Urquhart. 4th Edition. (London: Crosby, Lockwood & Son.)

## TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

TENDERS INVITED.—The Gas Committee of the Corporation of Nelson are prepared to receive tenders for the supply and erection of an installation capable of supplying electricity for 300 lights. The drawings and specifications may be seen, and all further information obtained, from Mr. Wm. Foster, Engineer's Office, Gas Works, Nelson. Copies of quantities and form of tender may be obtained from the said engineer on deposit of two guineas, which will be returned on receipt of a *bonâ fide* tender. Tenders are to be sent in to Mr. R. M. Prescott, Town Clerk, on or before the 13th inst.

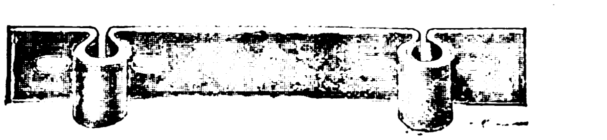
——— Friday, November 28th (not later than two o'clock) is the date fixed for the sending in of tenders for the lighting of the Western District of the City of London. (*See* our issue of October 25th.)

MESSRS. LACOMBE AND CO.—A gold medal has been awarded to Messrs. Lacombe and Co. for their carbon exhibit in the French electrical section of the Edinburgh Exhibition.

Digitized by Google

THE PLANET ENGINEERING COMPANY.—At a meeting held at the Royal Institute of British Architects on Monday last, the Council Room of the Institute was lit by the electric light. The installation at the Institute is being carried out by the above Company, and for the evening a temporary connection was made with accumulators in the Council Room to the satisfaction of the members.

A FIBRE CLEAT.—Messrs. David Moseley and Sons are introducing a cleat made of Celluvert or Kartavert. They are made for



single or for double wires, and are insulating when dry. They are largely used in America, and those who use cleats in this country will find them to be strong and light.

NEW YORK INSULATED WIRE COMPANY.—This Company notify us that they have received a large order for the Grimshaw wires for the Executive Buildings, Washington. They also take pride in having supplied the wire for the Statue of Liberty, the Washington Monument, and the American Departments of War and Navy.

## LEGAL INTELLIGENCE.

### The Halifax and Bermuda Cable Company v. Magniac.

This was an action before Mr. Justice Charles, on Tuesday last, to recover £3,988 and interest, being balance of calls due on Debentures of the Company applied for by the defendant.

Mr. Crump, Q.C., and Mr. Spokes appeared for the plaintiffs; Mr. Haughton for the defendant.

Mr. CRUMP said defendant applied for fifty Debentures of £100 each, in May, 1889, and forty-nine were allotted him; he paid £500 on application and another £500 on allotment, but, applications for the balance being unattended to, after some difficulty an action was commenced by substituted service, the defendant, being abroad, and judgment was signed against him. Afterwards, on the application of the defendant, the judgment was set aside, and a defence was put in to the effect that he had been induced to apply for the Debentures by misrepresentation.

Mr. HAUGHTON said he need not trouble his friend to go into the case at length. The defendant had satisfied himself that the prospectus was issued *bona fide*, and negotiations had been going on with a view to his paying the whole amount due, and the Company abandoning any claim for costs, which he understood was agreed to; but when the friend who had conducted the negotiations said he should like to have the debentures on paying over the money, it appeared that these very debentures which had been allotted to Mr. Magniac, and on the footing of which he was sued, had been deposited by the Company as security for a loan, and the parties with whom they were pledged declined to release them on payment of the amount due on the calls, their claim being somewhat larger on account of interest. He asked, therefore, not making any objection to paying the amount, and even the costs that the money might be paid into court or deposited with someone who would hand it over on receiving the debentures.

Mr. CRUMP said his friend was quite mistaken. When the defendant paid the money the debentures would be handed to him.

Mr. HAUGHTON asked leave to prove what he had stated, but

Mr. JUSTICE CHARLES said such an issue was not raised on the pleadings. He must accept Mr. Crump's statement, and as the only defence raised was abandoned, he must give judgment for the plaintiffs.

### The Edison and Swan Electric Light Company v. Robertson.

This matter came before Mr. Justice Stirling on Tuesday on a motion brought by the plaintiffs for judgment in default of appearance. The statement of claim asked for an injunction to restrain the defendant from further infringing the plaintiff's patent, an order for the delivery up to the plaintiffs of the infringing lamps, and an order for damages. Inasmuch as the plaintiffs had previously established the validity of their patent, they now asked for costs as between solicitor and client. His Lordship made the order as asked.

### Douse's Patent Fire-Check Company.

In this petition, which was brought by Mr. T. J. W. Buckley, for the winding-up of the Company, Mr. Alexander Young, who appeared for the petitioner, stated that he had the consent of the petitioner and of the Company, signed by their respective solicitors, that no order should be made on the petition, except that the costs of the petitioner and of the creditors supporting the petition be taxed and paid. The Company had, as a matter of fact, paid 20s. in the £.—Mr. Justice Stirling acceded to the application.

## COMPANIES' MEETINGS.

### Monte Video Telephone Company (Limited).

The annual ordinary general meeting of this Company was held at the offices, 25, Abchurch-lane, E.C., on the 31st ult., under the presidency of Mr. Arthur Holland.

The SECRETARY (Mr. Edward Johnson) having read the notice calling the meeting,

The CHAIRMAN said that the report was not so satisfactory as they could have desired, and certainly not in accord with the indications held out at the previous meeting, and at others when they were asked to increase the capital of the Company for the purpose of multiple switch boards and other improvements. It was satisfactory, however, in respect of profits, for, as shown in the report, it was about equal to that of last year, and this time they had passed through a period of real depression which was felt both at Monte Video and Buenos Ayres. Although telephones in many cases were articles of necessity, they were in many others articles of luxury and convenience, and when there came a time in which it was imperative for customers to exercise economy, the tendency was to dispense with them. The Company had suffered a great deal in this way, and many withdrawals had resulted from the stagnant state of business in Monte Video. On the other hand, owing to the improvements which the shareholders sanctioned some time ago, they had a considerable number of new shareholders to take the place of those who had withdrawn. Consequently they were, from a financial point of view, in about the same position as they were last year. They had deducted from the profits small sums for preliminary expenses and depreciation of furniture. This would be written off in a few years. They would propose a full dividend of 6 per cent. on the Preference shares, and to carry £1,000 to depreciation, and another £1,000 to reserve fund, because in the present state of things they deemed it prudent to have a substantial reserve. He continued to hope that when the wave of depression had passed, they would receive the full benefit of all the money they had spent out there. As stated in the report, they had spent a considerable amount in extending wires and cables to new subscribers; and under the head of profit and loss there was an increase in the subscriptions of £891. On the other hand, there was an advance in the expenditure of £1,130, owing to the extra taxes which they had been called upon to pay, and also on account of extra insurance. Expenses in London were a little higher, owing to the fact that in the previous twelve months they had received a little consideration from the Company for whom they had turned out of their old offices. Expenses in Monte Video amounted to 48 per cent. of their receipts. This showed a favourable comparison with the outlay of the Telephone Company on the other side of the river, whose expenses were 61 per cent. of their earnings. It showed that they must have had good management. He considered that the ordinary stocks of the Company would, before long, be a very valuable property. Had there been no withdrawals and the same influx of new subscribers, they could have paid their Ordinary shareholders 6 per cent. He concluded by moving the adoption of the report and accounts.

Mr. THOS. D. PETERS seconded the resolution, which was unanimously agreed to.

The CHAIRMAN them moved, and Mr. E. F. POWERS seconded, the declaration of the full dividend of 6 per cent. on the Preference shares of the Company.

The resolution was carried *nem. con.*

On the motion of the CHAIRMAN, seconded by Mr. POWERS, the retiring Director, Mr. Peters, was re-elected to his seat at the Board.

The auditors, Messrs. Gerard, Van de Linde and Son, were subsequently reappointed, and the proceedings terminated with a vote of thanks to the Chairman.

### Westminster Electric Supply Corporation (Limited).

The ordinary general meeting of the shareholders of this Corporation was held on Wednesday last at the offices, 4, Victoria Mansions, Westminster, under the presidency of the Right Hon. Lord Suffield, K.C.B.

The SECRETARY (Mr. Frank Iago) read the notice convening the meeting, and the report of the Directors was taken as read.

The CHAIRMAN said he had not much to add beyond what the shareholders already knew from the report. The maps hanging on the walls (as to which Prof. Kennedy would be happy to give any explanation that might be required) represented the work done up to last week. But since the maps were made up still further progress had been made, nearly 11¾ miles of mains now being laid. They all knew as well as he did the position of the Company, and the trouble and delay, partly necessary and partly otherwise, that had been caused in the progress of their operations not to speak of the difficulties that they had to deal with in obtaining stations and so on. But he must congratulate them, as he did himself, upon the great progress that had been made, considering the time that had been at their disposal in which to pursue their work. They had already a station at Millbank-street, Westminster, which, he was happy to say, was now in working order. And here he must give credit to their chief engineer for the great ability and energy which he had shown in carrying out the undertaking. Their other works were also progressing. They had already completed excavations at Davies-street, Mayfair, and some of the plant, two engines or more, he believed, and a considerable portion of the other necessary plant had been ordered, and was ready to be delivered. The works at Eccleston-place, Belgravia, were also proceeding apace. In fact, though they were not in a position to supply current to any great extent at present, he hoped that before long they would be able to do so. Any shareholders who might feel disposed to do so could go and see the Millbank-street station, and they would thus be able to form an opinion of the

kind and extent of the work that had been accomplished. He could assure them that the Directors had done everything they could to attend to the interests of the shareholders.

A SHAREHOLDER asked whether the applications for the electric light were very numerous.

The CHAIRMAN replied that they were, and were coming in every day. Of course the Company was not in a position to satisfy them as yet, and in many cases they had been obliged to say that they would not be able to supply current so early as was desired. He hoped that by the early part of January they would be able to supply nearly all the lights that were required. He believed he was within the mark in saying so.

A SHAREHOLDER wished to know whether an application had been made to the Stock Exchange for a settlement.

The CHAIRMAN replied that the application had been made and granted.

Mr. E. A. FRANKENSTEIN said he desired to ask three questions, which were of some importance. The first was when would the remainder of the capital be called up? The second was, what prospect of a dividend had they? And the third was, had they an absolute monopoly of electric lighting in the various districts mentioned in the Report?

The CHAIRMAN, in reply, said it would be impossible to say when the capital would be called up. As they all knew, their expenses were very great, and they would have to make another call shortly, payable early in the New Year; but when the whole of the uncalled capital would be applied for he was not in a position to state. With respect to the dividend, when they considered how much they had yet to do, he was afraid that they could not expect an early return. The third question was an important one. They had not an absolute monopoly. He understood from Mr. Wallace that they had a monopoly in a part of, but not throughout the whole of the district. He supposed that there would always be some rivalry on the part of other companies, and it would be their aim to attain such perfection in their arrangements as to give them a fair start of competitors. They were the only Company supplying in the district on their particular system, which they considered the best. They believed, also, that those to whom they supplied considered it the best. One very important feature in connection with it was the fact that in taking on new customers they had not to cut off the current from anyone else, as was the case with other companies—the London Company, for instance.

Mr. FRANKENSTEIN presumed, therefore, that so long as they remained best, the monopoly would be virtually assured.

The CHAIRMAN thought this to be practically the case. He might say that the only company in competition with them was the London Company.

Mr. S. R. SCOTT said he would like to say a few words from a shareholder's point of view. Having been long interested in this concern, and believing it to be an undertaking which would be eventually remunerative, he would say in answer to the shareholder opposite that they must give the Board some time to carry out an important work of this kind. With respect to the question of competition, he had always understood—perhaps they would correct him if he were wrong—that Parliament had given them, so to speak, half of their district to light, and that if they did their duty reasonably, the Board of Trade would maintain them in their position. Although they had a competitor, he was assured from the remarks that had been made that that competitor would not be a serious one, inasmuch as their system was likely to be more suitable and satisfactory in its working. He did not wish to mention names, but the impression which he had was that inasmuch as a company had to withdraw its light from some premises which this Company had already lighted seemed to point to that conclusion. He would like to say that, having had the opportunity through the kindness of Prof. Kennedy, of going over the works the previous day, he was quite astonished to find the progress which the Directors had made in providing for the lighting of that district. The station by the waterside, near the House of Commons, was in a very forward condition. In fact, practical working was going on when he was on the premises, so that within a day or two the station would be in full working order, and would render unnecessary the temporary iron shed which first of all contained the apparatus for supplying the Houses of Parliament. The other two stations had also progressed considerably, more especially the one at Eccleston-place, which would before Christmas make a great show. At the third station, and the last taken in hand, excavation was proceeding rapidly, and the workmen were putting in concrete at the present time, preparatory for the reception of the plant. Mr. Wallace reminded him of this fact, that when they got this station ready, they would not have to stand waiting for their machinery, which had been ordered, and was, in some cases, now ready. This was a matter which, in the first instance, appeared to some shareholders to be alarming because they thought that demands of this kind would be so great that they should have to wait for their plant. This was not so, however, for the plant was ready to put in position when the stations were ready to receive it. As to the dividend, he had heard that a neighbouring company doing business much on the same lines as their own, he believed (and he had heard this indirectly) was earning a very good dividend, and at its coming meeting it was going to show, though it had been at work only a few months longer than themselves, excellent profits, out of which they could distribute a good return. Another thing which he would like to say to his fellow shareholders was this. The Articles of Association of this Company were made at an early date — before the Company assumed its present proportions and its present capital. Under the head of "Directors" the Articles of Association said: "The remuneration of the Directors shall be £200 to the Chairman and £100 to each of the other Directors, and such other sum as shall be voted by the Company in general meeting." Now, he thought that seeing that the Directors had been working very hard, and, as they knew, most successfully, he did not think that that article in the Articles of Association mentioned an adequate sum for the payment of such a Board as they possessed. He would like to suggest to the Board on that occasion that they should at an early opportunity call a statutory meeting in order to alter the article he referred to. He understood that the Directors had taken no remuneration as yet, and he was sure that the shareholders did not want Directors, however good and however great they might be, to work for nothing. It would be absurd and unfair, and he, for one, having a large interest in the Company, was prepared to say that their Board ought to be properly paid. This came from him in his own private capacity as a shareholder. The Directors had not prompted him to say this. He said it as a shareholder, in the interests of other shareholders. He wished to see the work of the undertaking carried on as it had been hitherto, and in order to see this done, and to ensure the retention of those gentlemen on the Board they ought to be paid well. The present sum was not adequate for their service. He hoped that the article would be altered at an early date. With these remarks he would conclude by congratulating the shareholders on the position they now occupied. It appeared to him that the Company was going on rapidly to success. He spoke as a man of business, and not as an electrician. He kept his eyes open to what was going on, and he thought they were approaching success.

Mr. STEWART said he would be glad to hear whether the expenditure already made did or did not exceed, or was likely to exceed, to any great extent the estimates originally made. He wished also to ask the Board whether the capital was adequate to carry out the work.

Prof. KENNEDY said that the expenditure up to this time had been well within the estimates. The other question was not quite within his province.

Mr. STEWART thought it had been answered a good deal by what Prof. Kennedy had just said.

The CHAIRMAN thought that the capital at present was quite adequate to carry out the work. He did not know what might have to be done later on. In answer to a further question, he added that they were quite unable to judge what the sites would come to, but they considered that the prices had been reasonable. He thought there was every reason to anticipate a good dividend when they were fully at work.

Prof. KENNEDY, at the request of a shareholder, then gave an outline of the work done by the Company up to date by means of charts on the walls.

A SHAREHOLDER asked whether all the shares had been taken up.

The CHAIRMAN replied that all the shares issued had been taken up, and that there was a certain portion reserved.

Another SHAREHOLDER wished to know whether the remaining shares were ever offered to the public.

Mr. SCOTT said that he was adviser to the Company on the occasion alluded to, and he wished to say that 60,000 shares were offered, and over 40,000 were taken up by the public, and the Directors agreed to withdraw the balance. It was upon the strength of these 40,000 shares that the Company was now proceeding.

A SHAREHOLDER wished to know whether there was any danger attached to their system of electric lighting?

The CHAIRMAN said he could answer the question himself, but perhaps they would prefer to hear the Engineer on the subject.

Prof. KENNEDY explained that the system adopted by the Company was a low-tension one, and he thought he might say that it was entirely without danger. They had no high-tension current for good or evil, and no one could get seriously hurt by it, even under the most unfavourable circumstances.

The CHAIRMAN then formally proposed the adoption of the report.

Mr. E. BULNOIS, M.P., seconded the motion, which was agreed to *nem. con.*

The CHAIRMAN said that in closing the meeting he could not do otherwise than thank Mr. Scott for the kind remarks which the gentleman had made with regard to the Directors. As to the remuneration of the Directors he felt quite certain that his brother Directors would agree with him in leaving the question entirely in the hands of the shareholder.

Mr. SCOTT then proposed a vote of thanks to the Chairman and Directors, and wished to emphasise the fact, from personal observation of the progress of the undertaking, that they had as good a Directorate as could be found in the City of London. He desired to couple the vote with the name of Prof. Kennedy and the staff, all of whom had been equally energetic in carrying on the work.

The motion was seconded and cordially carried.

The CHAIRMAN having acknowledged the compliment, the proceedings terminated.

---

The following is the report of the Board of Directors referred to above :—The Board are pleased to be able to state that the affairs of the Corporation are proceeding in a rapid and satisfactory manner. The first work which claimed their attenntion after the allotment of the shares was that of obtaining suitable sites for central stations, three of which were required for the supply of the district which had been allotted to the Corporation. In January last the Board acquired the undertaking of the City of Westminster Electrical Syndicate, Limited, who had commenced business in the district, and thereby obtained possession of St. John's Wharf, Millbank-street, and also of the contract for electric lighting in the Houses of Parliament. After considerable trouble and delay, the Board succeeded in obtaining two other eligible sites, one in Eccleston-place, Belgravia, and the other in Davies-street, Mayfair, both being on the Duke of Westminster's estate. Pending the installation of the large central stations, current has been supplied from two temporary stations, one in the stoneyard adjacent to the Houses of Parliamenon and the other in Dacre-street, Victoria-street By means of these temporary stations the nucleus of a good business has been formed, and at the present time current is being supplied from

underground mains equivalent to about 6,000 eight candle-power lamps on circuit. The demand for current already far exceeds the amount which can be generated from the plant in actual work, but the new station at St. John's Wharf is now running, and able to take over the work in the Westminster district, and allow the Dacre street plant to supply as far as Belgrave-square, pending the completion of the Eccleston-place station. The installations in Mayfair and Belgravia are rapidly advancing. The mains have been laid in many of the principal streets, and are being laid as quickly as possible in the others, and the Board hope that current will be supplied from both these stations early in the new year. The Board have ordered plant—viz., engines, boilers, dynamos, batteries, &c.—to the amount of about 2,600 indicated horse-power for the three stations, a large part of which has already been delivered. This will be sufficient to supply about 40,000 eight candle-power lamps alight at one time, allowing an ample margin for steam power in reserve. According to present experience this will correspond to upwards of 100,000 eight candle-power lamps on circuit. The system of distribution adopted is the low-tension continuous current. The mains already laid are shown on maps, which can be seen at the Corporation's offices, and amount in all to nearly 11 miles, and permission has already been obtained from the authorities for the whole system of proposed mains. The financial year ends on December 31st, and the accounts will be made up and audited to that date, and the Board recommend that in future the annual general meeting of the shareholders should be held in the month of February, when the accounts would be ready for presentation.

## West India and Panama Telegraph Company (Limited).

The following is the report of the Directors for the half-year ended June 30 last, to be submitted to the twenty-seventh ordinary general meeting to be held at Winchester House, Old Broad-street, E.C., on Wednesday, next, the 12th inst., at 2 p.m.

The amount to credit of revenue is £52,351. 2s. 4d. (against £49,985. 11s. 9d. for the corresponding half-year of 1889), and the expenses have been £26,669. 17s. 4d. (against £24,458. 6s. 9d. for the same period in 1889), leaving a balance of £25,681. 5s. 0d., which, with the balance of £516. 19s. 8d., brought from the last account, makes a total of £26,198. 4s. 8d. Of this sum the Directors have placed £1,500 to reserve, leaving an available balance of £24,698. 4s. 8d., with which it is proposed to deal as follows:—

| | | | |
|---|---|---|---|
| First Preference Shares— | | | |
| Dividend, 6 months to June 30th, 6s. per share... | £10,368 | 18 | 0 |
| Second Preference Shares— | | | |
| On account of arrears of dividend to June 30th, £3 per share ...... | 14,007 | 0 | 0 |
| Balance to current half-year's account ...... | 322 | 6 | 8 |
| | £24,698 | 4 | 8 |

The traffic receipts for the six months show an increase of £2,779. 7s., as compared with the corresponding period.

Several interruptions to the cables occurred during the half-year, and the expenses for repairs amount to £13,936. 8s. 3d., being £2,900. 19s. 11d. more than those for the corresponding six months.

The shareholders will remember that at the time of the last general meeting negotiations were in progress with the Government of Barbadoes to lay a second cable to that colony in consideration of the continuance of the subsidy of £2,500 per annum for a period of 10 years. The necessary Act having been passed, the new cable was successfully laid between Barbadoes and St. Vincent in July last. In consequence of the laying of the new line above referred to out of the stock of cable in the West Indies, it has become necessary to replenish that stock for repairing purposes, and a contract has been entered into with Siemens Brothers and Company (Limited) for the manufacture of 215 knots of cable, which will be conveyed to the West Indies in the Company's steamship "Grappler," which arrived in the Thames on the 21st inst.

The Danish colonies of St. Thomas and St. Croix have renewed their subsidies for a further term of five years from December 31st last.

The Company was represented by the Chairman at the International Telegraph Conference recently held in Paris.

## Western and Brazilian Telegraph Company (Limited).

The following is the report of the Directors for the half-year ended June 30 last, to be presented at the twentieth ordinary general meeting of the Company, to be held at Winchester House, Old Broad-street, E.C., on Thursday next, the 13th inst., at 12 noon:—

The total earnings amount to £89,346. 13s. 9d., as against £86,555 17s. 10d., an increase of £3,290. 15s. 11d., compared with the half-year to June 30, 1889. The working expenses amount to £40,509. 13s. 3d., as against £39,104. 15s. 5d., an increase of £1,404. 17s. 10d. This increase is attributable to a larger sum having been written off the steamers on account of depreciation (£1,031), to the rise in the price of coals, to the opening of a new station, and to the larger volume of traffic. Including the amount brought forward from 1889 (£3,248. 16s. 6d.) and the dividend received upon the shares held in the "Platino" Company to June 30th, the balance to the credit of the revenue account is £59,970. 17s., from which has to be deducted £13,220 for Debenture interest, leaving £46,750. 17s., of which £7,500 has been placed to the renewal fund and £5,880 to the Debenture Redemption Fund. This leaves £33,370. 17s. The Directors recommend the payment of a dividend of 6s. per share, free of income tax, on the Ordinary shares for the half-year, being at the rate of £4 per cent. per annum, carrying forward £5,751. 7s. At the corresponding period last year the dividend was at the same rate. Since the last half-year's report 30 "Platino" shares have been exchanged for 18 shares of this Company. The dividend warrants will be posted on the 14th November.

An agreement for the absorption of the Montevidean and Brazilian Telegraph Company (Limited) will be submitted for the approval of the meeting. The undertakings are so closely allied that it is most desirable they should be brought under common control, and it is now proposed to purchase the above Company by an issue of 5,300 Ordinary shares of £15 each in the Western and Brazilian Telegraph Company (Limited), ranking for dividend earned after January 1st next. The agreement at present subsisting provides for the payment to that Company of a percentage of the gross receipts of the Western and Brazilian Telegraph Company (Limited). This payment, forming a portion of the amount paid to the London Platino-Brazilian Telegraph Company (Limited) is a charge coming between the A and B Debenture issue of the Western and Brazilian Telegraph Company (Limited). Consequent upon the arrangement now proposed, the proportion of this charge, hitherto paid to the Montevidean Company, will disappear.

The Directors have the pleasure to state that after long and difficult negotiation, the Government of Brazil have authorised the Company to lay alternative cables. The thanks of the Company are due to the Government of the United States of Brazil for this decision. Steps will be now taken to lay the lines immediately necessary.

## The Metropolitan Electric Supply Company, Limited.

The following is the report of the Directors, to be presented to the shareholders at the meeting to be held at Winchester House, Old Broad-street, E.C., to-day (Friday) at 12 noon:—

PATENT

SILICIUM BRONZE AND SILICIUM COPPER WIRE.

The best for overhead Telephone and Telegraph Lines,

AND ALL ELECTRICAL PURPOSES.

Hard Drawn High Conductivity Copper Wire.

ROLLED AND DRAWN PHOSPHOR BRONZE.

PHOSPHOR BRONZE — VULCAN — PHOSPHOR — DURO METAL

PHOSPHOR BRONZE BEARINGS, BUSHES, AND OTHER PARTS OF ELECTRICAL MACHINERY.

*SOLE PROPRIETORS of the British, Indian and Colonial Patents,*

THE PHOSPHOR BRONZE COMPANY (Limited),

*87, Sumner Street, Southwark, London, S.E.*

WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

Digitized by Google

Under the Electric Lighting Act it has been provided that the accounts of statutory supply companies shall be made up to the 31st December in each year, and that these accounts shall be presented to the Board of Trade not later than the 25th March in the year following. It will be remembered that last year the accounts were made up to the 30th September; in order, therefore, to comply with the above-mentioned statutory requirements, it is necessary to alter the period of the Company's financial year to the end of December, and the date of the annual general meeting to the beginning of next year. The accounts for the fifteen months ending the 31st December next will therefore be submitted to the meeting to be held early in 1891. The present meeting has been convened in accordance with Article 71 of the Company's Articles of Association, which provides that an ordinary meeting shall be held annually.

The Directors are pleased to have the opportunity of informing the shareholders that the Company is making steady and substantial progress in its works, and that what promises to be a large and remunerative business is being built up. During the fourteen months which have elapsed since the Company obtained Parliamentary powers, upwards of forty miles of electric light mains have been laid in pipes under the streets of the principal thoroughfares of the Company's districts. Current is being supplied from four central stations, two of which—viz., Whitehall and Sardinia-street—are fully equipped, while the other two—viz., Rathbone-place and Manchester-square—are on the eve of completion.

The Company's area of supply has been enlarged by the addition of the important and valuable district of Paddington. The Directors are giving careful consideration of the best means of supplying current in this district, and an advantageous site on which to erect a central station has already been acquired on favourable terms. While it is impossible, until the accounts have been made up and audited, to review the Company's financial position in detail, the Directors are of opinion that the prospects of the Company are such as to warrant them in looking forward to a satisfactory dividend being earned during the ensuing year.

In accordance with the Articles of Association, three of the Directors—viz., Sir James Anderson, Mr. J. Spencer Balfour, M.P., and Sir George Elliott, Bart, M.P., retire by rotation, and, being eligible, offer themselves for re-election. The auditors, Messrs. Deloitte, Dever, Griffiths, and Co. retire, and offer themselves for re-election.

## NEW COMPANIES REGISTERED.

**J. H. EVANS AND CO.**—Registered with a capital of £25,000 in £5 shares. Objects: To carry on the business of mechanical engineers, and machine and engineering tool makers.

**UNITED ALKALI COMPANY.**—Registered by H. Fonshaw and Hawkins, 5, Castle-street, Liverpool, with a capital of £6,000,000, in 300,000 Preference and 300,000 Ordinary shares of £10 each. Among the objects of the Company are the carrying on business as manufacturers of chemical products and drugs of all kinds, and as metallurgists in all its branches, and the carrying on of any business directly or indirectly connected with the generation, accumulation, distribution, supply, or application of electricity. Sir Charles Tennant, Bart., is to be the first honorary president.

## CITY NOTES, &c.

**BRAZILIAN SUBMARINE TELEGRAPH COMPANY.**—The receipts of this Company for the week ended October 31st amounted to £5,411.

**BRITISH INSULATED WIRE COMPANY (LIMITED).**—The Prospectus of this Company was issued on Friday last. The capital is £60,000, divided into 3,950 Cumulative £7 per Cent. Preference Shares; 3,450 Ordinary "A" Shares; 4,300 Ordinary "B" or Deferred Shares, and 300 Founders' Shares, all of £5 each. The present issue is for 3,450 Preference Shares, and 3,450 Ordinary "A" Shares. The Directors are Theodor Guillaume, (Messrs. Felten and Guillaume), 11, Billiter Street, London, E C., and Mulheim-on-the-Rhine, Germany; James B. Atherton, Mayfield, Huyton, Lancashire; W. Marriner Brigg, Hawkstone, Keighley, Yorkshire, and T. P. Hewitt, Eccleston Park, Prescot, Lancashire. The Consulting Engineer is Mr. R. E. Crompton. The Secretary *(pro tem.)* is Mr. E. England, and the Registered Office is situate at 15, Union Court, Castle Street, Liverpool. The Prospectus states that the Company has been formed for the purpose of acquiring, working and developing the British rights in the Patents now being worked in America by the Norwich Insulated Wire Company in the production of paper insulated telephone, telegraph, and electric light wires and cables of high insulation resistance, and low static capacity. The basis of the Patents is the recent discovery that pure vegetable paper possesses in a high degree all the qualities needed for an insulated material. The Norwich Insulated Wire Company's Works are capable of turning out, per month, 15,000 miles of insulated telephone and electric light wire, and the Company has large orders now on hand. The Company has secured the services of Mr. J. B. Atherton as General Manager. The Cables have been submitted to the examination of many leading electrical engineers both England, America, and the Continent, and in every instance with a highly satisfactory result. It is intended to proceed at once with the erection of a suitable factory on the land at Prescot already mentioned, with all the necessary machinery, for the manufacture, by means of the patents acquired, of cables, and all kinds of electrical conductors. The list of applications for shares opened on Friday last, and closed on Tuesday.

**CUBA SUBMARINE TELEGRAPH COMPANY.**—The estimated traffic receipts of this Company for the month of October were £3,200, as compared with £2,903 in the corresponding month of last year. The receipts for the month of July, estimated at £3,150, realised £3,134.

**DIRECT SPANISH TELEGRAPH COMPANY.**—The traffic receipts of this Company for the month of October show an increase of £154, as compared with the corresponding period last year.

**EASTERN TELEGRAPH COMPANY, LIMITED.**—The traffic receipts of this Company for the month of October, 1890, amounted to £59,589, as against £62,981 for the corresponding period of 1889, or a decrease of £3,392.

**EASTERN SOUTH AFRICAN TELEGRAPH COMPANY (LIMITED).**—On Monday, the 17th inst., at 2 o'clock p.m., at the Company's Offices, 50, Old Broad Street, E.C., 298 First Mortgage Debentures of £100 each will be drawn for payment on the 1st January 1891.

**EASTERN EXTENSION TELEGRAPH COMPANY.**—The receipts of this Company for October amounted to £47,117, as against £45,679 in the corresponding period, showing an increase of £1,438.

**GREAT NORTHERN TELEGRAPH COMPANY.**—The traffic returns of this Company are as follows:—Receipts in October, 1890, £26,000; 1st January to 31st October, 1890, £232,800; corresponding months, 1889, £229,200; corresponding months, 1888, £226,200.

**MIDDLESBOROUGH (U.S.A.) ELECTRIC LIGHT, HEAT, AND POWER COMPANY.**—Certificates for this Company are now ready, and will be exchanged for banker's receipts at the London office, Blomfield House, New Broad-street, London, E.C.

**MESSRS. RUSTON, PROCTER AND CO.**—This Company has declared an interim dividend of 5s. per share.

**STOCK EXCHANGE.**—Application has been made to the Committee to appoint a settling day for the shares of Elmore's French Patent Copper Depositing Company (Limited). The Committee have appointed special settling-days as under: Friday, Nov. 7th—International Okonite Company (Limited), Preference shares, Nos. 5,667 to 17,000, and Ordinary shares, Nos. 22,667 to 34,000 (also to be quoted in the Official List); Wednesday, November 12th—Dee Oil Company (Limited), shares, Nos. 1 to 13,400; and White's Asbestos (Limited), shares, Nos. 20,001 to 35,000. The Committee have ordered the undermentioned securities to be quoted in the Official List: Bell's Asbestos Company (Limited), 4,000 new shares, Nos. 20,001 to 24,000, and vendors' £6,000 Debentures, Nos. 249 to 308.

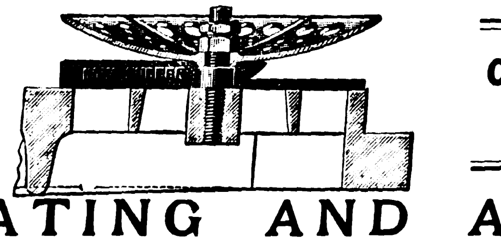
**WEST COAST OF AMERICA TELEGRAPH COMPANY.**—The traffic receipts of this Company for the month ending 31st October, 1890, amounted to £5,800.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY.**—At a meeting of the Board of this Company on Monday last it was decided that, after placing £7,500 to the renewal fund and £5,880 to the Debenture redemption fund, the Directors would recommend, at the forthcoming meeting, a dividend of 6s. per share (free of income-tax), being at the rate of £4 per cent. per annum, for the six months ended June 30 last. The traffic receipts of this Company for the week ending October 31, 1890, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £4,235.

**WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).**—The estimated traffic receipts for the half-month ended Oct. 31st were £2,910, against £2,735 in the corresponding period of 1889.


NEW VALVE

No Rubber, Percha, or Leather.



One-half the price of Rubber or Metal.

FOR CIRCULATING AND AIR PUMPS.

Unaffected by any Lubricating Oils. Does not Expand in diameter. Feed Water may be worked at any temperature Suitable for any shaped guards. Only one quality manufactured.

"12, John-street, Sunderland, 26th Sept. 1885.

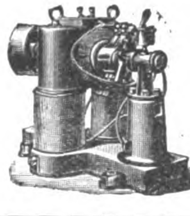
"DEAR SIRS,—In reply to your letter of the 25th inst., the Valves I got from you have done their work well, and ARE AN UNQUALIFIED SUCCESS. I will continue to get them from you as required.—Yours faithfully, JAMES WESTOLL."

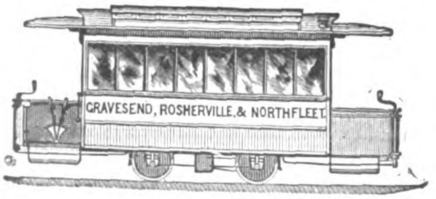
For further Testimony and Prices, apply to MOSSES & MITCHELL, 68-71, Chiswell Street, London.

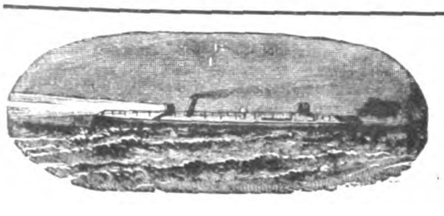

Digitized by Google

# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name. | Previous Week's Price, Oct. 29. | | Price Wednesday, Nov. 5. | | Rate per Cent. Yielded. £ s. d. | Dividend Due. | Business Done During Week Ending Nov. 5. Highest | Lowest. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **TELEGRAPHS.** | | | | | | | | |
| 1,381,380 | Stock | 15/0 | Anglo-American | 48½ | 49½ | 48½ | 49½ | 5 16 2 | Jan., Apr., July, Oct. | 49 | .. |
| 2,809,310 | Stock | 30/0 | Do. Preferred | 84½ | 85½ | 84½ | 85½ | 6 14 6 | ,, ,, | 85½ | 85¼ |
| 2,809,310 | Stock | .. | Do. Deferred | 13 | 13½ | 13 | 13½ | .. | | 13 5/16 | 13⅛ |
| 250,000 | £100 | 4% | African Direct, 4 per Cent. Debentures | 99 | 102 | 99 | 102 | 3 18 5 | January and July .. | .. | .. |
| 130,000 | 10 | 3/0 | Brazilian Submarine xd and Bonus | 11¼ | 11¾ | 11¼ | 11¾ | 5 10 8 | Mar., June, Oct., Dec. | 11¾ | 11⅝ |
| 84,500 | 100 | 5% | Do. 5 per Cent. Bonds | 100 | 102 | 101 | 103 | 4 17 1 | January and July .. | .. | .. |
| 75,000 | 100 | 8½ | Do. 5 per Cent. Bonds (2nd Series) | 103 | 107 | 104 | 108 | 4 12 7 | June and December | .. | .. |
| $7,216,000 | $100 | .. | Commercial Cables | 102 | 104 | 102 | 104 | 5 15 5 | April and October .. | 103½ | .. |
| £16,000 | £10 | 8/0 | Cuba Submarine | 11½ | 12 | 11½ | 12 | 7 1 8 | February and August | 12 | 11⅞ |
| 6,000 | 10 | 10% | Do. Preference 10% | 17 | 18 | 17 | 18 | 5 11 1 | ,, ,, | .. | .. |
| 12,931 | 5 | 2/4½ | Direct Spanish (£4 paid) | 3¾ | 4¼ | 3¾ | 4¼ | 5 12 11 | April and October.. | .. | .. |
| 6,000 | 5 | 10% | Do. Preference 10% | 8½ | 9½ | 8¾ | 9¾ | 5 5 3 | ,, ,, | .. | .. |
| 60,710 | 20 | 3/6 | Direct United States xd | 10¼ | 10½ | 10¼ | 10½ | 6 13 4 | Jan., Apr., July, Oct. | 10⅜ | 10⅛ |
| 400,000 | 10 | 2/6 | Eastern | 13¾ | 14 | 13¾ | 14 | 4 12 10 | ,, ,, | 14 | 13¾ |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference | 14¾ | 15¼ | 14¾ | 15¼ | 3 18 8 | ,, ,, | 14⅞ | .. |
| 1,200,000 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock.. xd | 103 | 106 | 103 | 106 | 3 15 6 | May and November | 106 | 105 |
| 200,000 | £100 | 5% | Do. 5 per Cent. Debentures, 1899 | 106 | 109 | 106 | 109 | 4 11 9 | February & August | .. | .. |
| 250,000 | 10 | 2/6 | Eastern Extension | 14 | 14¼ | 14 | 14¼ | 4 18 3 | Jan., Apr., July, Oct. | 14¾ | 14 |
| 320,000 | 100 | 6% | Do. 6 per Cent. Debentures, 1891 | 100 | 102 | 100 | 102 | 5 17 8 | February & August | .. | .. |
| 91,800 | 100 | 5% | Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900 | 102 | 105 | 102 | 105 | 4 15 3 | January and July .. | .. | .. |
| 145,300 | 100 | 5% | Eastern & S. African 5 per Cent. Mor. Deb., 1900.. | 101 | 104 | 101 | 104 | 4 16 2 | ,, ,, | .. | .. |
| 180,227 | 10 | 1/9 | Globe Telegraph and Trust | 8¾ | 9 | 8¾ | 9 | 5 8 4 | Jan., Apr., July, Oct. | 9 | 8 13/16 |
| 180,042 | 10 | 6% | Do. 6 per Cent. Preference | 14½ | 14¾ | 14½ | 14¾ | 4 1 4 | ,, ,, | 14¾ | 14½ |
| 150,000 | 10 | 5/0 | Great Northern | 15¾ | 16¼ | 15¾ | 16¼ | 4 12 4 | Jan., April, and July | 15⅞ | 15¾ |
| 15,000 | 100 | 5% | Do. 5 per Cent Debentures, 1881 | 101 | 104 | 101 | 104 | 4 16 2 | January and July .. | .. | .. |
| 230,000 | 100 | 5% | Do. 5 per Cent. Debentures, 1883 | 104 | 107 | 104 | 107 | 4 13 6 | March & September | .. | .. |
| 17,000 | 25 | 37/6 | Indo-European xd | 35 | 37 | 36 | 37 | 6 15 2 | May and November | .. | .. |
| 38,348 | 10 | 4/0 | London Platino-Brazilian | 6½ | 7½ | 6½ | 7½ | 5 6 8 | ,, ,, | .. | .. |
| 100,000 | 100 | 6% | Do. 6 per Cent. Debentures | 105 | 108 | 105 | 108 | 5 11 1 | March & September | .. | .. |
| 9,000 | 8 | 4/0 | Reuter's | 8¼ | 8¾ | 8¼ | 8¾ | 5 14 4 | April and October.. | .. | .. |
| 3,381 | £100 Cert. | 6% | Submarine Cables Trust ....x April Coupon, 1890 | 110 | 114 | 110 | 114 | 5 5 3 | ,, ,, | .. | .. |
| 15,609 | £10 | 6/6 | West African | 8½ | 9½ | 8½ | 9½ | 5 5 3 | January and July .. | .. | .. |
| 290,000 | 100 | 5% | Do. 5 per Cent. Debentures | 98 | 101 | 98 | 101 | 4 19 0 | March & September | .. | .. |
| 30,000 | 10 | 3/0 | West Coast of America | 4 | 5 | 4 | 5 | 10 0 0 | January and July .. | 4 | .. |
| 150,000 | 100 | 8% | Do. Debentures 8% | 102 | 107 | 102 | 107 | 7 9 7 | June and December | .. | .. |
| 88,321 | 10 | Nil. | West India and Panama | 3 | 3¼ | 3 | 3¼ | .. | .. | 3¼ | 3 3/16 |
| 34,563 | 10 | 6/0 | Do. 1st Preference 6% | 11½ | 12 | 11½ | 12 | 5 0 0 | May and November | 11¾ | 11⅜ |
| 4,669 | 10 | 27/6 | Do. 6 p. c. 2nd Pref. | 14 | 15 | 14 | 15 | 4 0 0 | ,, ,, | .. | .. |
| 64,174 | 15 | 6/0 | Western and Brazilian | 11 | 11½ | 11 | 11½ | 5 4 3 | ,, ,, | 11⅝ | .. |
| 27,873 | 7½ | 1/6 | Do. 5 per Cent. Cumulative Preferred | 6¾ | 7 | 6¾ | 7 | .. | – | 6 15/16 | 6⅞ |
| 27,873 | 7½ | 4/6 | Do. 5 per Cent. Deferred | 4½ | 5 | 4½ | 5 | .. | .. | .. | .. |
| 200,000 | 100 | 6% | Do. 6 per Cent. Debs., Series "A" | 103 | 106 | 103 | 106 | 5 13 2 | February & August | .. | .. |
| 250,000 | 100 | 6% | Do. 6 per Cent. Mort. Debs., Series "B" | 103 | 106 | 103 | 106 | 5 13 2 | ,, ,, | .. | .. |
| $1,336,000 | $1,000 | 7% | Western Union 7 per Cent. 1st Mortgage...... xd | 122 | 127 | 120 | 125 | 5 12 0 | May and November | 122½ | .. |
| £175,100 | £100 | 6% | Do. 6 per Cent. Sterling Bonds | 99 | 103 | 99 | 103 | 5 16 6 | March & September | .. | .. |
| | | | **TELEPHONES.** | | | | | | | | |
| 224,850 | 14/0 | 0/5¾ | Consolidated Telephone Const. & Maintenance. xd | ½ | ⅝ | ½ | ⅝ | .. | May and November | .. | .. |
| 220,000 | £1 | .. | Oriental (11s. paid) | ⅜ | ⅝ | ⅜ | ⅝ | 4 8 3 | Yearly ........... | .. | .. |
| 438,984 | 5 | 3/0 | National | 4¼ | 4½ | 4⅛ | 4⅜ | 6 17 2 | June and December | 4⅜ | 4 5/16 |
| 15,000 | 10 | 6/0 | Do. 6 per Cent. Cumulative 1st Pref. | 12 | 12½ | 12 | 12½ | 4 16 0 | ,, ,, | .. | .. |
| 15,000 | 10 | 4/9¾ | Do. 6 per Cent. Cumulative 2nd Pref. | 9½ | 10½ | 9½ | 10½ | 5 14 3 | ,, ,, | .. | .. |
| 209,750 | 1 | .. | South of England, Ordinary | ⅛ | ⅜ | ⅛ | ⅜ | .. | .. | .. | .. |
| 20,000 | 5 | 2/0 | Do. 6 per Cent. Cumulative Pf. (£3 10s pd). xd | 2½ | 3 | 2½ | 3 | .. | .. | 2 15/16 | .. |
| 58,000 | 5 | 1/0 | United River Plate | 3 | 4 | 3 | 4 | .. | .. | .. | .. |
| 146,128 | Stock | .. | Do. 5 per Cent. Debenture Stock | 90 | 94 | 90 | 94 | 5 6 5 | January and July .. | .. | .. |
| 3,200 | 100 | .. | Do. 7 per Cent. Debentures | .. | | .. | | .. | .. | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | | | |
| 200,000 | £5 | .. | London Electric Supply | 2⅜ | 2⅝ | 2⅜ | 2⅝ | .. | .. | .. | .. |
| 43,900 | 10 | .. | Metropolitan Electric Supply (£8 paid) | 4¾ | 5¼ | 5 | 5½ | .. | .. | .. | .. |
| 42,853 | 5 | .. | Westminster Electric Supply (£3 paid) | 2½ | 3 | 2½ | 3 | .. | .. | 2¾ | .. |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | | | |
| 63,416 | 3 | .. | Brush Electrical Engineering | 1¼ | 1¾ | 1¼ | 1¾ | .. | .. | .. | .. |
| 63,416 | 2 | 0/10 | Do. 6 per Cent. Preference | 1½ | 2 | 1½ | 2 | 6 0 0 | June and December | .. | – |
| 20,000 | 5 | .. | Crompton and Co , 7 per Cent. Pref. Shares | 5¼ | 5¾ | 5¼ | 5¾ | 6 1 9 | January and July .. | .. | .. |
| 17,139 | 5 | .. | Edison and Swan United | .. | | .. | | .. | .. | .. | .. |
| 45,000 | 10 | .. | Electric Construction | 7½ | 8 | 8 | 8½ | .. | .. | .. | .. |
| 70,000 | 2 | 10/0 | Elmore's Patent Copper Depositing | 5 | 5½ | 5 | 5½ | .. | .. | .. | .. |
| 20,000 | 5 | .. | Fowler-Waring Cables (£4 paid) | 2½ | 3½ | 2½ | 3½ | .. | .. | 5 | .. |
| 41,600 | 10 | 10/0 | India Rubber, Gutta Percha & Telegraph Works... | 18½ | 19½ | 18 | 19 | 5 5 3 | February & August | 19 | 18¼ |
| 200,000 | 100 | 4½% | Do. 4½ per Cent. Debentures, 1896 | 100 | 102 | 100 | 102 | 4 8 3 | March & September | .. | .. |
| 78,949 | 5 | 6% | Swan United (£3. 10s. paid) | 5 | 5½ | 5 | 5½ | 3 16 5 | May and November | 5⅜ | 5¼ |
| 37,350 | 12 | 12/0 | Telegraph Construction and Maintenance | 43 | 45 | 43 | 45 | 5 6 8 | March and July..... | 45 | .. |
| 150,000 | 100 | 5% | Do. 5 per Cent. Bonds, red. 1894 | 100 | 102 | 100 | 102 | 4 18 0 | January and July .. | .. | .. |






# BEFORE ORDERING!

## ELECTRICAL PLANT & ACCESSORIES

(Statter's) WRITE FOR THE FOLLOWING PAMPHLETS TO THE (United)

## ELECTRICAL ENGINEERING CORPORATION, Ld.

PLANT WORKS: WEST DRAYTON, near LONDON.
FITTINGS WORKS: ALBERT WORKS, 36, ALBERT EMBANKMENT, S.E.
LONDON OFFICES: 3, PRINCES MANSIONS, VICTORIA STREET, WESTMINSTER.

"ELECTRICAL DISTRIBUTION."—Commercially considered, with Estimates.
"MACHINE DRIVING BY ELECTRICITY."—The Uses of Electro-Motors for Traction and Stationary Purposes.
"THE TELPHER SYSTEM OF CHEAP TRANSPORT," for Minerals, Goods and Passengers.
"ELECTRICAL SUPPLIES."—Prices and Particulars of the most approved Electrical Appliances

**ELECTRICAL PLANT ON VIEW.**


Digitized by Google

# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 652.—Vol. XXVI. FRIDAY, NOVEMBER 14, 1890. Price Fourpence.

## NOTES.

The Metropolitan Electric Supply Company, if we may judge from the figures placed before the shareholders on Friday last, has not let the grass grow under its feet during the first few months of its statutory existence. Since March last the Company has increased the number of lamps connected to its mains by 140 per cent., and its four generating centres, with their total capacity of nearly 7,000 horse-power, have now been got into working order. Supplying, as the Metropolitan Company does, an area of close upon five square miles, comprising some of the wealthiest districts of London, its Directors may well rest content with the development of the splendid territory already acquired, the more so since the station capacity still exceeds the present demand. It is satisfactory to learn that the "cost of coal and of working the machinery" has been found not to exceed 3½d. per unit; but it is the total cost per unit—that is to say, production plus distribution and management—upon which financial success will ultimately depend.

We wish every success to Mr. Crompton's scheme for the interchange of useful information, and hope that the first two forms, relating to efficiency at various loads and to the cost of producing and of distributing energy, will meet with less indifference than most of the circulars issued by the Chamber of Commerce. There are some matters which ever evade human inquiry. Where do dead donkeys and bent pins go? Is a tube boiler better than a shell? In reply to the first question, some thinkers suggest that they pass into the fourth dimension; but the second is as yet beyond our ken. We therefore wait for the replies to the circular.

The second form is excellent as far as it goes, but it may be feared that the request which follows it will be thought to have a somewhat personal colouring. Cables and other conductors covered with continuous insulation are to be charged with 5 per cent. for maintenance, but bare conductors, insulated by means of glass, porcelain, or other such imperishable materials, are to be debited with only 1 per cent. As we do not know, we will not prophecy about the relative cost of maintenance of the two systems of mains; but if Mr. Crompton will undertake to maintain the mains which he has laid for several different companies at 1 per cent., with say another tenth per cent. for net profit, we should congratulate the companies on their bargain. Fifteen per cent. on accumulators is a guaranteed figure, but although the old A. T. v. B. T. controversy resulted in a drawn battle as regards economy of generation and distribution, there is not any conceivable reason for supposing that a transformer need be charged with three times the depreciation that is set against engines and dynamos.

The operations of the Chemical Union, which has been registered under the title of the United Alkali Company (Limited), with a capital of six millions, has produced a further advance in bleaching powder, which has risen from £5 to over £6 per ton. This will give a better chance for the electrolytic methods of bleaching described in the article which is concluded in this issue, and may make the production of peroxide of hydrogen and of ozone of more commercial importance than hitherto.

Mr. Lane Fox has nearly lost the valuable services of Sir Richard Webster and Mr. J. F. Moulton, Q.C., by the smartness of his numerous opponents. These learned counsel have had a retainer from Mr. Lane Fox of ten years' standing, but the new Lane Fox Electrical Company was made a party to the case which is impending, and after examining precedents Sir Richard Webster found that the prior retainer was thereby invalidated. This case will therefore be dropped, and in a new case Mr. Lane Fox will be the sole plaintiff.

The only claim which the Lane Fox Company have hitherto attempted to enforce has been based on patent No. 3,988** of 1878, but since they consider that in certain quarters there is a disposition to evade rather than to fairly discuss terms, it is threatened that patent 4,626 of 1878 will be produced for the purpose of including all voltmeters as belonging to the category of "shunt electrometers." We understand from Mr. Lane Fox that no shunt instruments for measuring difference of potential had been suggested at that date, when the current for electric lighting was not "divided," and working at constant pressure was unknown. How many other patents Mr. Lane Fox has up his sleeve if his opponents do not play fair, we have no opportunity for estimating. Meanwhile, we congratulate him on being the inventor not only of parallel distribution but of the voltmeter.

We publish this week a Paper by Prof. Kimball on Electromagnetic Radiation, which briefly summarises the modern theory of electric action. Although very little will be found in it which has not already been stated, the simple manner in which

Digitized by Google

most of the new notions have been explained will form a welcome addition to the literature of the subject. Perhaps the most obvious tendency of recent electrical work is to bring out clearly the function of the wire conveying the current. The old notion was that the energy was in some way carried along the wire with the current, and the heating of the conductor was vaguely supposed to be due to frictional loss occurring in the passage. The view now held is, however, that the function of the wire is merely directive. The energy of the current exists in the air, or medium outside the wire, and is located in the magnetic whirls represented by the lines of force. Energy can only be transmitted when variations take place in these lines, and these variations are controlled by the current flowing in the surrounding wire. The manner in which the energy flows through the air has been studied more especially by Prof. POYNTING, whose views have, however, been subjected to a guarded criticism by Prof. HERTZ.

IT is an easy matter to see that the transmission of energy by electricity is strikingly different from the commoner methods. Whenever power is transmitted by ordinary means, material of great mechanical is necessary either as the active agent as in shafting, or as a means of constraint as in the steam engine, or as in transmission of power by compressed air. With electricity, however, two thin wires carrying 10 amperes at a pressure of a little over 2,000 volts will transmit 30 horse-power, although the carrying wires may be not only flexible but mechanically very weak. The strength of the leads has, indeed, no influence on the process. The energy flows through the air from the dynamo to the motor or lamps, and the current in the wires merely controls the flow which occurs. The actual mechanism involved in the process is as much a mystery as that causing gravitational attraction, though a general idea as to how a conductor can direct the flow of energy without being traversed by it, may be found on page 199 of Dr. OLIVER LODGE'S "Modern Views."

THE tests of the Willans engine and dynamo, which will be found in another column, significantly show how a dynamo excels a steam engine in commercial efficiency, not only on full load, but when giving a comparatively small output. Of the theoretical efficiency we need say nothing. There seems to be but little hope that any steam engine will ever give one-eighth of the energy which is contained in the coal, while it is a poor dynamo indeed that will not yield back seven-eighths of the energy imparted to its shaft. It is remarkable that the efficiency of a good dynamo remains high even at one-quarter load, and we have calculated the one-eighth, one-sixteenth, and one thirty-second loads for the purpose of drawing the curves. With a good indicator and careful observers the system employed is one which commends itself to engineers. Scientifically, a transmission dynamometer might give another decimal place; but that is quite unnecessary for the present purpose, and whatever may be the merits of such a method, they lose nearly all their weight when it is remembered that the dynamo in question was tested on its own bedplate and bearings, and coupled to and driven by its own engine.

The reduced price of glow lamps in the United States, which is referred to in our notes, raises several questions of interest, but the deductions which may be made in America are not of equal importance in this country. The practice of including lamp renewals in the charge for the supply of electric light has been seldom attempted with us, but it is a common custom in America. We are offered no guarantee of the duration of a lamp, nor, under the present monopoly, can we demand it. The vague tradition that a lamp should last for 1,000 hours is about as useful and reliable as that which recommends 1,000 amperes to the square inch as a maximum current density for wiring. Experience has shown that both traditions are safe. The one may be further investigated by simple arithmetic, in conjunction with the Board of Trade regulations and Mr. KENELLY'S researches, but the other can be confirmed only by the slow accumulation of records which are rarely kept, and which, when brought to light, too often refer to such phenomena as that which is described in our correspondence columns. A glow lamp will burn out as surely as a wax candle, but with the disadvantage that we can never tell how much longer it will last. Many other articles, however, an umbrella for example, have as uncertain a span of durability, but if we doubt the quality of one maker we can always try the productions of another. It is not improbable that the flood of cheap lamps, which may be expected when the spell of Cheesborough is broken, at the close of 1892, and that of Edison in November of the following year, will bring the question of durability *versus* cost into prominence.

**Poole.**—Consent has been given to the application made by the Brush Electrical Engineering Company for a Provisional Order.

**City and South London Railway.**—It is stated that the City and South London Railway will be opened to the public on the 26th inst.

**Lecture on Magnetism.**—Prof. J. A. Ewing delivered a lecture last week before the Dundee Naturalists' Society on his molecular theory of induced magnetism.

**Bromley.**—A formal resolution was passed at the last meeting of the Local Board empowering the clerk to take the necessary steps for obtaining a Provisional Order.

**Telegraph Line from Bombay to Calcutta.**—The new through telegraph line from Bombay to Calcutta, *viâ* the Bengal-Nagpore Railway, is expected to be opened on April 1st next.

**Appointment.**—The Secretary of State for India has appointed Mr. Arthur W. Thomson, C.E., B.Sc., of the Glasgow and West of Scotland Technical College, to be Professor of Mechanism and Applied Science in the College of Science, Poona.

**Electrical Trades Union.**—Members of the above union are specially requested to attend the fortnightly meeting on Saturday, November 15th, as business of great importance will be discussed, including Report of Delegate to London Trade Council.

**Trient.**—The Municipals central station at Trient is now in full work. This station possesses interest owing to the conductors being laid on the five-wire system, and also from the fact that the dynamos are on the same shafts as the turbines that drive them.

**The German Telegraph Department.** — The German Postmaster-General, Herr Stephan, issued last week a general order for facilitating the rapid despatch by telegraph of the Speech from the Throne, delivered on Wednesday at the opening of the Prussian Diet. The number of telegraph clerks at the chief office was doubled on that occasion.

Digitized by Google

**Commercial Cable Company.**—The Commercial Cable Company has opened a branch office at No. 4, Charing-cross, S.W. (opposite the Grand Hotel), and by means of this new office the West End of London is now in direct communication with the United States and Canada, &c.

**Anglo-American Telegraph Company.**—This Company has opened an office for the reception and delivery of telegrams at No. 2, Northumberland-avenue, Charing Cross, thus placing the West-end of London in direct telegraphic communication with New York, Canada, West Indies, &c.

**The Series System of Electric Traction.**—Early in April of the present year a large contract (100 cars) was obtained by the Short Electric Railway Company, at Rochester, N.Y. This Company has now made a successful start, though it is not mentioned whether the series method of working has been adhered to.

**Electricity and Gas in the United States.** — More than 300 gas companies are now operating electric lights in connection with their gas works, and supplying current to 32,000 arcs and 140,000 incandescents. In one year—from March, 1889, to 1890—the gas companies increased their ownership in electric lights to the extent of almost fifty per cent.

**Southend.**—The following resolution was carried unanimously at the last meeting of the Local Board:—"That the Local Board do forthwith make application to the Board of Trade for a Provisional Order authorising the board to supply electricity for public and private purposes within and throughout the whole or any part of the district of the Local Board."

**Electric Ploughing.**—An installation for the purpose of ploughing the land by electric motors has, says *Industries*, been set up in Spain on property belonging to the Marquis de la Laguna. The power of a water-wheel of some 20 horse-power will be employed, and the implement for working the land is expected to work at a distance of three miles from the generating dynamo.

**Woking.**—The Woking installation has been completed, and on Tuesday night the light was supplied for the first time to private consumers. The plant consists of two multitubular boilers of 100 horse-power each and two high-speed triple expansion engines, each driving a dynamo capable of supplying 2,000 eight candle-power incandescent lamps. The price charged is 8d. per unit.

**Proposed International Exhibition in Canada.**—A movement is on foot with a view to holding an International Exhibition in Canada during 1892, to celebrate the centenary of the opening of the first Canadian Parliament, the jubilee of the granting of responsible government to the colony, and the twenty-fifth anniversary of the establishment of the confederation of the Canadian provinces.

**Societe des Metaux.**—The official report made by M. Levasseur, liquidator of the Société des Métaux, shows that, notwithstanding the rise in copper, the liquidation will be of a disastrous character, the shareholders not receiving anything, and the holders of debentures and mortgages and other creditors only 34 per cent. of the amounts due to them. The final indebtedness is estimated at about 111,000,000fr., and the assets at 38,000,000fr.

**The Laying of the First Atlantic Cable.**—A drawing giving the longitudinal sections of the old "Agamemnon" and of the United States frigate "Niagara," the steamers engaged in laying the first (1858) Atlantic cable, has just been published by Mr. F. C. Webb, of 27, Forest-road, Dalston, N.E. The situations of the various cable-tanks in the two vessels are clearly shown, together with the length of cable in each. The drawing should be of great historic interest to submarine cable men.

**The Encouragement of Science.**—Mr. Frank McClean, of Rusthall House, Tunbridge Wells, has offered £12,000 to Cambridge University for the purpose of founding three Isaac Newton studentships for the encouragement of the study of astronomy and physical optics; one studentship to be filled annually, and to be tenable for three years. The offer is in reply to the Vice-Chancellor's invitation for outside assistance, contained in his address to the Senate on the first day of the October term.

**The French Post-Office.**—The French Chamber of Deputies has adopted a proposal brought forward by M. de Lannessan to the effect that each year one-twentieth of the receipts of the previous year but one of the Administration des Postes et Télégraphs should be devoted to the augmentation of the sums granted to that department, the money being applied to the improvement of the *personnel* and apparatus. Under this scheme the 1891 vote will be increased by one-twentieth of the 1889 receipts.

**Leamington.**—At a recent meeting of the Watch Committee of the Leamington Corporation, a letter was read from Messrs. Chamberlain and Hookham, contractors for the supply of electric light to the borough. Messrs. Chamberlain and Hookham demanded 5 per cent. on the unpaid account, and gave the Corporation six months' notice to terminate the contract. They disputed the accuracy of the surveyor's photometric tests, and added that they intended to apply for a Provisional Order to light the town. At a subsequent meeting of the Town Council the Watch Committee reported on this correspondence, which they advised should be left in the hands of the clerk. The report was adopted.

**The Civilian Electrician in Modern War.**—In a Paper recently read before the New York Electrical Society, Lieut. Bradley A. Fiske, of the United States Navy, takes for his text the fact that the regular naval and military forces of the United States would, in the event of war, be utterly unable to cope with all the electrical work that would be thrown upon them; and he proposes that a corps of military and naval electricians should be raised at each great electrical centre to assist the regular army and navy. The Americans have always encouraged and made great use of "irregular" corps, and doubtless Lieut. Fiske's idea will be speedily acted on, and the corps so formed should be able to afford much assistance to the authorities.

**Halle (Saxony).**—The horse tramway has been transformed into an electric tramway on the Sprague system by the Allgemeine Elektricitats Gesellschaft. The line, which is single, is four miles in length. Eventually twenty-five cars will be placed on the line, but at present only eight are in use. In the wide streets the conductor is carried on standards 18½ft. high, arranged close to the kerb, but in narrow thoroughfares it is supported on insulators attached to wires arranged transversely, the wires being fixed on insulators to the walls of the houses. Each car carries twenty-two passengers, and has two 15 horse-power motors. The line comprises several gradients, and the high maximum speed of 25 miles an hour is allowed.

**The Society of Arts.**—The first meeting of the one hundred and thirty-seventh session of this society will be held on Wednesday, November 19th, when the opening address will be delivered by the Attorney-General, Chairman of the Council. The following are some of the Papers which have been arranged for:—Ordinary meetings—December 10th, F. Bailey, "Electric Lighting Progress in London." Papers for which no dates have as yet been fixed:—"The Use of Petroleum in Prime Motors," by William Robinson; "Electricity in relation to the Human Body," by H. Newman Lawrence and Arthur Harries, M.D. Cantor Lectures—Gisbert Kapp, "The Electric Transmission of Power," February 16th, 23rd, and March 2nd.

**The Winston-Salem (N.C.) Electric Light and Power Station.**—An interesting instance of a combined power and light station is to be found at Winston-Salem (N.C.), where a local company has in operation an incandescent plant, consisting of four 400 light Edison dynamos; an arc light plant, consisting of two 50 light Brush arc machines; and a railway plant of two 50,000 watt Edison generators. The street railway has five miles of track, and there are seven passenger cars and four freight cars running. There are 38 tobacco factories and warehouses in the town, which ship 15,000,000lb. of tobacco every year. The roads have been very bad in this neighbourhood, and the grades very steep; hence the Company expect to do a profitable business in freight handling.

**Institution of Electrical Engineers.**—Among those who have accepted the invitation of the President and Council to the annual dinner of this Institution on the 20th inst. are the

Digitized by Google

Postmaster-General, the Attorney-General, the Presidents of the Royal Society, the Chemical Society, and the Institution of Mechanical Engineers, and the Vice-Presidents of the Institution of Civil Engineers, Sir Arthur Blackwood, the Astronomer-Royal, and Dr. Coleman Sellers, one of the members of the International Niagara Commission.—*President's Soirée:* We understand that in anticipation of the large numbers who are expected to respond to the invitation of the President and Mrs. Hopkinson on the evening of the 19th inst., the Prince's Hall has been engaged in addition to the Galleries of the Royal Institute of Painters in Water-colours.

**Copper.**—Subjoined are the Customs imports and exports of copper for the past ten months, and the figures for the same period of 1889:—

| | 1890. Tons. | 1889. Tons. |
|---|---|---|
| Copper in Pyrites | 1,097 | 1,115 |
| „ Ore | 1,606 | 1,624 |
| „ Regulus | 1,734 | 3,122 |
| „ Precipitate | 2,228 | 4,220 |
| | 6,665 | 10,081 |
| Foreign raw copper | 5,315 | 2,782 |
| Imports, October | 11,980 | 12,863 |
| Exports, October | 7,971 | 8,534 |
| Imports, January 1st to October 31st | 116,871 | 120,525 |
| Exports, January 1st to October 31st | 74,818 | 56,663 |

**Telegraphic Communication with Paraguay.**—The British Minister to the Argentine Republic and Paraguay states that since visiting the latter country in 1886 he notices a very considerable advance in the progress of the country in every way. Still, he adds, "that a want very largely felt at Asuncion is regular telegraphic communication with Monte Video or Buenos Ayres, and so with the world in general. At present (August, 1890), as in 1886, the telegraph line stops on the frontier of the Argentine province of Corrientes, the missing link between which and the line in Paraguay being furnished by a person of apparently somewhat lethargic habit, whose movements on the Parana in a canoe seem rather to depend on the rule of avoirdupois, as applied to the bundle of telegrams whereof he is bearer, than to the urgency or value of the messages themselves. Doubtless, however, an improvement will be apparent in this direction ere long.

**The Professorship of Mechanics at Cambridge.**—After a long discussion, it was decided yesterday to appoint J. A. Ewing, B.Sc., Professor of Engineering and Geometry at University College, Dundee, as the successor to Prof. Stuart. The appointment of Prof. Ewing, says an evening paper, is only a confirmation of the views which have been expressed by the Workshops Inquiry Syndicate in favour of developing the present material into a really good engineering school. It will be interesting to see whether it is followed by the foundation of an engineering laboratory, which has been declared to be the first necessity. It will be remembered that the plan by which the University bought over the shops from Prof. Stuart, and shared the management with him, had not worked satisfactorily, and it has been already decided that complete power is to be vested in the new Professor. Before, however, he is required to enter upon the details of management, the ground has been cleared by the decision to give up the secondary object previously attempted of doing work for profit, and everything is to be arranged in the interests of the students.

**The Introduction of Electric Power.**—The *Elektrotechnischer Anzeiger* is evidently no believer in the vision conjured up by Lord Salisbury in his speech at the first annual dinner of the Institution of Electrical Engineers in November last. "The event of the last century," said Lord Salisbury on that occasion, "was the discovery of the steam-engine. Now an agent has been discovered by which the force of the steam-engine, confined to its own centre, can be carried along far away from its original source. I do not despair that this distribution of force may scatter the present unhealthy aggregations of humanity. If it shall ever happen that distribution of power shall be so organised, you will then see men and women able to pursue in their own houses many industries which now require the aggregation of the factory." This idea, according to the journal in question, is quite wrong. Electricity is destined, it asserts, to annihilate small industries. A truce, therefore, to the songs praising electricity as the social panacea. Some such rôle may possibly be its destiny in a far-distant future; but meanwhile the introduction of electric power will only be the signal for a harsh industrial tyranny.

**Lower Prices for Incandescent Lamps.**—In commenting upon the present ruling prices of incandescent lamps in the States, 16 candle-power incandescent lamps now selling at 44 cents, against $1 in 1887, the *Electrical Engineer* of New York points out that this is due in a large measure to the reduced cost of obtaining a good vacuum. "There can be no question," says our contemporary, "that this considerable reduction in the price of incandescent lamps will lead to the manufacture and consumption of an increased number of lamps. It will, without doubt, also be followed by a notable change in the methods of operation of many central stations and perhaps private plants. With the cheaper lamp, it is evident that the life is not as important a factor in the cost of operation as formerly; so that lamps may be run at a higher candle-power and be more economical in the use of current than was desirable in the past. There is, therefore, every reason to believe that the lowering of the price of incandescent lamps will not only give us more of them, but will tend to brighten them, and this again will lead to greater demand for them."

**Electricity and Storms.**—The violent storms which occurred in France in August last, and about which considerable difference of opinion prevails amongst French meteorologists as to the part played by electricity, recalls, says *l'Electricité*, similar occurrences which happened some forty years ago, and which resulted in an interesting legal decision. The valleys of Mouville and Malaunay were visited by a terrific storm, and the spinning mills suffered severely. These were insured against fire and lightning, and the mill owners promptly applied to the insurance offices, who declined to pay on the ground that the damage had been done by the wind. The insurance offices urged in support of their statement a report recently presented to the Académie des Sciences by Pouillet, who asserted that electricity had but little to do with the storm. The mill-owners replied with a Paper read before the same body by Peltier, who attributed a similar storm at Cette to an electrical cause. The question was argued before the Tribunal de Commerce at Rouen, which nominated a committee of experts to investigate the matter. The case occupied the Court 10 days, and some 150 witnesses were examined. In the result the committee, which consisted of Gay-Lussac, Becquerel, Petit, and Lamé, solemnly affirmed that the storm in question was "eminently electrical," and judgment was given against the insurance offices accordingly. The case was carried to the Supreme Court with the same result.

**Porcelain Insulator Fittings for Mines.**—Mr. R. Oliver G. Drummond, electrical engineer to the De Beer's Consolidated Mines, of Kimberley, South Africa, has designed some fittings for use in mines. The switches and fuses are mounted on specially designed bases, insulated from the bolt that secures them to the timber or roof, and fitted with a cover to keep off the dust, &c., and to protect the workmen from shocks. The wires are drawn in from the lower side of the base, and consequently the water cannot run into the switch or the fuse. The lamps are suspended from a holder fitted inside a porcelain insulator, which is of such a shape that it becomes a reflector to the lamp, throwing the light downwards, and the heat of the lamp rising into this insulator keeps it warm and dry, no matter how full of moisture the air is. Any water dripping on to it from the roof runs off the outside of it, so that the lamps and holders are thoroughly insulated; and faults from bad insulation are impossible. When it is necessary to hang lamps in very wet places, the combination fitting is recommended, as the switch and cut-outs are arranged inside the reflector or porcelain insulator, and, as will be seen, the heat of the lamp is utilised to keep the insulation of these fittings good. This fitting has

Digitized by Google

many advantages in rock tunnels, or places where it is necessary to suspend the wires from the roof by insulators, and where there is no timber to which to attach the wires, lamps, cut-outs, or switches, and consequently holes have to be bored in the rock. These fittings are being supplied by the Electrical Engineering Corporation.

**Dynamo Telegraph Plants.**—The U.S. Postal Telegraph-Cable Company have recently had a very complete dynamo plant installed at their Boston office in Devonshire-street. The plant consists of eight dynamos and two motors of the Westinghouse direct current type. The total current capacity of the eight dynamos is 26 amperes, and they are so arranged as to provide for four different voltages, viz. : 40, 90, 130 and 375 volts. Seven machines are in constant use, while one is kept in reserve. The current from these dynamos is used to operate all of the Company's local, city, main, duplex and quadruplex circuits, including repeaters. Not a single cell has been left in the establishment. The number of cells replaced by this plant is 4,000. Power to drive the dynamos is furnished by the two Westinghouse direct current motors, which have a capacity of 10 horse-power each. The motors are supplied with current from the underground system of the Edison Company, connection being made with two of that company's Boston central stations so that any serious accident at either one of these would not result in a failure of the supply of current. One motor is sufficient to furnish all the necessary power. The current on the various circuits is regulated by 500 resistance coils. The Postal Telegraph Cable Company, says the *Electrical World*, is well established in Boston, having 20 branch offices in the most important business centres of the city, all in a flourishing condition. The system of the Company now reaches all but six States and Territories of the country and covers the larger part of Canada. About 1,500 offices and 90,000 miles of telegraph line are now in daily operation for the transaction of the Company's business.

**Electric Transmission of Power at Calais.**—For the past three months the Northern Railway Company of France has had in operation at Calais an electric light installation which possesses some peculiar features. At Calais three stations require lighting, namely, the town station, the harbour station, and the goods depôt. The generating plant is situated close to the town station, but is several kilometres distant from the harbour station and goods depôt. The plant consists of two 150 horse-power Chaligny engines, four 13 kilowatt (65 volts × 200 amperes) compound-wound dynamos, and four series wound dynamos, having a maximum output of 27 amperes and 1,200 volts (32·4 kilowatts). At the harbour station there are two series-wound motors, which drive two low-tension dynamos through shafting. At the goods depôt there is one series-wound motor, which drives two low-tension dynamos. The electric transmission of power is carried out on Brown of Oerlikon's principle; that is to say, a series-wound motor is driven by a series-wound generator at an almost constant speed, which is nearly, but not quite, equal to that of the generator. The electrical plant was constructed by the firm of Bréguet, and at each lighting centre a battery of accumulators is provided as a stand-bye, and to supply current during the hours of light load. The efficiency of this arrangement is, of course, considerably lower than would be the case if the lighting were carried out on the alternate-current tranformer system. The two motors at the harbour station, have at ¾ load, an efficiency of 55 per cent., and at full load an efficiency of about 60 per cent. Taking the commercial efficiency of the generators to be 85 per cent., the commercial efficiency of the whole arrangement at ¾ load is about 44 per cent.

**Electric Street Railways at Minneapolis and St. Paul.**—The St. Paul and Minneapolis electric street railway systems may be considered, says the *Western Electrician*, as one, as a car from any point in either city may reach any point in the other city by a continuous unbroken trip under a trolley wire. In the Minneapolis station the generating plant has a capacity of 3,000 horse-power. Oil is used as fuel. When complete there will be 15 150 kilowatt Edison compound dynamos. Two 15-horse power Sprague motors are used on each car. The novelty of this particular system lies in the fact that there is not a wire in sight except the overhead trolley wire. The feeders, mains, and track feeders are contained in a conduit underground. The conduit is located between the tracks, and is built as follows: Two-inch plank, first treated with fernoline, is used for constructing a long trough, a number of paper tubes, of the Interior Conduit Company's make, are laid in the box, and thoroughly joined together in continuous lengths. The tubes are raised a short distance from the bottom of the trough by cross-pieces. When the conduit has been completed bare copper wires are drawn in, and the trough filled with an insulating compound. The top of 2-inch pine is then nailed on. The upper surface of the trough is 8 inches below the paving stones. The manholes are 400 feet apart. A continuous unbroken main, except for fuses, is laid throughout the entire system. Numerous feeders join it at intervals, and equalise the pressure. Iron poles between the tracks are used entirely, and sub-feeders come out of the conduit from the main up through the hollow iron poles, and are connected to the trolley wires through fuse wires at every manhole. When the Minneapolis system is equipped it will include more than one hundred and forty miles of track, and two hundred electric cars will be in operation. There are now about forty cars in operation, and about one-fourth of the road has been completed. The St. Paul system will differ from that of Minneapolis in two very important features. A combination of underground lead cables and overhead construction will be used, and side poles will be employed instead of centre poles. The generating plant used in St. Paul will have a capacity of 7,000 horse-power. There will be ninety miles of track, and one hundred and forty electric cars in operation.

**Platinum.**—The market value of platinum is at the present moment nearly equal to that of gold, their respective prices being £4 and £4. 3s. Eighteen months ago platinum was to be had for about 30s. an ounce, and six months ago the price was under £3. Apart from the question of a possible "corner," and the ever increasing demand for platinum for electrical purposes, this 166 per cent. rise in price within eighteen months may be attributed in a large measure to the increased cost of production at the mines in the Ural mountains, whence we draw our chief supply of this metal. The owners of these mines, owing to their large yield of gold, were able to sell platinum comparatively cheaply; the gold, however, is now becoming scarce, and hence the platinum, which is still plentiful, can no longer be sold at so low a figure. Platinum, besides being used for the leading in wires of glow lamps, is largely used for electrodes in electro-chemical work, and up to the present no satisfactory substitute for it has been found so far as these applications are concerned. The history of platinum is as interesting as its characteristics are remarkable. During the sixteenth century it was observed that the gold ore from the Darien mines included grains of a whitish metal. This discovery was not made known by the Spanish Government, because they found that it furnished an excellent material for adulterating gold. It was only about the middle of the last century that the metal began to find its way into Europe. The Ural Mountain deposits were discovered about 1823, and they have been worked by the Russian Government since about 1828. Platinum is generally found in small grains, but masses of considerable size have been discovered, thus in 1822 a specimen, which weighed 11,641gr., from Condato, was placed in the Madrid museum Platinum was coined by Russia to the extent of half a million sterling between 1826 and 1864, when the coinage was discontinued. Almost all platinum contains iridium, which greatly increases its hardness and durability without impairing its power of resisting chemical agents. Liebig said that "without platinum crucibles, which share the infusibility of porcelain with the chemical inertness of gold ones, the composition of most metals could not have been ascertained, and chemistry could not have come to its present level." One of its most important uses is for large evaporating stills for the concentration of sulphuric acid. A still of this kind valued at nearly £4,000, exhibited at Vienna in 1873, was capable of concentrating 20,000lb. of sulphuric acid daily. This particular use for platinum has to a large extent been discontinued, and at one time the quantity of platinum thus set free caused a decline in its market value.

Digitized by Google

## AN IDEAL PHYSICAL LABORATORY FOR A COLLEGE.

BY PROF. OLIVER LODGE.

Sir W. Thomson has laid down the rule, and it is obviously an excellent one, that when one sets to work to design anything, be it a bit of apparatus or anything else, the right plan is first to contemplate ideal conditions and arrange the most perfect thing that can be devised, without regard to practical limitations and hindrances, and subsequently to modify the design so as to comply with these practical considerations.

Anyone designing a college laboratory is usually hampered by a multiplicity of local and other circumstances, of which scantiness of site and scarcity of coin are commonly chief. But in Utopia no such limitations exist, and hence in an ideal laboratory they are to be ignored.

What, then, are the requirements of a physical department, such as now exists at many of our chief Universities and Colleges? The following at least: a students' laboratory, a research laboratory, a lecture theatre, a workshop, and an apparatus store. To these, nowadays, it is becoming necessary to add an electrotechnical department. Private rooms for professors and demonstrators are also desirable.

The students' laboratory subdivides into senior and junior portions; the lecture theatre requires an annexe or preparation room; the apparatus store may develop into a museum on the one hand, and a common store-room on the other; the workshop requires power which is conveniently shared with the electrotechnical department; and a desk-room, or drawing office for diagram making, note writing, and book reference, is another desirable appendage.

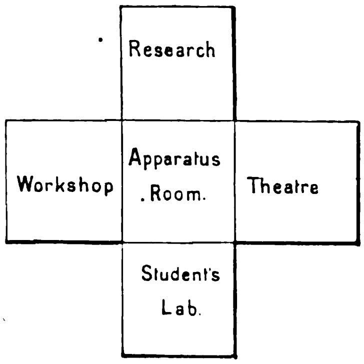



FIG 1.

South or north light at pleasure is useful in the research laboratory, and it will be as well to keep vibrating machinery as far from it and from the lecture theatre as convenient.

An underground basement for researches demanding constant temperature may also occasionally be useful. Absence of magnetic materials is a troublesome fad which can seldom be really carried out, and which it is simplest to ignore altogether. Nowhere, except in a terrestrial magnetic observatory, is it of any real consequence, nor is it feasible to consistently maintain it anywhere else under the stress of actual miscellaneous work.

A rock foundation away from rail and road traffic is an obvious desideratum. The securing of steadiness is a very real advantage, and makes many experiments easy which else would involve either special and troublesome devices or much night-work.

The carrying of apparatus up and down stairs is undesirable, and long staircases greatly add to the labour of supervision. Hence as much ground floor accommodation as possible is desirable; the rock not to be excavated by cellarage except in the one place where the uniform temperature basement is constructed. The rock should be levelled up and boarded over in such a way that when wished a semi-permanent masonry structure can be erected on it in any convenient place. Whether the joists that support the flooring could be bedded in indiarubber sockets, so as to prevent walking about jarring the rock, I don't yet know.

Side lights are best; low side lights for some, high side lights for most. The lighting should be thoroughly under control, but should always be potentially abundant, especially in dingy climates.

Furthermore, in the arrangement of the rooms, the principle made use of by Mr. Lewis Carroll in one of his numerical tales concerning the best position for the common eating-room of a definitely scattered family, is applicable also here, viz., that each room should be accessible to those others with which it has most immediate affinity by the smallest amount of walking.

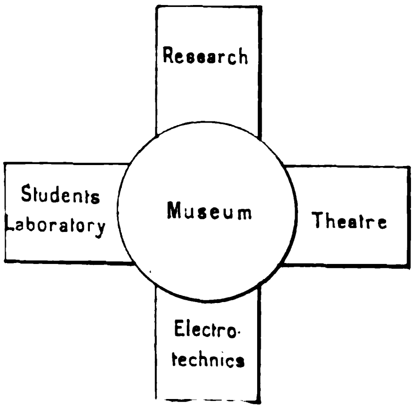



FIG. 2.

Applying these considerations, we get as the crudest possible design that shown in Fig. 1.

Below the apparatus room is, perhaps, the best place for the basement cavity. The workshop is unnecessarily large, and may include electrotechnics, especially as it may be two or more stories high. The students' laboratory will also be two stories, the upper one for junior students the lower for senior. It may be better to interchange the position of theatre and research laboratory if too much vibration is felt from machinery.

The theatre has no upper floor except a good experimental gallery, which is very useful. The apparatus-room must be lighted from above, and may have a gallery round it to permit free communication everywhere on the upper floor.

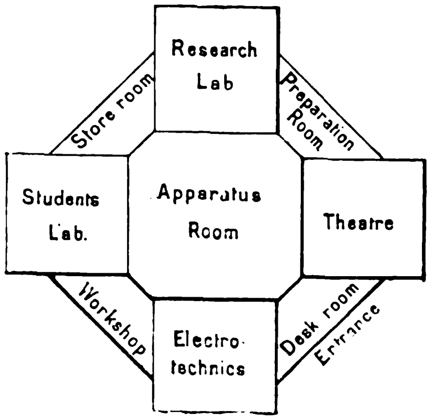



FIG. 3.

A lofty tower, open all the way down, with a spiral staircase like a shot-tower, is advantageous; and it may be a central feature, the base of it resting on columns and arches at the middle of the museum-room.

If some side light is desirable in the central room, it may be secured by such a modification as Fig. 2.

Minor details are not here entered into, such as the position of the preparation-room, the dark-room, store-room, and so on; but it is quite feasible in this last scheme to light the central chamber in a clere-story fashion, and to build four single-story chambers outside, one in each angle; especially since the lighting of the four wing rooms is in excess of requirements.

This brings us to the scheme of Fig. 3, and I incline to think that, in its broad features, this is a good design. Here the

Digitized by Google

store-room is readily accessible from the research department and from the ground floor (or senior students') laboratory. The preparation room is handy for the lecture assistant, who commonly (at least in my experience) assists the professor also in research. The workshop is near the power department, and is also near the students, over whom the mechanic in charge can exercise some supervision, and to whom he can give some assistance. The desk room is a quiet place, inoffensive to the theatre, and may also be, as regards diagrams, a kind of supplementary preparation room. If desirable to make the workshop less accessible to students, the two latter places may be interchanged. Absolute size is a matter of detail; but 40 feet square for each of the four wing blocks, and 60 feet across for the central octagon, strike me as suitable dimensions.

No details of internal arrangement, such as position of private rooms, and subdivision of the main blocks, are here entered into. So far, nothing but the relative positions of the blocks themselves is under consideration, and, before going further, I would ask the favour of criticisms; for the matter seems one of fairly general interest. In so far as it specially concerns me, it concerns me only as an affair of the future, not of the immediate present.

*(To be continued.)*

## ELECTRO-MAGNETIC RADIATION.[1]

BY PROF. A. L. KIMBALL, PH.D.

It is an interesting fact that the old notion that electricity is a substance, one of the so-called class of imponderables held by the earlier investigators of electrical phenomena, after being generally supposed to be dead and buried, should be resurrected and in a dress to suit the times should become a part of the orthodox scientific creed of to-day. Yet this is the case. The discovery that heat, instead of being a substance caloric, is the energy of motion of the particles of a body, together with the establishment of the principle of the conservation of energy, led to the idea that perhaps electricity was also in some way a form of energy. It is apparent, however, that this view is untenable, for there is this striking difference between the case of electricity and that of heat, in that a given amount of heat is always equivalent to the same amount of energy whether it is in a hot body or a cold body, whereas the amount of energy which a given quantity of electricity possesses depends entirely on its potential, or voltage.

But in saying that electricity is a substance it is not intended to convey the idea that like ordinary matter it has weight, and is subject to gravitation attraction, or that it excludes ordinary matter from the regions which it fills. It is rather to be conceived as a substance in the same sense as the luminiferous ether is a substance—that is, that it is an entity which is never transformed or changed into anything else, and so is indestructible, and its total amount unchanged. Whether it is subject to gravitation attraction and so has weight is entirely unknown.

The modern theory differs from the older ones, however, in this important respect: that whereas Franklin thought of each particle of the electrical fluid as acting at a distance, repelling every other particle, the modern theory supposes no such repulsive force, and all actions are explained by taking account of the strains in the medium surrounding the charged bodies; for the electric fluid, while pervading all bodies, is not equally free to flow in all. In some, according to this view, the particles of electricity are not free to move, but if forced aside spring back to their original position as soon as the straining force is removed, just as shot would if embedded in a mass of indiarubber. Such bodies are insulators. In others the particles of electricity can be moved from one place to another, just as shot can be moved about in a mass of tar or molasses; a certain amount of resistance is experienced, but when the force is removed there is no tendency for the particles to spring back to their original places. Such bodies are conductors; and one offering great resistance to the electric displacement is a poor conductor, while one offering but little resistance is a good conductor. It is the elastic force with which the displacement of the electricity in insulators is opposed which gives rise to the attractions and repulsions of electrified bodies in insulating media.

The discharge of an electrified body is due to the forcing of electricity out of the body by the pressure of the displaced electricity in the surrounding medium, and not to any inherent repulsion of one particle of electricity for another. Thus, in case of a Leyden jar the electrical strain in the glass between the two coatings, and to some extent in the air around it, is the cause of the discharge, since this strain cannot be relieved without forcing some electricity from one coating round to the other.

It appears, then, that the characteristic distinction between the older and modern theories of electricity is the recognition by the latter of the fundamental importance of the *dielectric* or insulating media. This great step forward was made by Faraday.

As soon as it is clearly perceived that electrical disturbances are communicated from one point to another by means of the intervening dielectric, the question at once arises: are these disturbances communicated instantly or are they propagated with a certain finite velocity? Within the past few years the experiments of Hertz have definitely answered this question, and there is now no doubt but that electric disturbances, like sound and light, advance with a certain definite velocity, which depends on the medium through which they are communicated.

### *Two Kinds of Electrical Energy.*

One way in which electrical energy may be stored up in the medium is illustrated in case of the charged Leyden jar, and the energy of the charge exists as a strain in the insulating medium, and is analogous to the energy of a coiled spring. There is another most important mode in which electrical energy can exist in the medium, and that is as the energy of a magnetic field. No energy has to be expended to keep up a magnetic field. A horse-shoe magnet may retain its magnetism for years, and is certainly not expending energy all the time; but to make a magnet requires a certain expenditure of energy which depends on the number of lines of force set up and on the strength of the magnetising current. While a current is flowing steadily around an electro-magnet it is expending energy, but that energy is merely being dissipated as heat in the conductor; there is no storing up of energy in the medium going on; but when we try to stop the current and make the magnet lose its magnetism, there is a sudden strong rush of electricity, greatly increasing the current. This is called the extra current, or current of self-induction; but it is simply the energy which was stored up as the energy of the magnetic field, which is thus suddenly returned to us as an increase of current. In the same way, on starting a current in an electro-magnet it may be some seconds, in case of a large magnet, before the current reaches its full strength. The reason is obvious; the energy supplied by the battery is being partly expended in setting up this magnetic field, and the current cannot reach its steady state until the magnetism is fully established.

It is believed that this energy exists in the medium in some way as energy of motion or rotation, the axis of the rotating particles being in the direction of the lines of force.

### *The Nature of an Electro-magnetic Wave.*

It has already been noticed that there is experimental proof that the inducing effect of an electric disturbance is propagated with a velocity which, as near as can be determined, is the same as the velocity of light. But it is important to go behind this fact to inquire in what way this disturbance exists in the medium, and what are the elements that determine its velocity. Let us first examine somewhat closely what takes place when a current is induced in a coil by the starting or stopping of a current in an adjoining coil. Let A and B (Fig. 1), represent two parallel coils of wire, and suppose a current is set up in A, then the lines of magnetic force will be somewhat as represented in the diagram, and the number of lines passing through the coil B, together with the resistance of the coil B, determines the amount of the induced current in B. This is the state of things as we ordinarily think of it, and

Digitized by Google

is true enough after the induced current has died out, and everything has come to a steady state; but when the current *begins* to flow in A the lines of force or magnetic whirls in the medium are first set up close around the coil A and spread outwards till they come to their final state, more and more being sent out from the coil till the field is fully established. Now the effect upon the coil B is produced in some way by the medium at the point where it is placed, as we have abandoned the idea of the coil A acting at a distance upon the coil B. The induced current is then set up in B by the action of the magnetic whirls in the medium cutting across the coil B as they spread out from the coil A. Of course, all these whirls that finally go through B must cut across that coil, and since each causes a certain amount of inducing action the total induced current must depend on the number of lines of force that finally thread through the coil B.

Now, an induced current always opposes the change in the magnetic field which brings it about. In the case under consideration the induced current is in such a direction as to oppose the cutting across the coil by the lines of force, and it is only when the induced current has died out, owing to the resistance of the coil B, that the lines of force come to their final state. But now suppose B is not a conductor at all, but an insulator, just like any other part of the surrounding medium, the inducing action due to the magnetic whirls cutting across B is just the same as if it were a conductor; the difference is that in case of the insulator the electricity cannot flow, but can merely be displaced a little, and springs back as soon as the displacing face is removed. This action must, therefore, go on in every part of the medium through which

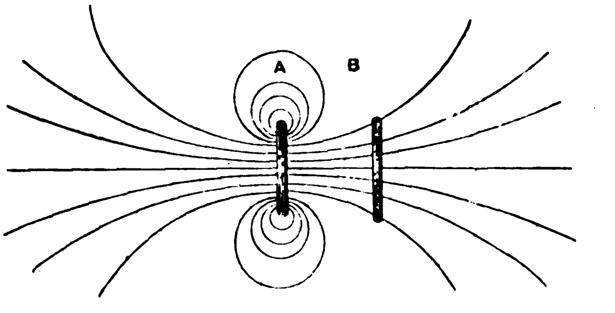



FIG. 1.

lines of force pass, or, in other words, in which magnetic whirls are set up. On starting the current, as the magnetic lines of force spread out in the medium, or as the magnetic rotation is communicated to more and more distant parts of the dielectric, at every point the starting of the magnetic rotation produces a displacement of the electricity, and this elastic resistance to displacement enables the motion to be communicated to more distant parts. The following analogy will make this clear: Let A, B, and C (Fig. 2) be three wheels geared together, and capable of rotating without friction. A and C are to represent two magnetic whirls, while B is a particle of electricity held in position by the springs on each side, which represent the elastic action of the insulating medium in urging the electricity back to its position when displaced. It requires energy to set up a magnetic field, as we have already seen. The energy is that of motion, and the analogy is to the energy of a rotating wheel. The wheels A and C, at least, must therefore be thought of as having a certain inertia, and when set in rotation their energy of motion represents the energy of the magnetic whirls.

Starting with the system at rest, suppose A to be set in rotation, it is easy to see that the inertia of C will cause the rotation of A to displace B to one side; if the rotation of A is in the direction of the arrow B will be displaced downwards; but the elastic force of the medium resists the displacement of B, and as the motion is gradually given up to C, B will move back and will come to its original position as soon as C is turning as rapidly as A. If the springs holding B in place were very stiff, so that a great force was required to displace B even slightly, the motion would be communicated rapidly from A to C, and if the springs were very weak the motion would be given up much more slowly. We may think of a long row of such gear wheels, every other one being held in place by springs, and it is plain that the length of time which it takes to communicate a disturbance from A to the last one will depend on the stiffness of the springs and the inertia of the wheels. The stiffer the springs are the greater will be the velocity of propagation of the disturbance, and the greater the inertia of the wheels the less will be that velocity.

*How the Velocity of the Wave Depends on the Properties of the Medium.*

The velocity of a wave is always determined by the properties of the medium in which it moves. Newton showed that in such a case as a sound wave the velocity is $v = \sqrt{\frac{e}{d}}$, where $e$ is the elasticity of the medium and $d$ is its density. In case of electro-magnetic waves an exactly similar expression holds, except that instead of ordinary elasticity we must put the elastic resistance which the medium offers to electric displacements, and instead of density we must put the effective *inertie* of the magnetic whirls.

Now the specific inductive capacity of a dielectric is a property which bears a direct relation to the resistance which the medium offers to electric displacement. This is readily seen that the capacity of a Leyden jar is proportional to the specific inductive capacity of the dielectric. But the capacity of a

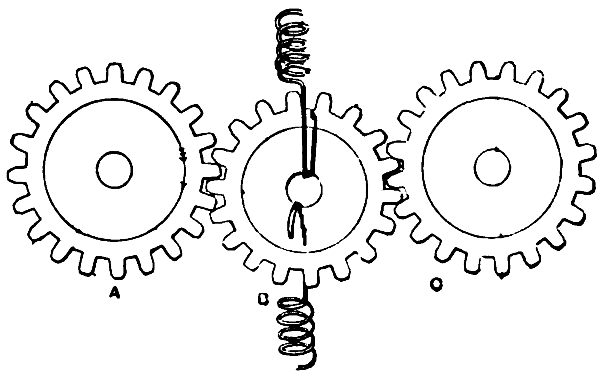



FIG. 2.

Leyden jar is evidently increased by *diminishing* the elastic resistance to displacement, for the less this resistance the greater the quantity of electricity than can be forced into a jar by a given difference in pressure or potential between the two coatings. It may be shown thus, that the specific inductive capacity of a medium is *inversely* proportional to its electrical elasticity, and therefore the greater the specific inductive capacity of the medium the less will be the velocity of the electromagnetic wave, other things being equal.

In a rotating wheel the energy of rotation is determined by the inertia of the wheel and the velocity of rotation. The inertia of the wheel belongs to it and cannot be changed, while the velocity of rotation may be made anything that is desired. In the same way, in determining the energy of a portion of a magnetic field, there is part that depends on the magnetising current and part depends only on the medium. It is this latter part, the *magnetic permeability* of the medium, as it is called, which corresponds to the inertia of the wheel; and it is this quantity which corresponds to density in the expression for the velocity of a wave given above. Thus the greater the magnetic permeability of the medium the less will be the velocity of the electric disturbance.

These two results are embodied in the following expression which was established by Maxwell:—

$$v = \frac{1}{\sqrt{K\mu}},$$

where $v$ is the velocity of the wave, K is the specific inductive capacity of the medium and $\mu$ is its magnetic permeability, all measured in the same system of units.

The value of this quantity has been carefully determined for

Digitized by Google

the case of vacuum where the insulating medium is the luminiferous ether, and is found to be the same as the velocity of light—186,330 miles per second, as nearly as experiment can determine. This is one of many remarkable facts connecting light and electricity.

*When are Electro-magnetic Waves Sent Out ?*

We have examined somewhat closely, in studying the nature of a wave of electrical disturbance, the wave sent out on starting a current, and evidently in a very short time the magnetic field, except at enormous distances from the current, comes to a steady state, and there is no longer anything like a wave. Of course, if we go far enough from the source of the disturbance the wave will be found there advancing with the velocity of light into the regions of space, but the magnetic effect of all disturbances such as we can produce must be vanishingly small, at a distance of a few thousand miles at most. If now the magnetising current is suddenly stopped, it is usual to think and speak of the magnetic field as being wholly done away, the magnetic whirls coming to rest and giving back their energy to the current, thus producing the extra current or current of self-induction. But this is not strictly true. Only a part of the energy that was expended in setting up the magnetic field is returned to the circuit in the self-induced current; the rest goes into space as a wave of electrical disturbance. The energy thus given off is sometimes said to be radiated, as a wave of energy is sent off from the electrical system just as the energy is radiated or sent off in waves from a hot body.

It is to be noticed, however, that there is no radiation or giving out of electrical waves from a steady current. The magnetic field around such a current remains constant, and energy is neither given up to it nor by it. It is only when changes occur in the magnetic field that the waves are set up. When a current is regularly reversed, as in the case of ordinary alternating currents, an electrical wave is sent out by each complete change, so that if the current is reversed 100 times a second, thus giving 50 complete alternations, there will be 50 waves a second sent out from the system, and since the velocity of propagation of the waves is 186,330 miles per second, the first will have gone that distance by the time the fiftieth is sent out: the waves will therefore each have a wave length of 3,726·6 miles. It is an interesting question whether the amount of energy thus given off is appreciable or not, for if a notable part of the energy of an alternating system is thus radiated by waves out into space it is an important point to be taken into consideration.

The amount of energy that is thus lost depends partly on the wave length and in part on the suddenness with which the current is started and stopped. The more abruptly a current is started and stopped the greater the amount of energy radiated. In all commercial cases of alternating currents, the amount of energy radiated must be inappreciably small, since the wave length of the disturbance is immensely great compared with the distance at which the magnetic field set up has any appreciable strength, and the reversal is not sudden, but very gradual, as the current rises to a positive maximum, and then, sinking to zero, passes to a negative maximum without any sudden or sharp changes in intensity.

When, however, the wave length is short compared with the distance to which the sensible magnetic field extends, a very considerable proportion of the energy expended in setting up the magnetic field will never be returned to the circuit, but will pass out into space in electro-magnetic waves. In order then that a series of energetic electro-magnetic waves may be set up, it is necessary to have an alternating current of considerable intensity, in which the reversals shall take place with such rapidity as to give rise to waves a few feet long.

*How to Obtain Short Electro-Magnetic Waves.*

When the electricity in a conductor is disturbed in any way it does not instantly come to rest, but surges to and fro, gradually coming to rest, just as when a tub of water is tilted the water oscillates from one side to the other, the motion dying out only gradually. The time it takes the water to surge backward and forward in a tub is perfectly definite, and depends on the shape and size of the vessel and the depth of the water. Just so in all conductors: when the electricity is disturbed it oscillates in a perfectly definite period, which depends on the shape and size of the conductor and the medium in which it is placed.

It will be found useful to compare the vibrations of the electricity on a conductor with the vibrations which a spring makes when set oscillating in a vessel of some viscous fluid, such as molasses. The spring rapidly comes to rest under these circumstances for two reasons—first, the resistance of the fluid causes some of the energy to be lost in heat; and secondly, part of the energy is sent out in waves in the fluid. As soon as all the original stock of energy is expended in this way the spring is at rest. So in a conductor the energy of the electrical oscillation is soon expended, partly in heating the conductor owing to its electrical resistance, and partly in electro-magnetic waves which are sent out into the surrounding medium.

In determining the time of vibration of a spring there are two elements that enter, its *stiffness* and its inertia. That is, the stiffness of the spring tends to make it vibrate quickly, while its mass and the mass of the liquid which it drags with it in oscillating tends to retard the vibration. In the same way, in an electric system, there are two elements which determine the period of vibration, its capacity, and its self-induction. Take the case of the discharge of a Leyden jar. When a jar is discharged the elastic force with which the charging is resisted is greater the *smaller* the capacity of the jar, so that a Leyden jar of small capacity may be compared with a stiff spring, and so the rapidity of the electrical vibration is increased by diminishing the capacity of the jar. In the discharge of the jar, as the electricity rushes from one coating to the other, it constitutes a *current*, and sets up a magnetic field around the conductor through which the discharge takes place; but it takes time to establish a magnetic field just as it takes time to set a heavy wheel rotating, and this constitute a *drag* on the electricity, so to speak, and the greater the number of lines of magnetic force thus set up the slower will be the rush of electricity, so that the greater the self-induction of the circuit in which the discharges take place (the coefficient of self-induction of a circuit being the number of lines of force which unit current will set up when flowing in the given circuit) the longer will be the time of oscillation of the discharge.

An exact mathematical discussion shows that the time of vibration of an electrical charge in a conductor when the resistance is so small that it may be neglected is

$$T = 2\pi\sqrt{CL}$$

where C is the capacity of the system and L its coefficient of self-induction.

*(To be continued.)*

**The Imitation of Solar Phenomena by Means of the Electric Discharge.**—In a recent communication to the Académie des Sciences M. Ch. V. Zenger states that observations of the effects produced by the Wimhurst machine on smoked glass plates led him to experiment with a view of obtaining an electrically produced imitation of various well-known solar phenomena. A large sheet of glass well dried on one face and covered with lamp-black on the other was placed between the terminals of a Wimshurst machine. The + pole was brought very close to the blackened surface, in the centre of which there was a circular tin disc. The − pole was from 10 to 20 cm. distant from the other side. Sparkless discharges disturbed the blackened surface, and a representation of the lines of electric force was drawn upon the glass. The result was a striking reproduction of a total eclipse of the sun, the metallic disc representing the moon. The lines of force produce around the edge of this disc all the chromospheric phenomena witnessed during a solar eclipse, such as eruptive, linguiform and auroral protuberances. If the experiment is carried out in a dark room red flames may be seen coming from the edge of the disc, which exactly resemble in form and colour those visible during a solar eclipse. Blackened glass balls submitted to the Wimshurst discharge exhibit white spots, the photographic negatives of which are precisely similar to those of sunspots.

Digitized by Google

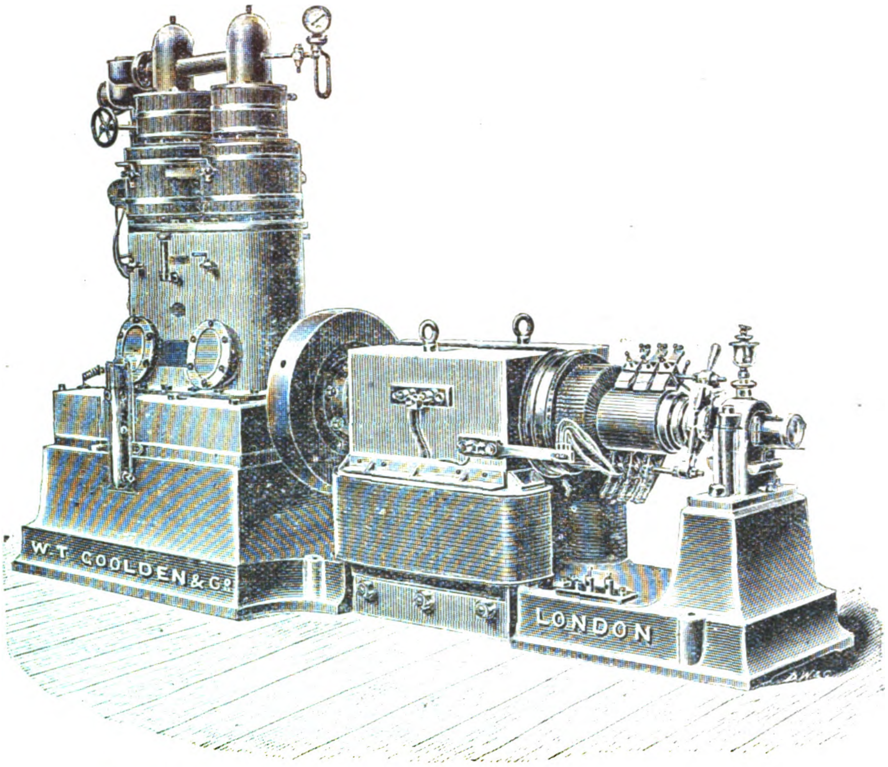
## TESTS OF A GOOLDEN-WILLANS COMBINATION.

Messrs. W. T. Goolden & Co. have recently made a series of tests of a 45-kilowatt dynamo, at their works in Woodfield Road, under exceptionally interesting circumstances. The Willans engine, which was destined to drive the machine, was delivered to the dynamo makers, instead of the more usual reversed custom, and, being ready for running, the tests were made during the building of the dynamo, thus enabling measurements of the various losses to be made as the different portions were put together. We are not aware that any such tests have been previously made, and, at all events, none have hitherto been published in such detail. The tests were made under several disadvantages; the engine and dynamo were quite new, and hence the mechanical efficiency, though high, is not as high as has been actually shown by later measurements, when the combination had been running a short time, and the journals had taken a *fair* bearing. The loss in the core was also probably augmented to no small extent, by the fact that this dynamo was originally designed for 105 volts, but the field excitation was raised to give 125 volts at the original speed, the induction being thus somewhat wastefully increased, and the leakage through the shaft and spider causing eddy currents and loss, being intensified.

The dynamo is one of a number which are being made for the station at St. John's Wharf, of the Westminster Electric Supply Corporation, whose stations were described in a recent issue. The arrangement of the dynamo differs from the well-known Willans combination bed plate, which is so largely adopted by the Admiralty, in the substitution of the well-known *overtype* pattern of dynamos for the *undertype*. Messrs. Goolden's reason for this is, that they consider that for dynamos up to, say 50 kilowatts, the greater accessibility of the brushes and ready removal of the armature, more than compensate for any advantage to be gained by keeping the shaft lower.

The dynamo itself has wrought-iron field-magnets, bored to receive the armature. The lower pole horn is of cast-iron, an arrangement suggested by Mr. Essen in his Paper to the Institution of Electrical Engineers last year, but previously in use by Messrs. Goolden and Co. The objection usually raised to overtype dynamos, that of the extra pull downwards, is met by an increased clearance being given on the lower side, so that the pressure on the outer bearing, which, when the dynamo is unexcited, amounts to 9 cwt., diminishes to 8½ cwt. when the magnets are excited. The outer end bearing is mounted in a spherical bed or seating, so as to automatically line itself in the event of the unequal wearing of the different bearings causing any twist to be thrown on the shaft.

The armature is a bar armature, the bars being laminated. The ends are Messrs. Goolden's "solid built," that is, they are composed of radial V-shaped strips, built up and insulated with mica after the manner of a commutator, thus presenting a completely solid end and preventing the ingress of dirt or wet. The field-magnet coils have internal ventilating space and outlets for the air. It will be noticed that all the electrical and mechanical sources of loss, except that in the armature coils, have been taken as constant at different loads. This is not theoretically correct, but the assumption is well within the limits of experimental error. The friction on the journals of the engine no doubt increases with a heavier pressure, but the principal friction is that of the pistons and valves, and this is constant. The friction of the shaft probably decreases slightly, and the eddy currents in the core are diminished, at heavy loads, by the demagnetising effects of the armature current. The dynamo was designed, and the tests were carried out by Mr. H. W. Ravenshaw.



Goolden-Willans Combination.—45 kilowatts at 440 revolutions per minute.

The electrical data are as follows:—Volts, 120; amperes, 375; watts, 45,000; speed, 440; armature resistance, ·013; resistance of field-magnet coils, 21·4 ohms.

INDICATOR TESTS OF GOOLDEN-WILLANS COMBINATION.

1. The engine was run with the armature disconnected, and found to absorb 8·43 indicated horse-power when running light at 430 revolutions.

2. The armature shaft and core were put in place, no windings being on, and running with the fields unexcited, 9·92 indicated horse-power was recorded; equivalent to 1·49 indicated horse-power for the shaft. (It is to be noted that this is excessive as the bearing at the time was running hot.)

3. The core only being in, the fields were excited, and 11·56 indicated horse-power recorded, the loss in the core being thus 1·64 indicated horse-power.

4. The armature was wound, and another test made, first unexcited, then excited, and deducting the value for the losses

*Commercial Efficiency of Dynamo and Steam Dynamo.*

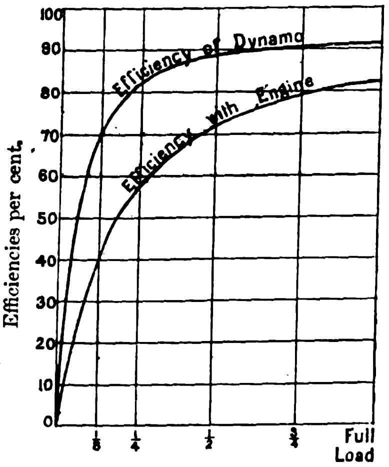
| | Indicated Horse-Power Reduced to Watts. | | | | | | | | | | Output in Watts. | | | Efficiency. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Proportion of Full Load. | Loss in Engine. | Loss in Shaft. | Loss in Core. | Loss in Bars Eddy Current. | Loss in Armature ($c^2 r$). | Loss in Magnet Coils. | Total Loss in Dynamos. | Total Loss in Dynamo and Engine. | Dynamo Losses per Cent. of I.H.P. | Total Losses per Cent. of I.H.P. | Volts. | Amperes. | Watts. | Commercial Efficiency of Dynamo. | Commercial Efficiency of Combination. |
| 1 | 6,300 | 290 | 1,220 | 254 | 1,820 | 660 | 4,244 | 10,544 | 7·64 | 19·0 | 120 | 375 | 45,000 | 91·2 | 81 |
| $\frac{1}{2}$ | 6,300 | 290 | 1,220 | 254 | 520 | 660 | 2,944 | 9,244 | 8·85 | 27·8 | 120 | 200 | 24,000 | 89·1 | 72·2 |
| $\frac{1}{4}$ | 6,300 | 290 | 1,220 | 254 | 130 | 660 | 2,554 | 8,854 | 12·45 | 42·5 | 120 | 100 | 12,000 | 82·5 | 57·5 |
| $\frac{1}{8}$ | 6,300 | 290 | 1,220 | 254 | 32·5 | 660 | 2,456·5 | 8,756 | 16·60 | 59·4 | 120 | 50 | 6,000 | 71 | 40·6 |
| $\frac{1}{16}$ | 6,300 | 290 | 1,220 | 254 | 8 | 660 | 2,432 | 8,732 | 20·70 | 74·4 | 120 | 25 | 3,000 | 55·3 | 25·6 |
| 0 | 6,300 | 290 | 1,220 | 254 | 0 | 660 | 2,424 | 8,724 | ∞ | ∞ | 120 | 0 | 0 | 0 | 0 |

These calculations accord well with direct indicator tests. The dynamo giving 43,400 watts, the efficiency as indicated was 80·4 per cent.; and, when giving 26,500 watts, the efficiency was 72 per cent.

in engine, shaft, and the core, previously ascertained, the loss in Foucault currents in the bars was found to be ·34 indicated horse-power.

The experience and experiments of Messrs. Willans show that the frictional loss in the engine is nearly independent of the load. Hence from the above figures the efficiency of the steam dynamo can be given for any load, and the commercial efficiency of the dynamo calculated for any output.

The table above shows the results tabulated by Messrs. Goolden and Co., together with additions which we have made from calculations based upon the above data, it being noted that the loss in the shaft friction has been taken at ·39 indicated horse-power. (This value was found to represent an average in later tests, the above value being exceptional owing to the circumstance mentioned; but the individual test being for a difference, this was unimportant.)




Efficiency of Goolden Dynamo and of Willans-Goolden Combination.

Independent tests of these dynamos and engines, at the station supplying current to the Houses of Parliament, have been since made by Prof. A. Kennedy, consulting engineer to the Westminster Electric Corporation, giving even better results than the above, the commercial efficiency in some tests reaching as high as 85 per cent. and 86 per cent., but as further tests are being carried out on the same machines, the results are not yet complete.

**The English and American Patent Offices.**—The report of the Commissioner of the United States Patent Office for the year ending June 30th, 1890, has just been issued. In May last the Comptroller-General's report for 1889 was published. During 1889 21,008 patents were applied for in England, while in the year 1889-90, the number of applications in the United States was 40,201. The total receipts of the English Patent Office in 1889 from all sources were in round numbers £173,000, the expenditure being £79,286, so that there was a surplus of nearly £94,000. The figures for the United States are, total receipts, £250,000; expenditure, £216,000; surplus, £34,000.

## DRUM ARMATURE WINDING.

BY F. M. WEYMOUTH.

(*Continued from page 9.*)

*Introductory.*

Now, an accident that is liable to happen to a dynamo is what is known as a "short-circuit." The current from the machine under ordinary circumstances has open to it a course only through an outer circuit, of lamps and so forth, offering resistance to its progress. If by some mischance, however, such as a wire or piece of metal falling across the positive and negative terminals of the switchboard, connecting them electrically, a much easier way of getting from the one terminal to the other will be open to the current, instead of its having to go through all the circuit with the lamps; in other words, the resistance of the outer circuit will be practically eliminated. There will be a rush of current which the armature will not be able to withstand. The armature winding will heat; and may get red hot, and perhaps even melt. The insulation is destroyed, and metallic connections thereby set up which are fatal to the proper action of the machine. The result of a bad short-circuit is, therefore, that the armature is rendered useless, though often only one or two or a few of the sections are burnt, the remainder being uninjured.

Recalling our attention now once more to the wire-wrapped drum armature, from which we may seem to have wandered, it will at once be obvious that with the overlay of the wrapping at the hemispherical ends, to renew a few burnt sections, especially if these should be among the innermost, the whole must be unwound, involving expense and trouble. This is thus one of the principal drawbacks of this form of drum-winding, though not altogether peculiar to it. Another drawback lies in the fact that it is not possible with this form of end winding, and so much crossing of the wires, to prevent the close proximity of wires of high and low potential. Hence especial care is necessary as to insulation. Again, the combined heating of the wires at the ends where lying in such a mass, is not so easy to prevent, or to mitigate by ventilation, as when arranged differently. It has, however, its merits. Each section of the winding, of howsoever many turns, is whole throughout its length, without joints, which involve labour and expense to make, and form possible sources of resistance. It is in some respects easy of construction, dealing only with flexible wire. The fact also of its allowing of many turns per section as compared with most other windings, gives it a distinct advantage for obtaining high volts out of a small machine without the necessity of an inconveniently high speed—when a small current only is required. This point may indeed perhaps be considered as its most valuable feature.

We may now, however, proceed to the consideration of armatures wound not only for high volts but also for a heavy current. The chief difference between these and those we have discussed is that the conductors must be of a much larger section than that of mere wires, and will, in fact, become "bars" rather than wires. Before going on to describe

any particular heavy current winding, however, it may be advantageous, perhaps, first to consider some of the points that have to be borne in mind when getting out the design of such a winding. These naturally fall under the heads of efficiency and economy. The question of efficiency, however, in this connection, is mostly disposed of in the fundamental calculations of the machine. Granting, then, that the sections of all the conductors are of sufficient size to carry the intended current without undue heating, it is a matter of contrivance so to arrange these on the armature, that while the greatest economy in labour and material is aimed at, efficiency shall not be sacrificed. It thus becomes an object in designing an end winding, while retaining the necessary cross section, to aim, for economy's sake, at a minimum total length of copper. Compactness is also required, so that the winding may project the smallest amount possible beyond the ends of the core. As these parts of the winding generate no current, there is no object in their enlargement; while compactness assists not only economy in the copper itself, but also, by keeping down the total length of the armature, the total length of the machine as a whole is kept down, together with its weight, first cost, and floor-space, minimum floor-space being frequently a desideratum, especially on board ship. But while aiming at compactness, ventilation must not be forgotten, especially in the case of large machines, though there are makers who do not attach the importance to this point that others, probably the majority, attach to it. Again, it is well to have as few joints as possible in the coils, as these, depending on the human factor for their perfection, may be faulty, and so cause resistance, the extra labour and expense incurred in making them must, moreover, be remembered. An armature should not be too complicated, so that its construction may be comparatively easy and straightforward; and all joints should be accessible. Labour is thus economised; besides, by avoiding work that is at all "fidgetty," dependence on a few special men who may acquire the particular aptitude necessary, and whose services may be lost in a strike or otherwise, is avoided. With this last desideratum is in some degree involved another point of importance, which is, that parts burnt or otherwise damaged may either be removed and replaced with facility, or else that the whole winding should be capable of being easily dismounted and put together again for the same purpose. The conductors require to be well held on by steel wire wound round in bands outside, circumferential slipping being besides still further prevented by projections from the core and end plates. It may be borne in mind, indeed, with regard to this latter point, that by virtue of the work done in driving the armature, the parallel conductor bars are subjected to a magnetic drag tending to hold them back from revolving with the core and spindle; and this drag is no light matter; hence the necessity of fixing the coils well. To this magnetic drag is added the centrifugal force tending to make the coils fly off altogether.

There are, however, still some two or three other points that require attention. Of these, one is the question of a true balance. It is necessary to put on the winding and form up the ends with such symmetry that the centre of gravity of the whole armature when complete shall be in the axis of the spindle, and not outside. Now, in ordinary practice, the armature, when finished, is tested for balance by being rolled with its spindle at each end resting on two horizontal "knife-edges." If the centre of gravity of the whole be in the axis, it will rest in any position; but if not in the axis, the armature will then roll, oscillating backwards and forwards till it rests with the heavy side downwards, when extra weight must be soldered or otherwise be attached to the light side till a balance be attained. But it has to be noted that this is not really a true test. It is a question whether or not armatures are sometimes made having the centres of gravity of their two ends, taken separately, not in the axis, though equi-distant on opposite sides of it. A fault of this nature would not show on the knife-edges. But when revolving rapidly, there would be a tendency in an armature thus faulty for its axis to gyrate round the true axis of revolution in two cones, one at each end, having their apices united at a point within the true axis somewhere between the two misplaced centres of gravity. Hence a greater or less tendency to vibrate will still exist, though the armature might show a perfect balance on the knife-edges. This kind of error might perhaps be detected by mounting the armature within a magnetic field, on bearings supported on flexible standards, or, better still, on bearings slung from adjustable springs, and then with brushes lightly touching the commutators, revolve it as a motor. If the balance be true, with the centre of gravity of each end within the axis, the armature, when rotating at a tolerable speed, would evince a tendency to maintain a constant and steady axis in any one position, like a gyroscope. But if the balance be out of truth in the particular manner under discussion, a decided desire to "wobble" would show itself.

Another reason, however, for being careful as to symmetry, is to secure the perfect roundness of the exterior circumference of the completed winding, and its centre within the shaft axis. The clearance between the armature and pole-pieces may thus be kept to a minimum.

A remaining, and very important point, however, that arises, especially in connection with heavy current windings, is the liability of the conductor bars to heat by reason of "Foucault" or "eddy" currents generated within them individually, apart from the main current. In some kinds of dynamos other than those with drum or Gramme armatures, such, for instance, as those used for alternating currents, the coils, instead of being *revolved* in a field, are *translated* across a field edgeways. In other words, the coil is so placed that its plane is perpendicular to the lines of force of the field; being still kept in this plane, it is moved across the lines of force, and so cuts them. A current is thus set up in the coil. Now if, instead of a flat coil, a flat metal plate were used, and were made to cut through the field edgeways in a similar manner, a current would be caused to circulate in the plate in a plane perpendicular to the lines of force, this, indeed, being much the principle of Faraday's first disc dynamo. If the plate were turned so that its plane were parallel with the lines of magnetic induction, and then moved through them, no current, comparatively speaking, would be generated within it. This point is important. Now if, again, instead of the plate, a single metal bar be moved sideways across the field in a plane normal to the lines of induction, a current will arise within the bar; and this current will circulate within the bar in planes perpendicular to the lines of force, running along one of the sides parallel with these lines, and returning by the other. Thus it is obvious that as a current will produce heat, if the experiment with either the coil, the plate, or the bar, be carried out to any great extent, and they be moved rapidly and continuously through a sufficiently strong field, they may be made red hot; and the fact remains, that if a single insulated bar be laid along the periphery of an armature parallel with its axis of rotation, or held in a frame, and then revolved in an ordinary magnetic field, such as used for drum or Gramme dynamos, it will get hot from these internal currents alone. But in dealing with large "bars," however, there may also be borne in mind their capability of cooling as compared with wire, or bars of small section. It will be noted that whereas the transverse sectional area of a bar increases with the *square* of its diameter if *round*, or as the *square* of the side if of square section, the circumference, or outer surface, increases only in proportion to its diameter or thickness. Now capability of cooling, whether by radiation or convection, varies with the surface. Hence, a bar, say six times the thickness of a small bar or wire of round or square section, while it will have $6^2 = 36$ times the sectional area of the smaller, and so may carry about 36 times the current, has only six times the cooling surface. Hence large bars as compared with small ones, beside being heated by the main current and by eddy currents, are still further handicapped, so to speak, by their greater difficulty in cooling. The eddy currents in wires, it may be mentioned, are so trifling as to be negligible. In ordinary drum or Gramme-wound dynamos, where the field is bored concentric with the axis of the armature, these Foucault currents arise principally, if not entirely, when the bars pass under the trailing horns of the pole-pieces where the induction lines are particularly dense. By "trailing" horn is meant the last horn of a pole-piece which the bars leave or recede from as they revolve.

Digitized by Google

We may now proceed to consider the matter of mechanical construction, and see how all the various points we have enumerated are, and have been, dealt with in practice.

As we have just been touching on the subject of conductor bars, it will be convenient if we at once commence with these, and consider some of the ways in which this heating difficulty has been surmounted. The methods may be divided under two heads. Under the first, the difficulty is met by removing the principal cause of the evil; while under the second, the cause remains, but its effects are prevented from occurring by some counter-arrangement.

The plan adopted by Messrs. Mather and Platt comes under the first head. They avoid the difficulty by making the air space between the armature and the pole-pieces greater as it nears the horns either way, as shown in Fig. 3. Thus the principal cause of the heating is removed, inasmuch as the

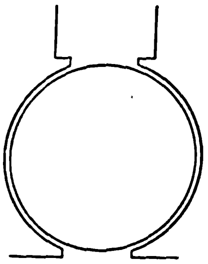


Fig. 3.

magnetic induction does not get so intense at the horns as it is wont to do when the air space is of even thickness. But it is under the second head that we may look for the most variety. The eddy currents may be prevented by so making or arranging the bars that a current *cannot* circulate within them. One method, instead of making the bar of one solid piece, is to compound it of several insulated wires or strips, in such manner that there shall be no internal circuit open to the current. Thus, Messrs. Siemens Brothers make their conductor bars of stranded copper wire cable, each wire separately insulated by varnish, and the whole brought into a rectangular section by hydraulic pressure, or by drawing through a die, or otherwise. As the Foucault currents will only circulate in an unbroken circuit lying in a plane normal to the lines of force, as already explained, it will be seen that no such circuit is open in the cable arrangement; conse-

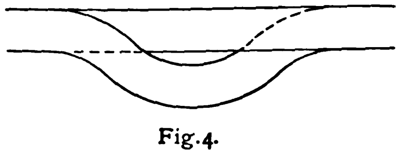


Fig. 4.

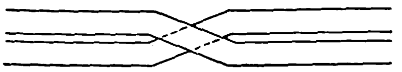


Fig. 5.

quently, the currents are not set up. Another method, somewhat similar, is to make the bar of insulated wires laid parallel, and soldered together at the ends so as to form a compound bar of rectangular section, to give the bar a half twist in the middle, and then to press or hammer the twisted portion in an iron mould so as to bring it to the same section as, and alignment with, the untwisted portions of the length. Yet another method is to make the bar of insulated copper strips or tape laid edgeways on the core in radial planes, and soldered together at the ends. The strips, thus laid, being in planes, for the most part approximately parallel to the lines of force they cut, will not, as we have already pointed out, be individually appreciably liable to eddy currents. But as they are in metallic connection at the ends, an internal circuit is open along the side strips and across both ends, which must to broken. Hence, this kind of bar also needs a half twist in the middle, and to be hammered in a mould, like the last. By means of the half twist, the current coursing along one side of the bar in each separate wire or strip is at the twist conducted to the other side, where it meets an opposing current, and so both are neutralised. It will, of course, be observed with regard to the strips, that if these be laid flat on the periphery of the drum, eddy currents could set up in each one separately.

A further method remaining to be mentioned, and still similar in principle, is one patented by Messrs. Crompton and Swinburne. This is illustrated, Figs. 4 to 7. The conductor bar here is simply made double; but at the middle of its length each half is so bent that it continues on the centre line of, and in alignment with, the other half. Figs. 4 and 5 show elevation and plan respectively, where one bar is bent to one side, and the other bent with a half-loop downwards, and also to one side, so that they thus cross each other. A groove is turned in the core to receive the half loops. Figs. 6 and 7 show an arrangement wherein the

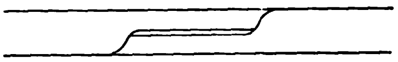


Fig. 6.

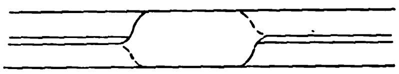


Fig. 7.

two bars are flattened merely, and so cross each other without the necessity of a groove in the core. Thus, the circulation of a current within the double bar is stopped by the tendencies in each half being opposed at the middle crossing, similarly as in those already described.

*(To be continued.)*

## MEETINGS OF SCIENTIFIC SOCIETIES, &c.

**FRIDAY, November 14th.**

Physical Society.

*5 p.m.* Papers to be read: "On Certain Relations existing among the Refraction Indices of some of the Chemical Elements," by Rev. T. Pelham Dale, M.A.; "Tables of Spherical Harmonics with examples of their practical use," by Prof. J. Perry, F.R.S.

**TUESDAY, November 18th.**

Institution of Civil Engineers.

*8 p.m.* Ordinary Meeting. Paper to be further discussed; "Steam on Common Roads," by John McLaren, A.M.I.C.E. Paper to be read, time permitting: "The Vibratory Movements of Locomotives," by Professor John Milne, F.R.S., and John McDonald.

Royal Victoria Hall.

*8.30 p.m.* Lecture: "Air and Water," by A. P. Laurie.

**WEDNESDAY, November 19th.**

Royal Meteorological Society.

*7 p.m.* Presidential Address: "The Relation of Ground Water to Disease," by Baldwin Latham, M.Inst.C.E.

Society of Arts.

*8 p.m.* Ordinary Meeting. Opening address of the Session, by Sir Richard Webster.

Royal Microscopical Society.

*8. p.m.* Papers to be read: "The Tube-building Habits of *Terebella littoralis*," by A. T. Watson; "Note on a New Marine Annelida," by Sarg. V. Gunson Thorpe. Adjourned Special General Meeting; Alteration of Bye-laws.

Institution of Electrical Engineers.

*9 p.m.* Conversazione at the Royal Institute of Painters in Water Colours.

**THURSDAY, November 20th.**

Institution of Electrical Engineers.

*7 p.m.* Annual Dinner at Criterion Restaurant.

Chemical Society.

*8 p.m.* Meeting.

**FRIDAY, November 21st.**

The Junior Engineering Society.

*8 p.m.* Presidential Address: "Electro-magnetic Mechanisms," by Prof. Silvanus Thompson, D.Sc.

Digitized by Google

# The Electrician.

**Published every Friday, Price Fourpence; Post Free, Fourpence Halfpenny.**
**Editorial, Publishing, and Printing Offices:**
**SALISBURY COURT, FLEET ST., LONDON, E.C.**
*Telephone No.* 2714. *Telegrams:* "ELECTRICIAN NEWSPAPER, LONDON."

*All Letters relating to Subscriptions, Advertisements and other business matters should be addressed to the Publisher, "*THE ELECTRICIAN,*" Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to "*THE ELECTRICIAN*" Printing and Publishing Company, Limited, and be crossed "Coutts and Co." All other letters to be addressed to the Editor.*

*All letters intended for insertion in "*THE ELECTRICIAN,*" or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

"THE ELECTRICIAN" *is published every Friday morning, in time for the morning mails. Subscribers should receive their copies by the first post on Friday morning.*

"THE ELECTRICIAN" *is on sale at the railway bookstalls throughout the Kingdom on Friday morning, and can be obtained of all Booksellers and Newsvendors; or direct from the Publishing Offices as above.*

*New Volumes of "*THE ELECTRICIAN*" commence in May and November.*

## SUBSCRIPTION RATES.

The rates for Subscriptions to "THE ELECTRICIAN" are as follows:—

| | 3 months. s. d. | 6 months. s. d. | 12 months. s. d. |
|---|---|---|---|
| For the United Kingdom | 5 0 | 10 0 | 19 6 |
| For Foreign Parts and Colonies:— | | | |
| Within Postal Union | 6 6 | 12 6 | 24 0 |
| Aden Borneo, Ceylon, China, India, Japan, Java, Labuan, Mozambique, New Caledonia, Persia, Philippine Islands, Siam, Transvaal, and Zanzibar | 7 6 | 14 6 | 28 0 |



## TO ADVERTISERS.

"THE ELECTRICIAN" *offers exceptional advantages to Advertisers.* **It has by far the largest circulation of any English Electrical paper, and circulates all over the World.**

*Particulars relating to Advertisements will be promptly forwarded on application to the Offices as above.*

TRADE ADVERTISEMENTS *intended for the current issue must reach the Offices not later than First Post on Thursday morning. Renewals of expiring advertisement orders and alterations to standing advertisements should be in the Publisher's hands by Wednesday at latest. No alteration can be made in Wrapper advertisements after Wednesday evening.*

SMALL PREPAID ADVERTISEMENTS *(for Rates see page xv.) are accepted up to 4 p.m. on Thursday.*

## TECHNICAL PRINTING.

"THE ELECTRICIAN" PRINTING AND PUBLISHING COMPANY (LIMITED) *inform Electricians, Electric Light Engineers, &c., that they make a specialty of Technical Printing, and have a large Staff thoroughly acquainted with Electro-Technology. They can, therefore, promise Accuracy and Despatch in the Printing of Electro-Technical Literature, &c.*

## "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. (Royal 8vo.)

*Early in each year is issued "*THE ELECTRICIAN*" *ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. *The* DIRECTORY *was established in 1883, and the 1890 Edition consisted of about 850 pages of printed matter. The names and addresses of all persons engaged in the Electrical Industries at home and abroad may be relied upon as accurate. Useful Tables and Electrical Formulæ, and information specially compiled for this work are given, together with popularly-written Biographical Notices of the leading Electricians, Electrical Engineers, &c., accompanied in many cases by Portraits.*

*Orders for the 1890 issue should be forwarded* AT ONCE *to the Publishing Offices, Salisbury-court, Fleet-street, London, E.C.*

*The 1891 Edition is now preparing, and New Names, &c., can now be received.*

## ELECTRICAL BOOKS AND PUBLICATIONS.

*All Books, Newspapers, and other publications, dealing with Electrical and kindred subjects, can be ordered direct of "*THE ELECTRICIAN*" Printing and Publishing Company, who are proprietors of the well known "*ELECTRICIAN*" Series of Standard Electrical Works, and are agents for all the leading publishing houses at home and abroad.*


## CONTENTS OF THE CURRENT NUMBER.


NOTES .......... 27
An Ideal Physical Laboratory for a College. By Prof. Oliver Lodge. Illustrated .......... 32
Electro-Magnetic Radiation. By Prof. A. L. Kimball, Ph.D. Illustrated .......... 33
Tests of a Goolden-Willans Combination. Illustrated... 36
Drum Armature Winding. By F. M. Weymouth. Illustrated Continued .......... 37
Meetings of Scientific Societies. 39
THE SCIENTIFIC PAPERS OF JAMES CLERK MAXWELL .......... 40
Electrical Distribution by Transformers from Central and Eccentric Stations. By Dr. J. A. Fleming, M.A. Illustrated. Continued .......... 42
The Electrolytic Preparation of Bleaching Agents. By A. Rigaut. Illus. Concluded. 45
Gelatinous Electrolyte for Storage Batteries—Report by Prof. Kohlrausch .......... 46
The Electro-Magnet. By Prof. Silvanus P. Thompson, D.Sc., B.A., M.I.E.E. Illus. Continued .......... 47
London Chamber of Commerce—Meeting of the Electrical Trades' Section Committee. 50
South Australia—Postal and Telegraph Conference held at Adelaide, May, 1890 .......... 52
The Canadian Government Telegraph and Signal Service 52
Paris Notes .......... 52
CORRESPONDENCE—
A New Empirical Formula for the Air-Space of Dynamos—F. V. Andersen .......... 53
Westminster Electric Supply Corporation (Limited)—A. H. W. Kennedy .......... 53
Life of Glow Lamps on the Series System—Frank Lott 53
Trade Notes and Notices .......... 53
PATENT RECORD .......... 54
COMPANIES' MEETINGS, &c.—
The Western and Brazilian Telegraph Company (Ltd.) 54
The West India and Panama Telegraph Company (Ltd.) 56
Metropolitan Electric Supply Company (Limited) .......... 56
City Notes, &c. .......... 59
New Companies Registered ... 59
Companies' Share List .......... 60


## THE SCIENTIFIC PAPERS OF JAMES CLERK MAXWELL.

Ten years ago the advance guard of physical science suffered a blow from which it has not yet recovered, a loss the full extent of which it may be impossible ever to estimate. The death of a veteran full of years and wisdom, though always a serious occurrence, is one that must occur now and again, and it is comparatively easy to acquiesce in it. But the death of CLERK MAXWELL at the age of forty-eight, on November 5th, 1879, came as an unexpected and withering blast to those students who were gathering inspiration from his writings, and hoping in time to be admitted to a stimulating and invigorating intimacy with the man himself. It deprived the younger generation of physicists of that which they felt almost a right to expect, the benefit of the nature wisdom, large experience, and kindly criticism, of one whose brilliant genius had already made itself lustrous. The man with all the potentialities latent in his brain has gone, and only the memory of a few privileged friends, a number of printed papers, and a couple of books remain. The books and the papers are fortunately immortal, and on their scientific value there is no need to dwell. Such a book as the Electricity and Magnetism marks an epoch: it is too early yet to estimate its influence. Sometimes it seems likely to take rank along with the Principia; while at the least it can be maintained that no book of equal importance and suggestiveness in physical science appeared between the two. The possible exception is Thomson and Tait; but it is too soon to institute comparisons, and there is really no antagonism between them; they cover a different field.

How MAXWELL'S work has proved the inspiration of Cambridge, and how splendidly the work which he began has been carried out and developed by his successors there is no need to tell. He was Professor at Aberdeen, in London, and at Cambridge (it was in London that he spun the B.A. unit coil), but it is with Cambridge that his name

Digitized by Google

will be associated, and it is a pity that he was ever tempted away into the less congenial atmosphere of Aberdeen. We waste our great men—they let themselves be wasted, not realising how great they are. No man as great as MAXWELL ught to be set to teach a set of young cubs such as a junior class is sure to be. Your steam hammer may be able to crack a walnut, but to see it cracking walnuts for its main work would be a pitiful spectacle. Three things MAXWELL did from which now we would have gladly freed him: he taught junior students the rudiments of physics, he superintended the erection of the Cavendish laboratory, and he edited the papers of CAVENDISH. The last he did well, but it was not work for him. CAVENDISH was a great man, but MAXWELL was a greater, and it were better to let some of CAVENDISH's fame rest in oblivion than to waste the last years, or any years, of MAXWELL's life over editing his unpublished papers. What a man does, he should publish himself, or take the consequences. The retentiveness and secrecy of CAVENDISH was a fault—a pardonable eccentricity it seemed, a wasteful error in reality; wasteful not only of his own, but of another's life. The greater the man, the worse the effect of this mania for secretiveness, for it takes another great man afterwards to understand and publish; and, moreover, the knowledge of the existence of a mass of unpublished material exerts a deterrent effect on the good work of younger men, and compels a self-criticism of their own work so severe as to be unhealthy. The best plan may be that adopted by those who boldly make up their minds to sacrifice any preposterous claim to infallibility, and publish as they go along.

Coming to the second act here suggested as in some sort wasteful, there may be a difference of opinion about it. Devising the Cavendish Laboratory is a good enough piece of work, but a smaller man might have done it equally well. Possibly better. It takes no heaven-sent genius to devise a laboratory. And as to the junior classes, whether in Scotland, in London, or in Cambridge, it is a barbarous and insular proceeding to use our leaders for such work, common as it is to this day in Great Britain. It is work from which the chief Continental philosophers are freed at a very early stage. The years of Maxwell's life most pleasant to contemplate scientifically are the early years, first with Forbes in Scotland, then as fellow and lecturer of Trinity, and his six later years of retirement at his country home in Glenlair (from 1865 to 1871), before accepting the Cambridge Chair. It was during these years that both the Electricity and the Heat were written.

The two large volumes which the Pitt Press has just issued under the editorship of Professor W. D. NIVEN, are a reprint of all his most serious contributions to the scientific literature of the day, together with a few memoirs and articles of a lighter cast judiciously introduced, such as biographical notices for *Nature* or elsewhere. A satisfactory and calmly judicious preface by the editor opens the first volume, which commences with an early note on ovals communicated through Professor FORBES to the Edinburgh Royal Society, when MAXWELL was a boy of 15. Then follow various optical and dynamical papers, with the early one on FARADAY's lines of force; and then come the tremendous memoirs on Saturn's rings, and on the dynamical theory of the electro-magnetic field. The second volume is largely occupied with papers on the kinetic theory of gases, on colour vision, and on dynamical chemistry. It contains, moreover, the selection of lighter memoirs and lectures which it has been deemed suitable to include. It is a pity that dates are not prefixed to the papers. Scientifically, the matter may be independent of date, but, considered from the point of view of the development of a human personality, dates add considerably to the interest. However, it is not our purpose now to formally review these volumes. We prefer to regard them as what they are intended to be, the memorial of one of the greatest geniuses of the age. They are but a fragment of what his life work might have been had he lived. He would have been only 59 now. Through all the recent development and apotheosis of his theories he might have lived, and we could have shared with him his keen interest and vivid appreciation, and have received from his own lips the most vividly telling presentment of it all.

But it is bootless now to speculate on what his influence might have been; and it is premature to discuss what his influence actually is. We are yet too near the source to be able to trace the course of the river of discovery which is flowing from this mighty peak. The words with which NIVEN concludes the more purely biographical portion of his preface, simple and studiously abstemious as they are, express a judgement in which everyone must concur:—"MAXWELL was thus cut off in the prime of his powers, and at a time when the departments of science which he had contributed so much to develop were being every day extended by fresh discoveries. His death was deplored as an irreparable loss to science and to the University, in which his amiable disposition was as universally esteemed as his genius was admired." . . . It does not appear "that the time has yet arrived when the quickening influence of MAXWELL's mind on modern scientific thought can be duly estimated."

## REVIEWS.

**Electric Light.** By JOHN W. URQUHART. Fourth Edition. (London: Crosby, Lockwood, 1891.)

This edition, which has been "carefully revised, with large additions," should have been carefully excised, with large subtractions. It aims at being a handbook, but its pages are seriously congested with obsolete matter. If a book be intended for a historical record, theories, definitions, and practical directions may be omitted; and, on the other hand, an elementary book, such as the one before us, should carefully distinguish between modern machinery and that which is old-fashioned. Typical specimens of the latter are useful in showing the germs from which the former have been developed, but their shortcomings should be pointed out. That the third edition was sold out in a few months shows that there is a want for such a book, but we hope that when the fifth makes its appearance a great deal of merely historical matter will be grouped by itself, or preferably omitted altogether.

**Practical Electrical Notes.** By PERREN MAYCOCK. Second Edition. (London: E. and F. N. Spon, 1890.)

Neither the title-page or the preface of this little book describe it as a pocket-book, and the contents are as unsuitable for a pocket-book as they could be. If it were bound in the ordinary fashion it would be a very fair little handbook on elementary electrical engineering. It is copiously illustrated with blocks from trade catalogues; a porcelain ceiling rose, for example, occupies a whole page. Joint-making is dismissed in one short paragraph, which describes a butt-joint as one which is made by bringing the ends of two wires close together and making fast by soldering, &c. The author does not inform us under what circumstances such a joint is generally used. The use of the words *decalescence, reluctancy, reluctivity, elastance, elastivity*, and *permittivity* might be well deferred until they are more generally adopted. Diagrams of no less than 34 methods of connecting electric bells are given, the subject being apparently more familiar to the author than dynamos, which are illustrated with equal profusion. We strongly recommend the slight alteration in binding, which will make it into a handy little book. The indexing should relate to pages, not to paragraphs.

Digitized by Google

## ELECTRICAL DISTRIBUTION BY TRANSFORMERS FROM CENTRAL AND ECCENTRIC STATIONS.*

BY DR. J. A. FLEMING, M.A.

*(Continued from page 15.)*

§ 20. **House-to-House Central Station at West Brompton.**— The House-to-House Electric Lighting Company have established at West Brompton, in London, a very complete Transformer station on the Lowrie-Hall system.

The site of the station is a plot of land 470ft. long by 60ft. wide, adjoining the Metropolitan District Railway. On this site has been erected a central station capable of supplying current to about 48,000 50-volt 10 candle-power incandescent lamps. The general appearance of a small portion of this station is shown in Fig. 55, and the whole station comprises dynamo and engine room, boiler house, testing-rooms, offices, stores, drawing and engineer's offices, water tank, coal stores, &c.

Then station when completed is intended to have 12 unit plants, each consisting of an engine, boiler, dynamo, and exciter, and capable of giving an electrical out-put of 100,000 volts. At the present time (1890) three such unit plants are actually in place, and the remainder will be added as required. The present supply is to about 16,000 eight candle-power 50-volt lamps, some 10,000 of which are at full load, burning at one time. The supply is to numerous private houses, flats, shops, St. Jude's Church, and other public buildings.

Each alternator is driven by a 200 horse-power horizontal coupled compound engine, by John Fowler and Co., of Leeds. The high-pressure cylinder is 15in. in diameter, the low-pressure 25in. in diameter; the stroke is 30in.; and the initial steam-pressure is 130lb. per square inch. The speed is 88 revolutions per minute. The cylinders are steam-jacketed. Between the high-pressure and low-pressure cylinder is suspended a massive flywheel, 14ft. in diameter, grooved for seven 1½in. ropes. The engines are governed by Hartnell's governor, which is driven from the shaft by cotton ropes, and controls the engine by acting direct on the expansion valves of the high and low-pressure cylinders, giving a range of cut-off in the high-pressure cylinder from 1 to 60 per cent. of the stroke, and governs the engine speed to within 2 per cent. The approximate weight of each engine is 24 tons. Each engine drives its associated dynamo and alternator by means of seven cotton ropes.

Efficient means for tightening the driving ropes are provided, consisting of two cast-iron rails of heavy section, fitted at one end of each with forcing screws; provided with holding-down bolts for the dynamo, the nuts of which are of rectangular form and sliding in grooves formed in the rails, the bolts being thus applied from above are removable without lifting the dynamo. The two rails are securely tied together with cast-iron distance pieces. Similar arrangements are supplied for the exciter. The foundations of all the engines and dynamos below ground are built of hard gault bricks, set in Portland cement, on a continuous slab of Portland concrete. The engine floor is raised three steps above the general floor line, and each engine base set up 14in. on a blue Staffordshire brick pedestal for conveniently reaching all the parts, and at the same time to secure natural drainage to the driving-wheel races. The floor on the raised platform is paved with blue Staffordshire bricks. All round the dynamos and exciters is a highly-insulated platform of crossed floor boards set on joists, with bitumen between the two sets of boards and linoleum laid through out. This platform is also raised 6in. above the general floor line

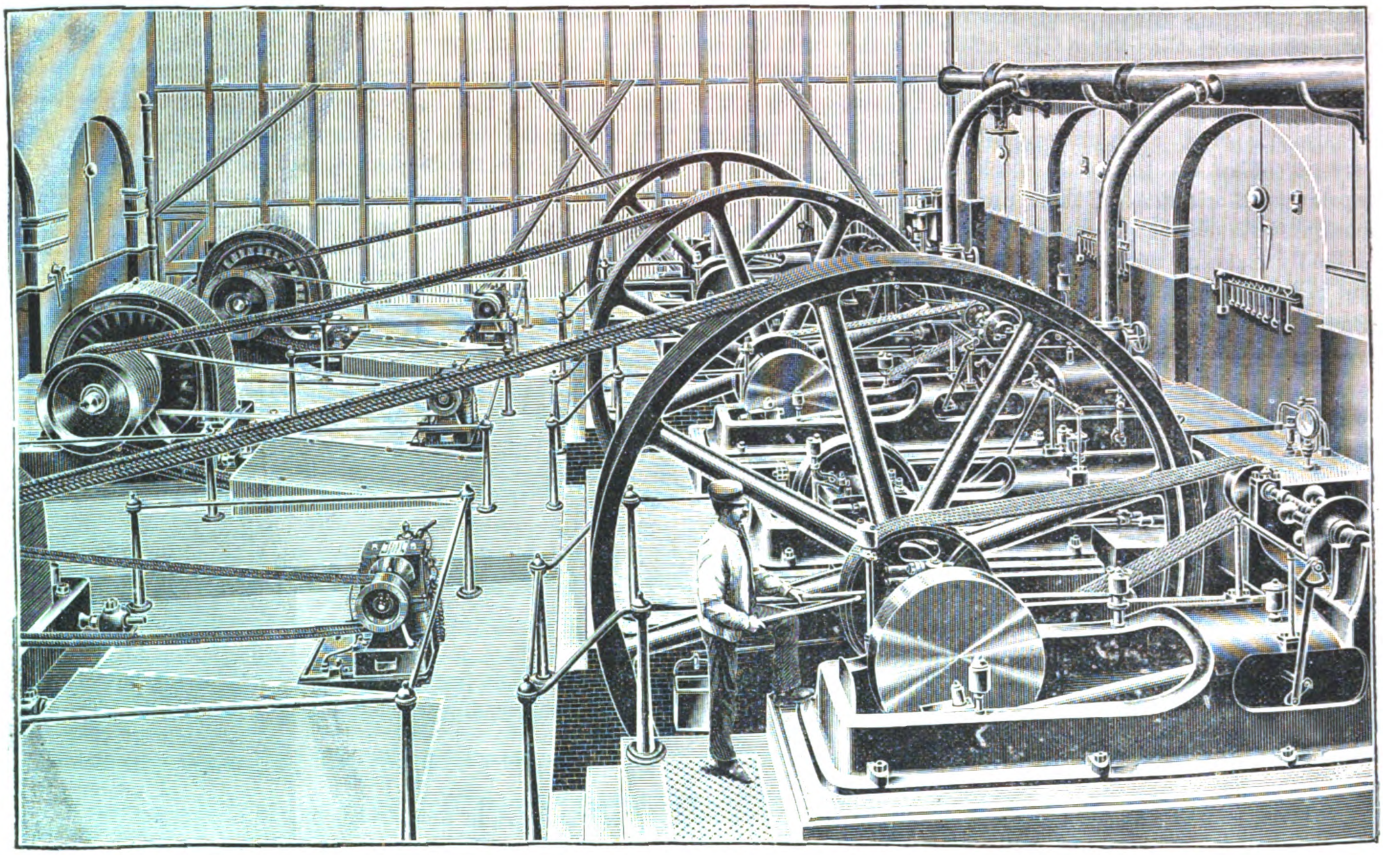


Fig. 55.—View of a part of the House-to-House Central Station, West Brompton. Main Engines and Alternators.

The boilers are the well-known Babcock and Wilcox water tube boilers with steam drum, capable of evaporating easily 5,500lb. of water per hour, and requiring not more than 1lb. best Welsh coal per 10½lb. water evaporated. Daily working pressure 150 (one hundred and fifty) lb. per square inch. The details of each boiler are as follows:—

| | Feet. | Inches. |
|---|---|---|
| Number of tubes in each boiler, 81 ......... | — | — |
| Length of tubes ................................ | 18 | — |
| Diameter of tubes ............................. | — | 4 |
| Length of steam drum ........................ | 23 | — |
| Diameter of steam drum ..................... | 4 | — |
| Length of mud drum .......................... | 5 | 6 |
| Diameter of mud drum ....................... | 1 | 6 |
| Number of sections or slabs in each boiler | 9 | — |
| Total length of boiler ......................... | 23 | — |
| ,, height | 14 | 8 |
| ,, breadth of all three boilers together | 22 | 9 |
| Heating surface on each boiler ............... | 1,790 | sq. ft. |
| Grate area in each boiler ...................... | 33½ | sq. ft. |

* All rights are reserved.

Digitized by Google

All joints in tubes, headers, hand-holes, &c., are metallic, no india-rubber, asbestos, or such like material being used. The entire boiler is suspended from a gallows or supporting frame, quite independent of the brick-work, thus allowing free expansion and contraction, and the removal, if necessary, of the brick-work, without disturbing the set of the boiler or connections. The steam drum, where exposed to radiation, is covered 2in. deep with non-conductor. The chimney shaft is common to all three boilers. Its dimensions are :—

| | Feet. | | Inches. | |
|---|---|---|---|---|
| Height from base-plate ......... | 100 | ... | 0 | above ground |
| Inside diameter ...................... | 5 | ... | 6 | |
| Outside diameter at base ...... | 11 | ... | 0 | |

These dimensions are sufficient for a battery of six boilers, the intention being to erect another shaft for the second six boilers. Below ground the chimney rests on a slab of concrete 20ft. square by 6ft. thick on the red London gravel.

The boilers are connected with copper connecting pipes to a 15-inch steel main pipe (this latter being of sufficient size to supply steam from 12 boilers to 12 sets of plant), carried on brackets fixed on the side of the wall, and each engine is again connected thereto by a copper bend pipe; the connections, both to engines and boilers, are arranged so that their spring or flexibility will allow for expansion of the main steam pipe, thus dispensing with any expansion joints. The condensed water from the pipe is collected in a receiver for use in the works and for the meters. The joints of this pipe are made with rings of copper tube covered with asbestos, fitting into a small spigot and faucet formed in the flanges. The exhaust pipe, 27-inch diameter, is also arranged to be common to all engines. It is of steel, similar to the steam pipe; the connection from the engines and to the heaters being of copper, arranged to take the expansion of the main pipe.

After passing through the heaters or the by-pass provided, the exhaust steam passes into the chimney, the drain from this pipe passes into a well, under the water level. The drain pipes from the engines are also all taken to a main drain pipe common to all engines and carried to this well and under water. This well is automatically drained of surplus water and prevents steam from being blown direct into the sewers.

The high pressure leads from the alternators are brought to a switch room, and all connections, governing, and changes are effected in this room. As at present (1890) arranged, each dynamo works on to a single and separate primary main. There are already about 25 miles of such primary main laid in the streets. The three pairs of leads from the three alternators and the ends of the three pairs of primary street mains are all brought to a switch-board, and by a simple 4 plug switch any dynamo can be put into any main. The leads from each dynamo have their own double-pole safety fuses, ammeter and voltmeter. There is also a double set of synchronising transformers for putting any pair of dynamos in parallel, as described in connection with the Leghorn Central Station. (See § 9.)

The mode in which this cross-connection of any dynamo to any main is made is very simple and practical.

Four straight terminals are mounted upon bosses of earthenware bolted to a slab of slate. The front earthenware bosses are deeper than the projection of the terminals from the face of the slate, to protect the terminals from dust, dirt, and the like, and to prevent accidental contact. The entrance orifices of these front bosses are funnel shaped, in order to guide the plugs to their respective seats in or upon the terminals. The back ends of the latter protrude through the back earthenware bosses, to which they are secured, and the terminals are formed to receive and bind the circuit conductors. This arrangement of four terminals upon their base is termed a terminal base. Upon a similar but smaller base of non-conducting material are also secured four plugs corresponding in position to the aforesaid terminals. In the centre a wooden or other insulated handle; a stop is fixed to limit the insertion of the plugs within the terminals. A strip of copper electrically connects each pair of plugs; and the base, with its handle and four plugs, is called a plug base. The combined four-terminal base and four-plug base is called a unit switch block.

The arrangement of the plugs, and that of their corresponding terminals, is that of a rectangle, nearly square in dimensions. This is to prevent the plug base being inserted wrongly in the terminal base, to make vertical connections (for example) instead of horizontal ones. The smoothing-iron form of the handle also serves to indicate the position in which the plug base should be held in switching, so that by the rectangular form and arrangement of the circuits it is impossible to plug the wrong terminals in a unit switch block. The terminals are made in the form of a split tube, to make spring contact upon the exterior surface of the solid plugs.

The requisite number of switch blocks are mounted upon a suitable support, in the form of a square. Upon one side of the square we connect each of the unit switch blocks to a generator, and upon a horizontal line with each of these a similar switch is placed, one for each, and connected to the working of the outer circuits.

In the respective circuits named are placed safety fuses, and the arrangement is such that one pole of a dynamo machine is connected to one terminal of a unit switch block, while the other pole is connected to the diagonally placed terminal of the same switch block. Similarly, each pole of the outer circuit switches is electrically connected to the remaining two terminals of the same block.

Provision is made by grooves at the back of each unit switch block to extend all the electrical connections to the adjoining unit blocks in the same symmetrical manner. For example, when four unit blocks are combined together as a square, with connections from two dynamos on one side, and connections to two

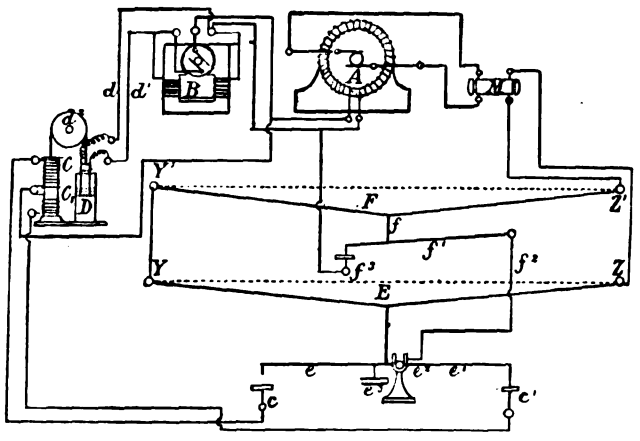



FIG. 56.—Diagram of Connections for Lowrie-Hall Pressure Regulator.

working circuits at right angles thereto, the whole of the current from the two generators can be conducted into one of the working circuits; or, the current from one machine led into one circuit, while the other machine is supplying the other circuit; or, one circuit is fed by both machines, while the other circuit draws its supply from one machine only; or, finally, both circuits may be fed by both generators, according to the number and arrangement of the plug bases engaged with their respective terminal bases. Thus, any number of generators and circuits can be electrically connected by adding the requisite number of unit switch blocks in the manner indicated.

The next important element in the system is the self-regulating arrangement, by means of which a constant electro-motive force of 2,000 volts is kept at the terminals of each dynamo. As the loss of volts in the primary mains between full load and lightest load is only $2\frac{1}{2}$ per cent., no adjustment is made for varying current in the main, but the terminal pressure difference is kept constant at the machine.

This is effected by regulating the exciter current by shunting more or less of the field current of the series-wound exciters.

From the terminals of one single coil of the armature of the dynamo is taken off a pair of wires, and the 75 volts of this coil is reduced by a small transformer to 50 volts. The current from the secondary of this small transformer is passed through two horizontal fine wires, like a Cardew voltmeter, and the greater or less expansion of these wires, as the E.M.F. of this coil of the armature varies, causes a greater or less sag of these wires. This expansion is then made to effect the regulation as follows:—

Across the terminals of the above-mentioned transformer, M, are the two fine wires, E and F (see Fig. 56), supported between

Digitized by Google

the fixed points, Z, Y, and $Z^1$, $Y^1$, whose normal positions when cold are shown by the dotted lines, the two wires being in series with one another, and connected by the wire, Y, $Y^1$. The field-magnets of the alternator, A, are excited by the exciter, B. Across the fields of this exciter a shunt of varying resistance is placed, connected by the wires, $d$, $d^1$; this shunt resistance is formed by two metal plates dipping in the solution in the electrolytic cell, D, and its resistance is altered by the raising and lowering of the plates into the solution, which is accomplished automatically by the passage of a current through either one of two solenoids or coils which pull up or down an iron core inside the coils; the top coil, C, lowers them, and the bottom coil, $C^1$, raises them, by the attraction of this movable iron core inside the coils.

This core is attached to the plates by a cord passing over a pulley $d^2$. To the centre of the wire E a cord is attached, the other end of which is fixed to the arm $e$ of the rocking arm $e$, $e^1$; this arm is pivoted at $e^2$ on a fixed support. If the electromotive force of the dynamo rises too high, the sag becomes greater, and the arm $e$ is pulled down by the weight $e^3$, and so makes contact on the table $c$; if, however, the electromotive force falls, the wire pulls the arm $e$ up, so causing the other arm $e^1$ to make contact with the table $c^1$. the resistance of the shunt, so that more current passes from the exciter round the fields of the dynamo A, whose electromotive force therefore rises. The arm $f^1$ is put in to cut out the action of the regulator in the event of the wire E breaking, for that wire by breaking would stop the passage of the current through the wire F, so making the latter contract and pull up the arm $f^1$, so breaking its connection with the table $f^3$. If no provision is made for this accident the arm $e$, by making permanent contact with the table $c$, would lower the electromotive force of the dynamo as far as the shunt would allow. In the shunt resistance, the two plates, which are fixed to an insulating piece, dip into the solution contained in the glass cell. The plates are supported by two chains, which pass over the two ebonite wheels; these chains make connection with the plates and terminate at two terminals, having sufficient slack to allow the wheels to turn their maximum distance either way. On a smaller pulley a chain is fixed, supporting the iron core, which moves up or down in the coils; the speed of the motion of the plates is increased or decreased by the ratio of the diameters of the pulleys. The coils are wound upon a brass tube, which is filled with glycerine to act as a dash-pot, the core acting as a plunger itself. The plates in the shunt resistance cell should be changed periodically to reverse the chemical action of the current

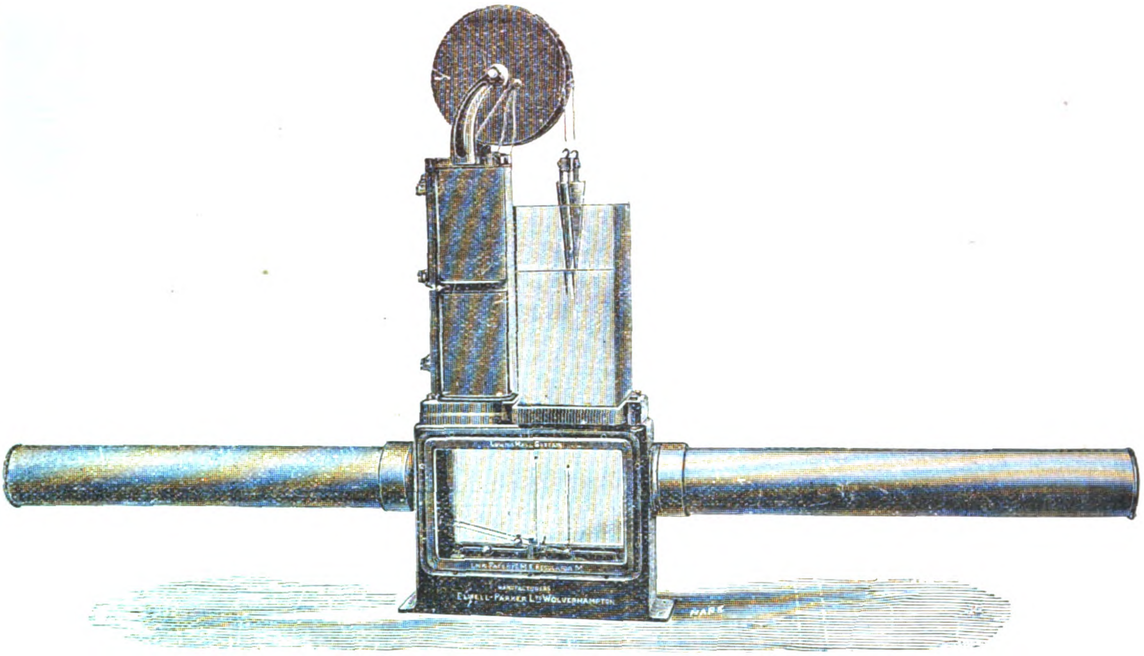


Fig. 57.—Lowrie-Hall Electromotive Force Regulator.

To the centre of the wire F the cord $f$ is attached, which raises or lowers the arm $f^1$, pivoted at its end, off or on to the table $f^3$. This table $f^3$ is connected to one pole of the exciter, and the pivot of the arm $f^1$ is connected by the wire $f^2$ to the pivot of the rocking arm $e^2$; the table $c$ is connected to the top coil C, and the table $c^1$ to the bottom coil $C^1$, the other ends of these two coils being jointly connected to the other pole of the exciter. If now the electromotive force of the dynamo rises too high, the arm $e$ falls, so making contact with the table $c$, the electromotive force of the exciter is therefore right across the coil C, one side being in metallic connection, and the other being connected through the table $f^3$, up the arm $f^1$, through the wire $f^2$, to arm $e$, so passing through the table $c$, connected with the coil C. This coil coming into action pulls the core up and so lowers the plates into the solution, which therefore lowers the resistance of the shunt, so causing less current to pass round the fields of the exciter and consequently weakening the field of the dynamo A, so lowering its electromotive force. These coils, C, $C_1$, it should be mentioned, are wound with fine wire and are of high resistance, so their connection across the exciter has no effect upon the dynamo A. If, however, the electromotive force is too low, the arm $e^1$ touches the table $c^1$, so shunting the current through the coil $C_1$, which, coming into action, raises the plates out of the solution, and consequently upon them. In the actual instrument thus designed to utilise the sag of a wire, the wires are stretched in a brass tube, in the centre of which is a containing box; at each end of the tube is a disc or insulation; on one of which are two movable brass strips to tighten the wires by the action of the thumbscrews. These are used to adjust the instrument; on each of these strips is a terminal, so that they make electrical connection to the wires. At the other end of the tube a brass piece is fixed, on to which both wires are screwed. The rocking arm is jewelled in both movements. The use of the guiding arm is to bring the centre pin on to the bridge, so that when the current ceases, the wire is free to contract. All the contacts are made of platinum, and the connections to the tables are made in the terminals underneath; these tables are all adjustable from below, so that their height may be altered, without allowing cold air to get into the tube whilst the current is on. The use of the other arm as a cut-out has already been described. The use of one wire is that of a cut-out as before described. It will be seen that another method of rendering the instrument still more sensitive or the reverse, is by moving the attachment of the cord on the rocking arm nearer to or farther from the pivot.

The external appearance of this regulator is shown in Fig. 57.

*(To be continued.)*

Digitized by Google

## THE ELECTROLYTIC PREPARATION OF BLEACHING AGENTS.*

BY A. RIGAUT.

*(Concluded from page 17.)*

But, after all, *the* important question is whether or not electro-chemically produced bleaching agents give results superior to chloride of lime? Here is a comparison between the cost of electric bleaching, mixed chlorides of magnesium and sodium being employed, and the ordinary chloride of lime process, the figures being taken from a recent pamphlet published by M. Hermite.

An "electrolyser" produces in 24 hours the equivalent of 100 kilogrammes of dry chloride of lime, 10 horse-power effective being required. The price of 100 kilogrammes of chloride of lime M. Hermite puts at 20 to 22fr., and the price is rising. For places where water power is available, we can have, according to M. Hermite, the equivalent of 100 kilogrammes of chloride of lime for 5·22fr. As the cost of labour is the same in the two cases, an economy of 80 per cent. is thus worked out. Where steam has to be employed we have—

| | Fr. |
|---|---|
| 10 horse-power for 24 hours (240 kilogrammes of coal, at 20fr. the ton) | 4·80 |
| 30 kilogrammes of sea salt, at 5fr. the 100 kilogrammes ... | 1·50 |
| 6 kilogrammes of magnesium chloride, at 12fr. the 100 kilogrammes | ·72 |
| Interest and depreciation (dynamo and electrolyser) | 3·0 |
| | 10·02 |

In this estimate, therefore, taking 1 horse-power hour as equal to 1 kilogramme (2¼lb.) of coal, at 20fr. (16s.) the ton, an economy of 50 per cent is effected. With less efficient steam plant and inferior coal the saving is still considerable. It is not surprising, therefore, to find that the electro-chemical method of preparing bleaching agents is being introduced into the bleaching industry. Employed, in the first instance, to bleach cottons and textile fabrics in the north of France[21], it has attained the most signal success in connection with the manufacture of paper.

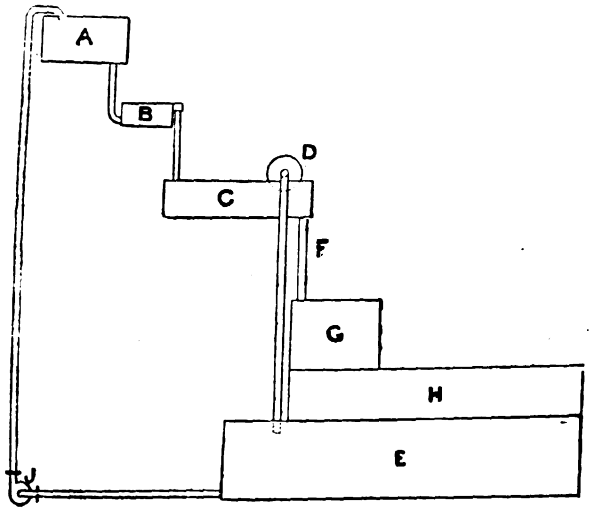



FIG. 3.

At the Centenary Exhibition a battery of "electrolysers" was at work in the Galérie des Machines. It was shown by M. M. Darblay, at whose works at Essonnes and Woergl no less than 15 "electrolysers" are actually employed. Other French firms employ the electro-chemical method, and in America, two years ago, 4·5 tons of pulp per day were treated by the Hermite process.

Figure 3 gives a general idea of an installation for electric bleaching as carried out in a paper factory. The liquid, containing a small quantity of free magnesia, passes from the vat A into a series of "electrolysers," B, and thence into the bleaching vessels C. The drum D takes the liquid off the pulp and sends it into the vessel E, where the centrifugal pump J returns it to A. Continual circulation is thus maintained, and the strength of the bleaching liquor is kept sensibly constant. When the pulp is well bleached it is sent down the tube F into the vessel G, whence it is passed through a press, which squeezes out most of the bleaching liquor, and this liquor falling into the vat E is also pumped back into A.

This electric bleaching of paper pulp is very suitable to the bleaching of difficult material such as jute, and it possesses the additional advantage that the fibres are not injured in the process. The increasing success of electric bleaching for this purpose has resulted in a whole series of patents in which electricity is specially applied to the paper industry, although the process is equally applicable to the purification of sewage, the purification of water, &c., &c. In 1886 Nation patented the application of electricity to the treatment of vegetable fibre for the production of paper pulp. He employed sea salt, but gave no details as to his apparatus. Stepanoff (1889) was engaged in investigating bleaching with sodium chloride, being of opinion that magnesium chloride was too dear in Russia. Stepanoff makes use of platinum and lead electrodes, and employs a current of 40 amperes at 45 volts. His plant can turn out 300 litres (66 gallons) of bleaching chloride per hour, that is to say, 72 hectolitres (1,584 gallons) per day of 24 hours; an amount equivalent to 37·5 kg. (82·5lb.) of chloride of lime. The quantity of platinum employed in the "electrolyser" is one-third of that employed in the Hermite apparatus.[22]

Kellner in Austria prepares a bleaching solution by the electrolysis of sea salt. In one of the processes which he has described, the saline solution has added to it an alkali (soda, lime, or magnesia) to prevent the escape of the free chlorine. The "electrolyser" is especially intended for the bleaching of paper pulp. The pulp impregnated with sodium chloride passes between two revolving electrodes which are in the shape of rollers, and placed face to face. The electrolysis of the salt is thus carried out in the pulp itself, which is bleached by the reactions produced. The roller forming the anode is of carbon. In the case of some fibres it is an advantage to pass the pulp *successively* over the cathode and anode. This result is arrived at by arranging a layer of felt between the two rollers so as to divide the pulp into two halves, one of which is in contact with the anode, and is impregnated with anions, chlorine, oxygen, &c., while the other half passes over the cathode, is charged with cathions, soda, and hydrogen. On the cathode, therefore, the fibre is washed and disintegrated, while at the anode there is a bleaching action due to the chlorine and oxgen. Another method of Kellner's consists in modifying the properties of the materials used in the manufacture of paper by the aid of the electric current. The texture of a paper depends on the nature of the fibre employed in its manufacture. Thus, paper made from flax differs considerably from that made from cotton. Kellner asserts that he is able at will to give paper the texture of flax paper or cotton paper. Weak alkaline solutions can, in the presence of the electric current, transform flax fibres into cotton fibres, while weak acid solutions do the reverse. Acids or alkalies are produced by the current in the fibre itself, and to effect this the pulp impregnated with a saline solution (and alkaline nitrate, acetate or sulphate), is passed between the revolving roller electrodes and along a sheet of felt, care being taken to place underneath the felt the roller on which form the elements which are not to act on the fibre. If it is required to give the flax fibres the properties of cotton fibres, the lower roller should be the anode and the upper the cathode, so that the pulp may be in contact with the nascent alkalies and the hydrogen. On the other hand, if it is desired to transform cotton pulp into flax pulp, the cathode is placed underneath the flax sheet, the moving pulp being exposed to the action of the acids, and oxygen formed at the anode. The manufacture of paper pulp from wood has also been proposed by Kellner. The disintegration and transformation of the pulp is carried out as follows:—The wood is cut up and impregnated with a slightly alkaline solution of sea salt, and is then placed in brick troughs, covered in with baked earth. In these troughs are placed the electrodes. When a current is passed the soda formed at the negative pole disintegrates the wood, while the chlorine and oxygen effectually bleaches the pulp. In the very latest methods employed by Kellner, he prepares the bleaching solution before hand, like M. Hermite. In his "electrolyser," Kellner employs zinc cathodes, and either carbon, platinum, or platinised porcelain for the anodes. The solution is sodium chloride (strength not given), to which is added a small quantity of a salt (salammoniac, sulphate, or nitrate of potassium), and it reaches the "electrolyser" at the bottom, and overflows at the top into the vessels containing the wood pulp. These latter are arranged so as to be heated, heat being efficacious in the preparation of wood pulp. The Kellner process is carried out amongst other places at some paper works established near a salt mine at Halleim, near Salzburg. Hydraulic power to the extent of nearly 800 horse-power is employed. The Kellner and Partington Company of Manchester have also constructed about a year since in Norway some wood pulp works. These works are situated in the district of Boregaard, on the right bank of the Glommen, close to the famous waterfall of Sarpfos. The head of water is about 19 metres (63 feet), and several thousand horse-power is available.

* From *La Lumière Electrique*.

[21] Ponthière. *Electrochimie.* (1886.)

[22] *Gazette de l'Electricité* (St. Petersburg), 1882. *La Lumière Electrique* February, 1890, p. 391.

Digitized by Google

Another electrical process for producing bleaching chlorides is that of Andreoli. The electrolysis of a solution of sea salt is again the basis of the method; but Andreoli has a special device for diminishing the secondary reactions which, as a rule, limit its applicability to the production of bleaching agents. According to the inventor, this result is obtained by employing a certain number of anodes, and only two cathodes of small surface. The anodes are of retort carbon, and arranged as shown in Fig. 4. Each carbon is coppered at the top, then tinned and fixed in a copper cartridge-case like cylinders. The carbons so prepared are soldered to a copper bar, B B (Fig. 4), and all the metallic portion of the arrangement is covered with varnish or enamel. The remaining three sides of the frame A A A (Fig. 4) are of wood. Twenty frames of this kind, 60 to 80 centimetres high, and each containing 10 to 20 carbon rods, are arranged parallel to one another along a slate-lined trough, having a capacity of 50 litres (11 gallons). At each end of this trough there is a cathode of iron-wire gauze. These cathodes are placed between wooden boxes, and are 2 or 3 centimetres higher than the trough itself. These boxes, which are pierced with holes, are filled with binoxide of manganese, the object of which is to prevent the hydrogen liberated at the cathode from reducing the oxygen-chlorine compounds formed at the anode. The electrolyte has a density of 5deg. to 8deg. Baumé, and one gramme (15·4 grains) of carbonate of soda is added to every hundred litres (22 gallons). According to Andreoli, taking 20 50-litre troughs and a dynamo giving 1,000 amperes at 100 volts, the yield of chlorine in each trough (premising that 1 gramme of chloride is liberated per ampere-hour) would be 1 kilogramme of chlorine—that is to say, 20 grammes of chloride per litre of liquid (1386 grains per gallon), which corresponds to a 5deg. Baumé solution of chloride of lime. In practice, if this degree of concentration is immediately arrived at, we have heating

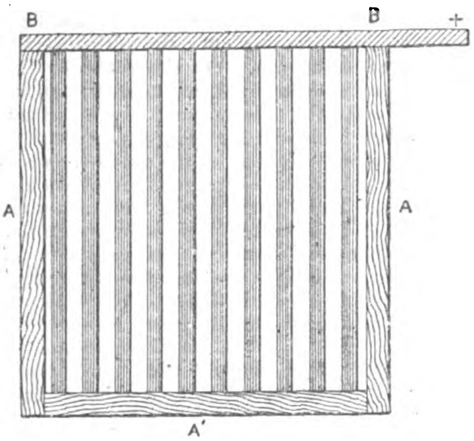



Fig. 4.

of the solution and the production of chlorates. The current, therefore, is only passed through the troughs for ten minutes at a time, until the strength of the solution is about 3 grammes per litre (about 70 grains per gallon). The vessels are arranged one above the other, so that there is constant circulation. In order to obtain a quantity of bleaching liquor equal to one ton of chloride of lime, 4,000 horse-power hours are required. If 1½kg. of coal is consumed per horse-power hour, the coal consumption for 4,000 horse-power hour will be 6 tons, and taking coal at 20fr., the cost of production is still less than one-half the price of a ton of chloride of lime. The Andreoli process is, we believe, worked by the London Electrical Bleaching Company.

Still, another electro-chemical method[23] consists in the electrolysis of a solution of 29kg. (64lb.) of calcined magnesia, 162kg. (356lb.) of hydrochloric acid (density 1·16), and 1,136 litres (250 gallons) of water; a solution in short of chloride of magnesium with excess of magnesia, since 164kg. of acid would be required to take up all the magnesia. After a current of 120 amperes at 6 volts has been passed through such a solution for 100 hours, it contains ·25 per cent. of active chlorine, and is capable of bleaching textiles without injuring them. The originality of the process lies chiefly in the material employed as electrodes. The cathodes are of sheet copper (68·5 × 45·75cms.); the anodes (18 × 10cms.) are of lithanode. The electrodes, to the number of 12, are arranged along the sides and at the bottom of the vessel, and are separated from the material to be bleached by wattle-work. The electrolysis, bleaching, and regeneration of the liquid are thus all carried out in the same bath.

In addition to the various electro-chemical methods mentioned above, M. Villon, in a recent issue of the *Revue de Chimie Industrielle et Agricole*, describes a process of bleaching paper pulp by ozone produced in the following manner. A box of hard wood is lined with glass slabs, and in this box, which is hermetically sealed, is placed a series of cells or partitions of glass. These cells or partitions are the exact height of the box, but 3 or 4cms. less in breadth, and they are filled with granulated lead or pieces of retort carbon. These cells are alternately connected to the + and − terminal of powerful induction coil. The space between the cells when the coil is at work is thus filled with sparks, and through this space oxygen cooled to 5°C. is forced, and is then passed out largely ozonised into the paper bleaching chambers. From the bleaching chambers the oxygen passes over sulphuric acid to dry it, and thence back again to the gasometer. Bleaching by ozone is quicker and more convenient than bleaching by chlorine, and the cellulose is not attacked. Taking the price of ozone at 75 centimes per cube metre (35·3 cube feet), the bleaching of 6 tons of pulp would cost 60fr. by this process, or 40 per cent. less than by the electro-chemical, and 70 cent. per less than by the old chloride of lime method.

The electrical preparation of bleaching agents is, it will thus be seen, rapidly becoming an established industry.

[23] *Elektrotechnische Zeitschrift*, September 12, 1890.

## GELATINOUS ELECTROLYTE FOR STORAGE BATTERIES.

REPORT BY PROF. W. KOHLRAUSCH.

During the last year an experimental research both of a theoretical and practical nature has been made by Prof. Dr. W. Kohlrausch, of the University of Hanover. The following is a translation of the opinion of this electrician:—

Since April 21st of this year I have made experiments with accumulator cells of the "Maschinenfabrik Oerlikon" (Dr. P. Schoop's patent), the result of which I have the honour to communicate to you.

The tests were made with a view to ascertain the behaviour of the accumulators if subjected to rough usage. For this reason severe tests were followed by regular tests with ordinary currents, in order to get an opinion as to the damage actually done by the severe handling. After a series of regular charges and discharges the cells were finally charged, and remained idle for a month. In charging the cells again 52 ampere-hours were absorbed, but a strong development of gases occurred at the end of the charging period. The whole capacity (in charging with 10 amperes) being 73 ampere-hours, it is obvious that about five-sevenths of the former charge seems to have disappeared during the rest of thirty days. Probably a part of this lost energy has been used up in a certain chemical or physical transformation of the active material, perhaps to the advantage of the accumulator.

A normal discharge and charge were now made, and it proved that the cells were still in good working order. The discharge amounted to 72 ampere-hours, indicating an increase of the capacity, the former trials having given only 65 ampere-hours in the average. (The makers claim 70 ampere-hours as a normal discharging capacity.)

Again, the same cells were discharged with the normal rate of current to, say, 9 amperes. After the discharge of about 73 ampere-hours, the current decreased and could only be maintained by decreasing the external resistance of the circuit; at last the cells were short-circuited in order to get the last energy out of the accumulators. In this way, again, 36 ampere-hours were drawn out, and the whole discharge was 109 ampere-hours. The cells were now charged with only 6 amperes (too weak a current) until gas bubbles were developed, and soon afterwards (after 1½ hours' rest) discharged with a current of 50 amperes—that is to say, five times the normal rate of discharging current.

The capacity was 41·6 ampere-hours, about four-sevenths of the normal capacity. It is a well-known fact that the capacity decreases if the discharging current increases.

Again, the accumulators were charged at the normal rate of current, and discharged with the normal current, 68·2 ampere-hours; charging and discharging was in every sense normal.

The discharged cells were now charged in the reversed direction of the current with 124 ampere-hours; the electro-chemical reactions on the plates were exchanged to, say, the former cathode was anode, and the former anode had become cathode; at the end the pressure of the cells was again two volts, but in the reversed sense of current.

During this trial at first 68·2 ampere-hours had passed the plates "voluntarily" in the direction as the discharging current, afterwards 124 ampere-hours had passed "involuntarily," together 192 ampere hours.

Now, the accumulators were again charged with 9 amperes (in the former right sense), and after 223 ampere-hours the cells were

Digitized by Google

again fully charged, and began to develop gases. During this forced charging and discharging the efficiency was still 86 per cent. (the efficiency under normal conditions being 89 per cent.) in ampere-hours.

The following discharge with 9 amperes yielded 68·3 ampere-hours; it is obvious that this series of abnormal tests did not at all decrease the working and capacity of the cells; the capacity increased rather a little. I think that during the long rest of the cells, probably also during this abnormal treatment, parts of the active material have been powerfully excited; parts which had before not worked electrically have been transformed into true active material.

One of the cells was now taken to pieces, and I saw that with the gelatinous electrolyte the whole construction of the cell was of a remarkable rigidity and constancy. The two sections of plates could only be separated with considerable force after a previous softening of the gelatine. After the plates had been fully cleaned from the gelatine it looked perfectly normal, just as before the trials. The grids are very thin and soft, but it is for this reason that I think it "improbable that plates can buckle." The stiff gelatine could not easily be removed by those soft plates in order to touch each other (short-circuiting), an inconvenience too often observed in other cells with thin plates and narrow distances between the plates. Falling or dropping of the active material off the plates is made impossible by the gelatine; also it is improbable that active material could penetrate through this gelatine.

The most important question now is that of the durability of those cells. Of course it is only possible after a longer time, at least a year or two, to give an opinion. How long will the thin grid of lead resist the combined action of the electrical and chemical changes within the electrodes? How long will it take to have the metallic support eaten up by a daily action of the cells, until the whole grid is converted into the same active material, which does only practical working, if embedded in a perfect metallic conductor? I have oberved on other systems with thin plates, that often the grid becomes brittle and breaks; again, a practical trouble with accumulators. I would say that the grids of the plates may last a year or two in daily use, but it is possible that the cells will only cease to give daily practical service after three to five years. I hope to have a more exact opinion in this direction after I shall have used the cells for another longer time, say a year or two. The present trials have shown that these cells endure an abnormal and very bad treatment in a very satisfactory manner indeed, and that this accumulator is a practical apparatus.

APPENDIX BY DR. PAUL SCHOOP.

The following data about the tested cells may be added:—

| | | |
|---|---|---|
| Number of plates | 17 | |
| Weight of plate | 8ko. | Total weight 11·7ko. |
| „ of electrolyte | 3ko. | |
| „ of ebonite box | 0·7ko. | |
| Box—Length | 125mm. | |
| „ Breadth | 160mm. | |
| „ Height | 205mm. | |
| Total height of cell | 250mm. | |
| Capacity (in discharging) | 70 ampere-hours. | |
| Strength of current | 9 to 10 amperes. | |

This cell represents the smallest type of cells, made especially for portable work, electric cars, and railway lighting.

During the last months, *The Electrician* twice mentioned the "gelatinous electrolyte" (August 12th and September 10th). In the August issue the mode of making the gelatine was described, together with a comparison of a cell filled with ordinary dilute acid and filled with gelatine. In the September issue was a translation of an experimental research of Dr. Kapp (Prof. Weber, University, Zürich), at first published in *La Lumière Electrique*. This latter publication has given most valuable light regarding the internal resistances of the cells. Perhaps it may be interesting to look a little deeper into what is called internal resistance.

This resistance is composed of:—

1st. Resistance of the electrolyte (the fluid or gelatinous dilute sulphuric acid).

2nd. Resistance of the grids (the metallic conductor, on which the spongy active materials are placed or adhere).

3rd. Resistance of the spongy material on the negative plate (cathode), saturated with dilute sulphuric acid.

4th. On the positive plate (anode), saturated with dilute acid.

5th. Resistance of the layer between the metallic grid (support) and the spongy material on the cathode.

6th. Resistance of the layer between the metallic grid (support), and the spongy material on the cathode.

Only the second named resistance is approximately constant during a trial of the accumulator; all other resistances may vary with the strength of current, with the condition of the cell, if more or less charged or discharged, with the temperature and with impurities of the materials. It is highly interesting to compare a Planté accumulator (a cell, the plates of which have been treated purely electrically in dilute sulphuric acid, until a certain capacity has been obtained) with a so-called "pasted" accumulator (Faure). Suppose the surface of the electrodes of a Planté cell and a "pasted" cell be the same, also the quantity of spongy or active material be the same, the acid the same, and the strength of current, it will be found that the internal resistance of the Planté cell is considerably less, about only one-third of what it is in the "pasted" cell.

It is very likely that the future accumulator will be made again without mechanical application of materials, but that the Planté process will be tried again with the view of obtaining a process of electrical formation which enables us to get within a short time, with less cost, a solid accumulator with a practical capacity.

## THE ELECTRO-MAGNET.*

BY PROFESSOR SILVANUS P. THOMPSON

(*Continued from page 20.*)

A rough and ready rule sometimes given for the size of wire is to allow $\frac{1}{1000}$ square inch per ampere. This is an absurd rule, however, as the figures in the table show. Under the heading 1,000 amperes to square inch, it appears that if a No. 18 S.W.G. wire is used, it will at that rate carry 1·81 amperes; that if there is only one layer of wire, it will only warm up 4·64°Fahr., consequently one might wind layer after layer to a depth of 3·3in. without getting up to the limit of allowing one square inch per watt for the emission of heat. In very few cases does one want to wind a coil so thick as 3·3in. For very few electro-magnets it is needful that the layer of coil should exceed ½in. in thickness; and if the layer is going to be only ½in. thick, or about $\frac{1}{7}$ of the 3·3, one may use a current density $\sqrt{7}$ times as great as 1,000 amperes per square inch, without exceeding the limit of safe working. Indeed, with coils only ½in. thick, one may safely employ a current density of 3,000 amperes per square inch, owing to the assistance which the core gives for the dissipation and emission of heat.

Suppose, then, we have designed a horse-shoe magnet, with a core 1in. in diameter, and that after considering the work it has to do, it is found that a magnetising power of 2,400 turns is required; suppose also that it is laid down as a condition that the coil must not warm up more than 50°F. above the surrounding air—what volume of coil will be required? Assume first that the current will be 1 ampere; then there will have to be 2,400 turns of a wire which will carry 1 ampere. If we took a No. 20 S.W.G. wire, and wound it to a depth of ½in., that would give 220 turns per inch length of coil; so that a coil 11in. long, and a little over ⅜in. deep (or 10 layers deep) would give 2,400 turns. Now Table X. shows that if this wire were to carry 1·018 ampere, it would heat up 225° Fahr., if wound to a depth of 3·9in. If wound to ½in., it would, therefore, heat up to 30° Fahr.; and with only 1 ampere would, of course, heat less. This is too good; try the next thinner wire. No. 22 S.W.G. wire, at 2,000 amperes to square inch, will carry 1·23 amperes; and heats 225° if wound up 1·13in. If it is only to heat 50° it must not be wound more than ¼in. deep; but if it only carries current of 1 ampere it may be wound a little deeper—say to 14 layers. There will then be wanted a coil about 7in. long to hold the 2,400 turns. The wire will occupy about 3·85 square inches of total cross section; and the volume of the space occupied by the winding will be 26·95 cubic inches. Two bobbins, each 3½in. long and ·65 deep, to allow for 14 layers, will be suitable to receive the coils.

By the light of the knowledge one possesses as to the relation between emissivity of surface, rate of heating by current, and limiting temperatures, it is seen how little justification there is for such empirical rules as that which is often given, namely, to make the depth of coil equal to the diameter of the iron core. Consider this in relation to the following fact: that in all those cases where leakage is negligible, the number of ampere-turns that will magnetise up a thin core to any prescribed degree of magnetisation will magnetise up a core of any section whatever, and of the same length, to the same degree of magnetisation. A rule that would increase the depth of copper proportionately to the diameter of the iron core is absurd.

Where less accurate approximations are all that is needed, more simple rules can be given. Here are two cases:—

*Case* 1.—*Leakage Assumed to be Negligible.*—Assume $B = 16{,}000$, then $H = 50$ (*see* Table III.). Hence the ampere-turns per centi-

* A series of four Cantor Lectures delivered before the Society of Arts, January—February, 1890.

Digitized by Google

metre of iron will have to be 40, or per inch of iron, 102; for H is equal to 1·2566 times the ampere-turns per centimetre. Now if the winding is not going to exceed ½in. in depth, we may allow 4,000 amperes per square inch without serious over-heating. And the 4,000 ampere-turns will require 2in. length of coil, for each inch of coil carries 2,000 ampere-turns without over-heating. Hence each inch of coil ½in. deep will suffice to magnetise up 20in. length of iron to the prescribed degree.

*Case* 2.—*Leakage Assumed to be 50 per cent.*—Assume B in air-gap = H = 8,000, then to force this across requires ampere-turns 6,400 per centimetre of air, or 16,250 per inch of air. Now if winding is not going to exceed ½in. depth, each inch length of coil will carry 2,000 ampere-turns. Hence, 8in. length of coil ½in. deep will be required for 1in. length of air, magnetised up to the prescribed degree.

WINDINGS FOR CONSTANT PRESSURE AND FOR CONSTANT CURRENT.

In winding coils for magnets that are to be used on any electric light system, it should be carefully borne in mind that there are separate rules to be considered according to the nature of the supply. If the electric supply is at *constant pressure*, as usual for glow lamps, the winding of coils of electro-magnets follow the same rule as the coils of voltmeters. If the supply is with *constant current*, as usual for arc lighting in series, then the coils must be wound with due regard to the current which the wire will carry, when lying in layers of suitable thickness, the number of turns being in this case the same whether thin or thick wire is used.

If we assume that a safe limit of temperature is 90° Fahr. higher than the surrounding air, then the largest current which may be used with a given electro-magnet is expressed by the formula:—

$$\text{Highest permissible amperes} = 0{\cdot}63\sqrt{\frac{s}{r}}$$

where $s$ is the number of square inches of surface of the coils, and $r$ their resistance in ohms.

Similarly for coils to be used as shunts, we have

$$\text{Highest permissible volts} = 0{\cdot}63\sqrt{sr}.$$

The magnetising power of a coil, supplied at a given number of volts of pressure, is independent of its length, and depends only on its gauge, but the longer the wire the *less* will be the heat waste. On the contrary, when the condition of supply is with a constant number of amperes of current, the magnetising power of a coil is independent of the gauge of the wire, and depends only on its length; but the larger the gauge the less will be the heat waste.

MISCELLANEOUS RULES ABOUT WINDING.

To reach the same limiting temperature with bobbins of equal size wound with wires of different gauge, the cross-section of the wire must vary with the current it is to carry; or, in other words, the current-density (amperes per square inch) must be the same in each. Table X. shows the amperages of the various sizes of wires, at four different values of current-density.

To raise to the same temperature two similarly-shaped coils, differing in size only, and having the gauges of the wires in the same ratio (so that there are the same number of turns on the large coil as on the small one), the currents must be proportional to the square roots of the cubes of the linear dimensions.

Sir William Thomson has given a useful rule for calculating windings of electro-magnets of the same type but of different sizes. Similar iron cores, similarly wound with lengths of wire proportional to the squares of their linear dimensions, will, when excited with equal currents, produce equal intensities of magnetic field at points similarly situated with respect to them.

Similar electro-magnets of different sizes must have ampere-turns proportional to their linear dimensions if they are to be magnetised up to an equal degree of saturation.

It is curious what erroneous notions crop up from time to time about winding electro-magnets. In 1869 a certain Mr. Lyttle took out a patent for winding the coils in the following way. Wind the

**TABLE X.**—*Wire Gauge and Amperage Table.*

| Dimensions. | | | | | Permissible Amperage, Probable Heating, and Permissible Depth. | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S.W.G. | Diam. (inch). | Section (sq. inch bare). | Turns to 1 linear inch (covered). | Turns per sq. inch (covered). | At 1,000 Amps. to sq. inch. A | F | D | At 2,000 Amps. to sq. inch. A | F | D | At 3,000 Amps. to sq. inch. A | F | D | At 4,000 Amps. to sq. inch. A | F | D |
| 22 | ·028 | ·00062 | 23·81 | 624· | ·616 | 2·28 | 4·5 | 1·23 | 9·12 | 1·13 | 1·85 | 20·52 | ·50 | 2·46 | 36·5 | ·28 |
| 20 | ·036 | ·0010 | 20·00 | 440· | 1·018 | 3·18 | 3·9 | 2·036 | 12·72 | ·97 | 3·05 | 28·62 | ·43 | 4·07 | 50·9 | ·24 |
| 19 | ·040 | ·0012 | 18·52 | 377· | 1·26 | 3·56 | 3·6 | 2·52 | 14·24 | ·92 | 3·78 | 32·04 | ·41 | 5·04 | 57·0 | ·23 |
| 18 | ·048 | ·0018 | 16·13 | 286· | 1·81 | 4·64 | 3·3 | 3·62 | 18·56 | ·83 | 5·43 | 41·76 | ·37 | 7·24 | 74·2 | ·21 |
| 17 | ·056 | ·0024 | 14·28 | 224· | 2·4 | 5·47 | 3·2 | 4·8 | 21·9 | ·79 | 7·2 | 49·2 | ·35 | 9·6 | 87·5 | ·19 |
| 16 | ·064 | ·0032 | 12·83 | 181· | 3·2 | 6·57 | 3·0 | 6·4 | 26·3 | ·74 | 9·6 | 59·1 | ·33 | 12·8 | 105·1 | ·18 |
| 15 | ·072 | ·0040 | 11·63 | 149· | 4·0 | 7·40 | 2·9 | 8·0 | 29·6 | ·72 | 12·0 | 66·6 | ·32 | 16·0 | 118·4 | ·17 |
| 14 | ·080 | ·0050 | 10·64 | 124· | 5·0 | 8·46 | 2·8 | 10·0 | 33.8 | ·70 | 15·0 | 76·3 | ·31 | 20·0 | 135·4 | ·17 |
| 13 | ·092 | ·0060 | 9·44 | 98·2 | 6·6 | 9·97 | 2·7 | 13·2 | 39·9 | ·67 | 19·8 | 89·7 | ·30 | 26·4 | 159·5 | ·16 |
| 12 | ·104 | ·0085 | 8·48 | 79·1 | 8·5 | 11·53 | 2·6 | 17·0 | 46·1 | ·65 | 25·5 | 103·8 | ·29 | 34·0 | 184·4 | ·16 |
| 11 | ·116 | ·0105 | 7·69 | 65·0 | 10·5 | 12·8 | 2·5 | 21·0 | 51·2 | ·63 | 31·5 | 115·2 | ·28 | 42·0 | 204·8 | ·16 |
| 10 | ·128 | ·0128 | 7·04 | 54·5 | 12·8 | 14·3 | 2·4 | 25·6 | 57·2 | ·61 | 38·4 | 128·7 | ·27 | 51·2 | 228·8 | ·15 |
| 9 | ·144 | ·0163 | 6·33 | 44·1 | 16·3 | 16·4 | 2·4 | 32·6 | 65·6 | ·60 | 48·9 | 147 6 | ·27 | 65·2 | 262·4 | ·15 |
| 8 | ·160 | ·0201 | 5·74 | 36·3 | 20·1 | 18·4 | 2·3 | 40·2 | 73·6 | ·59 | 60·3 | 165·6 | ·26 | 80·4 | 294·4 | ·15 |
| 7 | ·176 | ·0243 | 5·26 | 30·4 | 24·3 | 20·4 | 2·3 | 48·6 | 81·6 | ·58 | 72·9 | 183·6 | ·26 | 97·2 | 326·4 | ·15 |
| Stranded | | | | | | | | | | | | | | | | |
| 7/22 | 0·84 | ·0043 | 9·62 | 101·8 | 4·3 | 6·73 | 4·0 | 8·6 | 26·9 | ·99 | 12·9 | 24·6 | ·44 | 17·2 | 107·7 | ·25 |
| 7/20 | ·108 | ·0072 | 7·81 | 67·1 | 7·13 | 8·94 | 3·7 | 14·3 | 35·7 | ·92 | 21·4 | 80·5 | ·48 | 28·5 | 143·0 | ·23 |
| 7/18 | ·144 | ·0128 | 6·09 | 40·8 | 12·7 | 12·4 | 3·4 | 25·4 | 49·6 | ·83 | 38·1 | 111·6 | ·39 | 50·8 | 198·4 | ·21 |
| 7/16 | ·192 | ·0229 | 5·10 | 28·6 | 22·9 | 17·2 | 3·2 | 45·8 | 68·7 | ·79 | 68·7 | 154·5 | ·35 | 91·6 | 274·7 | ·20 |
| 7/15 | ·216 | ·0289 | 4·27 | 20·1 | 28·9 | 19·5 | 3·1 | 57·8 | 78·0 | ·78 | 86·7 | 175·4 | ·34 | 115·6 | 311·8 | ·20 |
| 7/14 | ·240 | ·0356 | 3·87 | 16·5 | 35·6 | 21·8 | 3·1 | 71·2 | 87·1 | ·76 | 106·8 | 195·9 | ·34 | 142·4 | 348·3 | ·19 |
| 7/13 | ·276 | ·0462 | 3·38 | 12·6 | 46·2 | 24·7 | 3·0 | 92·4 | 98·8 | ·74 | 138·6 | 222·3 | ·33 | 184·8 | 395·2 | ·19 |
| 7/12 | ·312 | ·0595 | 3·01 | 9·97 | 59·5 | 28·5 | 2·9 | 179·0 | 114·0 | ·72 | 178·5 | 256·5 | ·32 | 238·0 | 456 | ·18 |

Figures in columns marked A signify number of amperes the wire carries.

Figures in columns marked F signify number of degrees (Fahrenheit) that the coil will warm up if there is only one layer of wire, and on the assumption that the heat is radiated only from the outer surface of the coil: they are calculated by the following modification of Forbes's rule:—

Rise in temperature (Fahrenheit degrees) = 225 × No. of watts lost per square inch.

= 159 × sectional area × number of turns to 1in. (at 1,000 amperes per sq. in.).

Figures in columns marked D are the depths in inches to which wire may be wound if 1 watt be lost by each square inch of radiating surface, the outside radiating surface of the bobbin being only considered.

Rule for calculating a 7-strand cable:—Diameter of cable = 1·134 × diameter of equivalent round wire.

Figures under heading "Turns to 1 linear inch" are calculated for cotton-covered wires of average thicknesses of coverings used for the different gauges, viz., 14 mils. additional diameter on round wires (from No. 22), and 20 mils. on stranded or square wire.

Figures under heading "Turns per square inch" are calculated from preceding, allowing 10 per cent. for bedding of layers.

Resistance (ohms) of coil of copper wire, occupying $v$ cubic inches of coil-space, and of which the gauge is $d$ mils. uncovered, and D mils. covered, may be approximately calculated by the rule:—

$$\text{Ohms} = 960{,}700\frac{v}{D^2\,d^2}.$$

The data respecting sizes of wires of various gauges are kindly furnished by the London Electric Wire Company.

Digitized by Google

first layer as usual, then bring the wire back to the end where the winding began, and wind a second layer, and so on. In this way all the windings will be right-handed or else all left-handed, not alternately right and left as in the ordinary winding. Lyttle declared that this method of winding a coil gave more powerful effects; so did M. Brisson, who re-invented the same mode of winding in 1873, and solemnly described it. Its alleged superiority was at once disproved by Mr. W. H. Preece, who found the only difference to be that there was more difficulty in carrying out this mode of winding

Another popular error is that electro-magnets in which the wires are badly insulated are more powerful than those in which they are well insulated. This arose from the ignorant use of electro-magnets having long thin coils (of high resistance) with batteries consisting of a few cells (of low electromotive force). In such cases, if some of the coils are short-circuited, more current flows, and the magnetising power may be greater. But the scientific cure is either to re-wind the magnet with an appropriate coil of thick wire, or else to apply another battery having an electromotive force that is greater.

### Specifications of Electro-magnets.

One frequently comes across specifications for construction which prescribe that an electro-magnet shall be wound so that its coil shall have a certain resistance. This is an absurdity. Resistance does not help to magnetise the core. A better way of prescribing the winding is to name the ampere-turns and the temperature limit of heating. Another way is to prescribe the number of watts of energy which the magnet is to take. Indeed, it would be well if electricians could agree upon some sort of figure of merit by which to compare electro-magnets, which should take into account the magnetic output—*i.e.*, the product of magnetic flux into magnetomotive force—the consumption of energy in watts, the temperature rise, and the like.

### Amateur Rule about Resistance of Electro-magnet and Battery.

In dealing with this question of winding copper on a magnet core, I cannot desist from referring to that rule which is so often given, which I often wish might disappear from our text-books—the rule which tells you in effect that you are to waste 50 per cent. of the energy you employ. I refer to the rule which states that you will get the maximum effect out of an electro-magnet if you so wind it that the resistance is equal to the resistance of the battery you employ; or that if you have a magnet of a given resistance you ought to employ a battery of the same resistance. What is the meaning of this rule? It is a rule which is absolutely meaningless unless in the first case the volume of the coil is prescribed once for all, and you cannot alter it, or unless once for all the number of battery elements that you can have is prescribed. If you have to deal with a fixed number of battery elements, and you have to get out of them the biggest effect in your external circuit, and cannot beg, buy, or borrow any more cells, it is perfectly true that, for steady currents, you ought to group them so that their internal resistance is equal to the external resistance that they have to work through; and then, as a matter of fact, half the energy of the battery will be wasted, but the output will be a maximum. Now that is a very nice rule indeed for amateurs, because an amateur generally starts with the notion that he does not want to economise in his rate of working; it does not matter whether the battery is working away furiously, heating itself, and wasting a lot of power; all he wants is to have the biggest possible effect for a little time out of the fewest cells. It is purely an amateur's rule, therefore, about equating the resistance inside to the resistance outside. But it is absolutely fallacious to set up any such rule for serious working; and not only fallacious, but absolutely untrue if you are going to deal with currents that are going to be turned off and on quickly. For any apparatus like an electric bell, or rapid telegraph, or induction coil, or any of those things where the current is going to vary up and down rapidly, it is a false rule, as we shall see presently. What is the real point of view from which one ought to start? I am often asked questions by, shall I say, amateurs as well as by those who are not amateurs, about prescribing the battery for a given electro-magnet, or prescribing an electro-magnet for a given battery. Again, I am often told of cases of failure in which a very little common sense rightly directed might have made a success. What one ought to think about in every case is not the battery, not the electro-magnet, but *the line*. If you have a line, then you must have a battery and electro-magnet to correspond. If the line is short and thick, a few feet of good copper wire, you should have a short thick battery (a few big cells, or one big cell), and a short thick coil on your electro-magnet. If you have a long thin line, miles of it, say, you want a long thin battery (small cells, and a long row of them) and a long thin coil. That is then our rule; for a short thick line, a short thick battery, and a short thick coil; for a long thin line, a long thin battery; and electro-magnet coils to match. You smile: but it is a really good rule that I am giving you; vastly better than the worn-out amateur rule.

But, after all, my rule does not settle the whole question, because there is something more than the whole resistance of the circuit to be taken into account. Whenever you come to rapidly-acting apparatus, you have to think of the fact that the current, while varying, is governed not so much by the resistance as by the inertia of the circuit—its electro-magnetic inertia. As this is a matter which will claim our especial attention hereafter, I will leave battery rules for the present, and proceed with the question of design.

### Forms of Electro-magnets.

This at once leads us to consider the classification of forms of magnets. I do not pretend to have found a complete classification. There is a very singular book written by Mons. Nicklès, in which he classifies under 37 different heads all conceivable kinds of magnets, bidromic, tridomic, mononemic, multidromic, and I do not know how many more; but the classification is both unmeaning and unmanageable. For my present purposes I will simply pick out those which come under three or four heads, and deal separately with others that do not quite fit under any of the four categories.

*Bar Electro-magnets.*—In the first place there are those which have a straight core, of which there are several specimens on the table here.

*Horse-shoe Electro-magnets.*—Then there are the horse-shoes, of which some are of one piece bent, and others are of the more frequent shape, made of three pieces.

*Iron-clad Electro-magnets.*—Then from the horse-shoes I go to those magnets in which the return circuit of the iron comes back outside the coil either from one end or the other, or from both ends, sometimes in the form of an external tube or jacket, sometimes merely with a parallel return yoke, or two parallel return yokes.

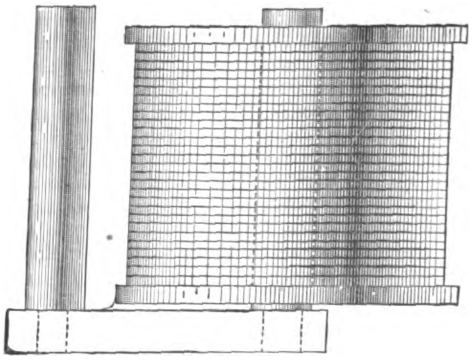


Fig. 50.—Club-footed Electro-magnet.

All such magnets I propose to call—following the fashion that has been adopted for dynamos—iron-clad electro-magnets. One of them, the jacketed electro-magnet, is shown in Fig. 12, and there are others not so well known. There is one used by Mr. Cromwell Varley, in which a straight magnet is placed between a couple of iron caps, which fit over the ends, and virtually bring the poles down close together; the circular rim of one cap being the north pole, and that of the other cap being the south pole, the two rims being close together. That plan of course produces a great tendency to leak across from one rim to the other all round. The advantages, as well as the disadvantages, of the jacketed magnet I alluded to in my last lecture, when I pointed out to you that for all action at a distance it is far better not to have an iron-clad return path, whereas for action in contact the iron-clad magnet was distinctly a very good form. In one form of iron-clad magnet the end of the straight central core is fixed to the middle of a bar of iron, the ends of which are bent up and brought flush with the top of the bobbin, making thus a tripolar magnet, with one pole between the other two. The armature in this form is a bar which lies right across the three poles. There is an example of this excellent kind of electromagnet applied in one of the forms of electric bell indicator made by Messrs. Gent, of Leicester.

Then besides these three main classes—the straight bar, the horse-shoe, and the iron-clad—there is another form which is so useful, and so commonly employed in certain work, that it deserves to have a name of its own. It is that called by Count Du Moncel the *aimant boiteux*, or club-footed magnet (Fig. 50). It is a horse-shoe, in fact, with a coil upon one pole and no coil upon the other. The advantage of that construction is simply, I suppose, that you will save labour—you will only have to wind the wire on one pole instead of two. Whether that is an improvement in any other sense is a question for experiment to determine; but on which theory perhaps might now be able to say something.

Digitized by Google

Count Du Moncel, who made may experiments on this form of magnet, ascertained that there was for an equal weight of copper a slight falling off in power with the club-footed magnet. Indeed one might almost predict, for a given weight of copper, if you wound all in one coil only, you will not make as many turns as if you wound it in two; the outer turns on the coil being so much larger than the average turn when wound in two coils. Consequently the number of ampere-turns with a given weight of copper would be rather smaller, and you would require more current to bring the magnetising power up to the same value as with the two coils. At the same time the one coil may be produced a little more cheaply than the two; and indeed such electromagnets are really quite common, being largely used, for the sake of cheapness and compactness, in indicators of electric bells.

Du Moncel tried various experiments about this form to find whether it acted better when the armature was pivotted over one pole or over the other, and found it worked best when the armature was actually hinged on to that pole which comes up through the coil. He made two experiments, trying coils on one or other limb, the armature being in each case set at an equal distance. In one experiment he found the pull was 35 grammes, with an armature hinged on to the idle pole, and 40 grammes when it was hinged on to the pole which carried the coil.

Another form of electromagnet, having but one coil, is used in the electric bells of church-bell pattern, of which Mr. H. Jensen is the designer. In Jensen's electromagnet a straight cylindrical core receives the bobbin for the coil, and, after this has been pushed into its place, two ovate pole-pieces are screwed upon its ends, serving thus to bring the magnetic circuit across the ends of the bobbin, and forming a magnetic gap along the side of the bobbin. The armature is a rectangular strip of soft iron, about the same length as the core, and is attracted at one end by one pole-piece, and at the other end by the other.

### Effect of Size of Coils.

Seeing that the magnetising power which a coil exerts on the magnetic circuit which it surrounds is simply proportional to the ampere-turns, it follows that those turns which lie on the outside layers of the coil, though they are further away from the iron core, possess precisely equal magnetising power. This is strictly true for all closed magnetic circuits; but in those open magnetic circuits where leakage occurs it is only true for those coils which encircle the leakage lines also. For example, in a short bar electro-magnet, of the wide turns on the outer layer, those which encircle the middle part of the bar do enclose all the magnetic lines, and are just as operative as the smaller turns that underlie them; whilst those wide turns which encircle the end portions of the bar are not so efficient, as some of the magnetic lines leak back past these coils.

### Effect of Position of Coils.

Among the other researches which Du Moncel made with respect to electro-magnets, was one on the best position for placing the coil upon the iron core. This is a matter that other experimenters have examined. In Dub's book, "Electromagnetismus," to which I have several times referred, you will also find many experiments on the best position of a coil; but it is perhaps sufficient to narrate a single example. Du Moncel had four pairs of bobbins made of exactly the same length, and with 50 metres of wire on each, one pair was 16 centimetres long, another pair 8 centimetres, or half the length, with not quite so many turns, because, of course, the diameter of the outer turns was larger, one 4 centimetres in length and another 2 centimetres. These were tried both with bar magnets and horse-shoes. It will suffice, perhaps, to give the result of the horse-shoe. The horse-shoe was made long enough—16 centimetres only, a little over 6in. long—to carry the longest coil. Now when the compact coils 2 centimetres long were used, the pull on the armature at a distance away of 2 millimetres (it was always the same, of course, in the experiments) was 40 grammes. Using the same weight of wire, but distributed on the coils twice as long, the pull was 55 grammes. Using the coils 8 centimetres long, it was 75 grammes; and using the coils 16 centimetres long, covering the length of each limb, the pull was 85, clearly showing that, where you have a given length of iron, the best way of winding a magnet to make it pull with its greatest pull is not to heap the coil up against the poles, but to wind it uniformly, for this mode of winding will give you more turns, therefore more ampere-turns, therefore more magnetisation. An exception might, however, occur in some case where there is a large percentage of leakage. With club-footed magnets results of the same kind are obtained. It was found in every case that it was well to distribute the coil as much as possible along the length of the limb. All these experiments were made with a steady current. It does not follow, however, because winding the wire over the whole length of core is best for steady currents that it is the best winding in the case of a rapidly varying current; indeed, we shall see that it is not.

*(To be continued.)*

## LONDON CHAMBER OF COMMERCE.

### MEETING OF THE ELECTRICAL TRADES' SECTION COMMITTEE.

A meeting of the Committee of the Electrical and Allied Trades' Section of the London Chamber of Commerce was held on Monday last at Botolph House, Eastcheap, under the presidency of Mr. R. E. Crompton (Chairman of the Committee). Amongst those present were Major Flood-Page and Messrs. Garcke, Swinburne, Erskine, Reeves, and Price. The minutes of the last meeting having been read by the Secretary of the Chambor (Mr. Kenric B. Murray,

The CHAIRMAN said that the first item on the agenda paper was the Board of Trade Rules. The committee was aware that four firms had memorialised the Board of Trade with a view of getting that department to introduce reasonable modifications into its "Regulations and Conditions for Securing the Safety of the Public, and for ensuring a proper and sufficient supply of Electrical Energy," and he suggested that a similar memorial be now sent to the Board of Trade by the Committee. Rule 33 of the New Rules was the one which appeared to him to be the most open to objection; indeed, as it stood, it was practically unworkable. This rule stipulated that:—"Every high-pressure aerial conductor shall be continuously insulated with a durable and efficient material to be approved by the Board of Trade, to a thickness of not less than one-tenth part of an inch; and in cases where the extreme difference of potential in the circuit exceeds 2,000 volts, the thickness of insulation shall not be less in inches or parts of an inch than the number obtained by dividing the number expressing the volts by 20,000. This insulation shall be further efficiently protected on the outside against injury or removal by abrasion. If this protection be wholly or partly metallic it shall be efficiently connected to earth." Such conductors, even for the smallest working current, could not be produced for less than £78 per mile, while a well-insulated conductor of the ordinary character could be turned out for £28 per mile. This meant a difference of several thousands of pounds to those engaged in running overhead wires. Rule 35, which ran as follows, was also open to objection:—"Every aerial high-pressure conductor shall be efficiently suspended by means of non-metallic ligaments to suspending wires, so that the weight of the conductor does not produce in it any sensible stress in the direction of its length, and the insulated conductors and suspending wires, where attached to supports, shall be in contact only with material of highly insulating quality, and shall be so attached and guarded, that in case they break away it shall not be possible for them to fall away clear of the support." He was of opinion that this was a case in which the section might well do its best to prevent the progress of the industry from being seriously hindered. The Council of the Institution of Electrical Engineers, so far as he could make out, were not inclined to take any steps in this matter until asked to by the Board of Trade.

In answer to a question by Major Flood-Page the CHAIRMAN said that the Board of Trade conductor was not, so he was assured by the Silvertown people, as safe as an ordinary insulated overhead wire.

Several gentlemen pointed out that the great thickness of the insulation rendered the centrality of the conductor very uncertain, moreover it was proposed to suspend this abnormally massive cable from leather or other similar ligaments which the weather would quickly rot away.

Major FLOOD-PAGE thought that if it could be brought home to the Board of Trade that their proposed overhead conductor, was, as a matter of fact, less safe than an ordinary overhead conductor, common sense would lead the department to revise its rules.

Mr. SWINBURNE pointed out that other rules than those referred to by the Chairman required revision. Thus rule 18 stipulated that transformers on the consumers' premises should be "completely enclosed in solid walls or in strong metal casing. . . ." The latter proviso affected the use of open-circuit transformers. He thought that the memorial should contain references to all the objectionable points in the rules.

Mr. GARCKE was astonished that such rules should have been framed without consultation with the trade.

Major FLOOD-PAGE suggested that perhaps the best course to take would be to pass a resolution to be forwarded to the Board of Trade asking them in the interest of the electrical industry to refer their rules again to the Council of the Institution of Electrical Engineers. The Committee might then ask the Council of the Institution to consider the matter together with them.

A discussion ensued, in the course of which it was pointed out that the previous communication of the Section to the Board of Trade on this subject had not received a very satisfactory reply (*The Electrician*, August 8, 1890, p. 385). The letter of the Board of Trade was then read by the Secretary, and it was unanimously resolved that the Chairman should be requested to bring the whole question before the general council of the Chamber at its next meeting, with a view of getting the Council to move in the matter, as one of a general trade interest.

Mr. GARCKE then brought forward the question of the Correspondent's duties. The matter, he said, had been left in the hands of the Chairman, Major Flood-Page and himself, and they, in conjunction with Mr. Murray, had gone very carefully into it. The outcome of their consultations was the following proposal:—That the Chairman and Vice-Chairman should be constituted into a sort of working executive committee. If the Chamber of Commerce could lend this sub-committee a little clerical assistance he thought its work would not trench unduly on the time of his colleagues and himself. If

Digitized by Google

this idea met with the approval of the Committee, the Section would possess an executive empowered to take prompt action in its name. The executive committee would, of course, report at every monthly meeting of the general committee.

Major FLOOD-PAGE pointed out that the Section was at present practically without an executive, hence many opportunities slipped by them for forwarding their general interests.

On the motion of Mr. PRICE, seconded by Mr. SWINBURNE, it was unanimously resolved to accept the admirable proposal of Mr. Garcke.

The CHAIRMAN then brought forward his scheme for the interchange of useful information. A circular letter had been prepared, also a couple of tables. He had devoted much time to the drawing up of the tables, and he now proposed that the letter and tables should, in the first instance, be sent to all the members of the Section for further suggestions, and with a view of gauging the probable amount of support the scheme would meet with; they could then be sent to electricians all over the world. The letter was then read, and copies of the tables distributed to those present.

Major FLOOD-PAGE thought that the Committee could hardly do better than agree to the letter and tables being sent out as a feeler. He begged to move that they be printed and circulated among all the members of the Section. The motion was agreed to.

Major FLOOD-PAGE said he hoped he was in order in referring to something not on the Agenda Paper; perhaps it would come under the head of "Other Matters," but he would like to know what was being done by those interested with regard to the Board of Trade form of accounts. It was really a very important question.

Mr. ERSKINE said that the supply company that he was connected with had been recently informed that the Board of Trade had a new form under consideration. The new form had not as yet been issued. One point with regard to these accounts was, he thought, worth calling attention to. The Board of Trade was proposing to make the supply companies write off depreciation on everything. Now, the water companies', and he thought the gas companies' plant was at its full value on their books, and a renewal account was kept up, depreciation only being written off works on leasehold property. The bearing of this on the question of purchase by local authorities was obvious.

After a few remarks by the Chairman on the valuable services recently rendered by the Chamber in preventing the formation of a monopoly in the Para rubber trade, the meeting terminated.

---

**The following is a copy of the circular letter and tables drawn up by Mr. Crompton :—**

*To the* SECRETARY *or* GENERAL MANAGER,

—— ———— *Lighting Company.*

DEAR SIR,—We shall be glad if you will bring before your Board of Directors or Board of Management (as the case may be) the following matter.

A great many English electrical engineers believe that the progress of the industry would be more rapid if there were, among the electrical engineers of all countries, a fuller interchange of ideas, and a freer publication of the data which are obtained in the practical working out of many of the great electrical problems which every day present themselves to us. It has been proposed at a meeting of the Electrical Section of the London Chamber of Commerce that steps should be taken to ascertain whether it is not possible to obtain mutual benefit from publication and circulation of a quarterly report compiled from data furnished not only from the various electrical manufacturers and electrical supply companies in the United Kingdom, but from those of the whole world, so far as it is possible to obtain them. In order to carry this out, it is thought that a start should be made in London by the Electrical Section of the London Chamber of Commerce, who would seek to add to their members as many foreign corresponding members as possible. With this end in view, I beg to ask you whether your Company would become members of such an international society. The terms of membership would be :—

(1.) A small subscription to meet the cost of printing, postage, &c.;

(2.) The members would be required to communicate to the head offices in London, from time to time, a correspondence letter giving in general terms the progress of the industry;

(3.) The members would be required to fill in, as far as they could do so without injury to themselves, on forms which should be from time to time furnished to them, the cost of production of electrical energy for lighting and power in a tabulated form under the various headings of material, labour, superintendence, wear and tear, renewals, and the other charges which go to make up the cost of production. In return for this they would each receive a copy of the quarterly report, in which would be added the whole of these correspondence letters, and the whole of the tabulated data.

We may add that the great steel industry of England and America, and on the continent, was very greatly benefited by a similar course in the early days of the Iron and Steel Institute, who took great pains to tabulate the results of blast furnaces, Bessemer convertors and such kinds of apparatus, and there is no doubt that enormous benefits accrued to that industry, from the study and comparison of the data obtained and circulated by means of the journal of the Iron and Steel Institute.

**Table I.**—*Efficiency at Varying Load Factors.*

| —— | A | B | C | D |
|---|---|---|---|---|
| Evaporative duty of boilers in pounds of water per pound of fuel ........ | ... | ... | ... | .. |
| Duty of engines in pounds of steam per I.H.P per hour ........ | ... | ... | ... | ... |
| Steam-engine efficiency or B.H.P. / I.H.P. | ... | ... | ... | ... |
| Dynamo efficiency or E.H.P. at terminals / B.H.P. of engines ... | ... | ... | ... | ... |
| Total generating efficiency or E.H.P. of dynamo / I.H P. of engines ...... | ... | ... | ... | ... |
| Distribution efficiency or E.H.P. deliv. to users... / E.H.P. at terminals ... | ... | ... | ... | ... |
| Total efficiency or E.H.P. deliv. to users... / I.H.P. of engines ...... | ... | ... | ... | ... |
| Load factor ........ | 100 | ... | ... | ... |

A. The figures for this column are those that have been obtained by actual test at trial runs at full power a sufficient number of hours to show that some results could be obtained from plant if run continuously the year round at full power. The 25 per cent. reserve plant being considered sufficient to allow every part of plant to be repaired and kept in thorough order. As such a condition has never yet been obtained in practice, of course, all figures must be calculated.

B. Figures from 12 months continuous working taken from the monthly or annual account of coal, water, and other materials used.

C. These figures to be the same as B, but for one month of heaviest load.

D. Same, for one month of lightest load.

By load factor is meant the relation which the actual output delivered to users bears to the actual output if plant were worked continuously throughout the year at its highest observed power. The factor for column A being 100.

For example: If the plant after allowing 25 per cent. for extra or reserve machinery is capable of delivering electrical energy to the consumer at the rate of 133 electrical horse-power, that is, 100 units per hour, or 8,760 hours × 100 = 876,000 units per annum. Then if the actual demand reached this figure, the load factor for columns B and A would be 100. But if the annual demand were 96,000 units, of which 12,000 was for December and 4,C00 for July, the load factors for B C D would be 11, 16·4, and 5·5 respectively.

**Table II.**—*Costs.*

| —— | B | | | C | | | D | | |
|---|---|---|---|---|---|---|---|---|---|
| | Per I. H. P. | Per Unit Generated. | Per Unit Sold. | — | — | — | — | — | — |
| Fuel ........ | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Water ........ | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Petty stores ........ | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Repairs and renewals of generating plant (inside) ........ | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Engine-room wages ........ | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Superintendence ........ | ... | ... | .. | ... | ... | ... | ... | ... | ... |
| Total cost of generating the energy | .. | ... | ... | ... | ... | ... | ... | ... | ... |
| Repairs and renewals of distributing plant ........ | ... | ... | ... | .. | ... | ... | ... | ... | ... |
| Wages outside generating station.. | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Superintendence do. do. | ... | ... | ... | ... | .. | ... | ... | ... | ... |
| Total cost of distribution ........ | ... | .. | ... | ... | ... | ... | ... | ... | ... |
| Total cost of producing and distributing the energy ........ | ... | ... | ... | ... | ... | ... | ... | ... | ... |

The columns B, C, D, correspond to similar columns in Table I., that is to say, the costs there recorded are to be annual, best and worst month respectively, in all cases to be from actual accounts, without deductions or allowances.

In order to bring repairs and renewal of plant to a common basis of calculation, it is requested that the annual sums to be divided into the units be taken at the following percentages on original cost of plant :—

Two and a-half per cent. on buildings, brickwork, and masonry.

Five per cent. on boilers, pipes, engines, dynamos, switchboards, and all cables or other conductors, covered with continuous insulation.

One per cent. on bare conductors, insulated by means of glass, porcelain, or other such like imperishable materials.

Fifteen per cent. on accumulators and transformers.

Superintendence.—The wages of same to be divided between costs of generating and distributing according to time occupied by each.

Digitized by Google

## SOUTH AUSTRALIA.

### POSTAL AND TELEGRAPH CONFERENCE HELD AT ADELAIDE, MAY, 1890.

The following is the text of the resolutions relating to Telegraph Service passed at the above conference, and signed by the Postmasters-General of New South Wales, Victoria, South Australia, Queensland,* and Tasmania.

1. That the following terms for reduction of cable rates, as proposed by the Eastern Extension Telegraph Company, be accepted, namely:—"Firstly, the tariff will be reduced to 4s. for ordinary messages, 3s. 6d. for Government messages, and 1s. 10d. for press messages during one year of trial. If at the end of the first year no very serious loss is involved, the experiment will be continued for two years more, and such extension must be at the option of the Company. If the loss should be nearly recovered at the end of the three years, the arrangement will be extended for the remainder of the subsidy. The whole proposal is conditional upon South Australia accepting 5d.—the transit rate." (Queensland dissented.)

2. "That in the event of South Australia reducing the telegraph rates on the trans-continental line, in accordance with any resolution agreed to by this Conference, the several colonies represented at this Conference, including South Australia, agree on the basis of population to guarantee to South Australia a revenue from the line equivalent to that received at present." (Queensland dissented.)

3. "That any colony or country not joining in the contribution to subsidy and guarantee, shall pay proportionately higher rates."

4. "That it be a recommendation to the various Governments represented at this Conference—1. That between any two contiguous colonies 1s. shall be the initial charge for twelve words, and 1½d. for each additional word; names and addresses to be paid for. 2. Between any three colonies 1s. 6d. to be the minimum charge for twelve words, and 2d. for each additional word. 3. Between Queensland and Western Australia 2s. to be the minimum charge for twelve words, and 3d. for every extra word. 4. Tasmania to be a minimum rate of 6d. for twelve words for each colony, plus the cable rates. Twelve words to be considered the minimum rate. Addresses and signatures to be paid for, and code addresses to be prohibited. 5. That the reduced rates come into operation on January 1st, 1891."

5. "That it is considered desirable to adopt a system of urgent telegrams, at double rates, locally and intercolonially."

6. "That the Uniform Intercolonial Telegraph Regulations, as drawn by heads of departments, be adopted."

7. "That in the opinion of this Conference it is very desirable that the heads of the Post and Telegraph Departments of the Australian colonies should frequently meet—annually, if possible—to consider and report to their respective Governments on all questions affecting the postal and telegraphic services generally."

8. "That the President forward to his Excellency the Governor of South Australia a copy of the resolutions agreed to by the Conference regarding the reduction of postal and cable rates to the United Kingdom, requesting that his Excellency will forward it to the British Government by cable, with the expression of the earnest desire of this Conference that, as England is equally interested with the colonies in securing and maintaining cheap telegraphic communication, the proposal of the Conference that Great Britain should contribute towards the subsidies and guarantees required may be accepted by the Imperial Government.

9. "That the President inform the Agent-General of South Australia of the acceptance by the Conference of the amended offer of the Eastern Extension Cable Company, and request him to confer with the Agents-General of the several colonies represented at this Conference in order that they may jointly urge upon the Imperial Government their acceptance of the proposal that England should contribute one-half of the subsidies and guarantees required in order to secure the reduced rates agreed to for telegraphic communication between England and the colonies of Australasia."

* Resolutions 4, 6, 7, 8, and 9 were passed after the Queensland Postmaster General had left the conference, and have not been assented to by him.

## THE CANADIAN GOVERNMENT TELEGRAPH AND SIGNAL SERVICE.

Under the direction of Sir Hector Langevin, Minister of Public Works, and the management of Mr. Gisborne, C.E., the Canadian Government have during the last decade gradually extended their telegraph and signal systems along their Atlantic, Gulf of St. Lawrence, and Pacific coast lines, submarine cables connecting the principal outlying islands dangerous to navigation. During the present season another cable has been laid from the west-end of the Island of Anticosti to Long Point, Mingan, some 600 miles below Quebec. When laying this cable one of the men in the tank stumbled, was caught by the cable, and instantly drawn through a 5½in. by 3ft. space between the top of the cone and the rigid 2in. iron ring known as the crinoline. The man's scalp was badly torn, chest crushed, two or three ribs and one leg broken, the cable snapping apart under the prompt application of the break. The poor man was promptly landed at Gaspe, and is now on the highroad to complete recovery. This parted cable having been duly recovered, and the laying successfully completed, the Government steamer "Newfield" then proceeded to Bird Rock, Magdalen Islands. This is a small island, 20 nautical miles distant from the group, having a superficial area of seven acres only, with overhanging cliffs from 110ft. to 140ft. in altitude, and upon which is a lighthouse and signalling station. The surrouding waters are shallow, viz., from two to three fathoms deep, with a flat rock bottom, covered with huge boulders, which move during heavy gales and when ice is running.

Notwithstanding every precaution, and the use of abnormally heavy shore end cables, eight seasons out of ten the line was out of order just at the time when reports as to the movements of the Gulf ice would have been of utility to passing shipping. The Government, therefore, decided upon abandoning the station in favour of one upon St. Paul's Island, at the entrance of the Gulf, between Cape Ray, Newfoundland, and Cape Breton, Nova Scotia, distant 20 nautical miles from West Cove station, on Cape Breton. The recovery, repairing, and relaying of the Bird Rock cable was entrusted to the skill of Captain Guildford, of the Government cable steamer "Newfield," and to Mr. Hartley Gisborne, son of the General Superintendent. Although over 10 years submerged, the deep-sea portion was recovered in half-a-dozen sections all in good condition, even the asphalte covering being intact wherever embedded in sand or mud, but entirely eaten away where it rested upon rock and seaweed. Some 16 miles of the recovered cable was thus available for the St. Paul's Island connection, which was duly completed, and is now operated by telephone. That the joints were skilfully made is best attested by the fact that "the Gaelic" spoken through the cable has not broken down the insulation! The "Newfield" next proceeded to the Bay of Fundy, where the Grand Manom Cable was repaired after being damaged by anchorage, and Cheney and White Head Islands of that group were connected with the Government system.

It now remains for the Canadian Government to connect that "graveyard" of the maritime world, Sable Island, with the mainland of Nova Scotia, only 100 miles distant from Halifax, to complete a service which has lately elicited the highest commendations from Sir George Baden-Powell, who is to report upon a similar telegraph and signal-service system for the British Isles at the next Session of the Imperial Parliament.

## PARIS NOTES.

(FROM OUR OWN CORRESPONDENT.)

PARIS, *November* 10, 1890.

The Préfecture de la Seine has just granted the Compagnie Parisienne d'Éclairage et de Chauffage par le Gaz a prolongation of its concession. The terms of this concession have now to be submitted to the Conseil Municipal for its approval. The Gas Company agrees to reduce the price of gas for lighting purposes from 30 to 25 centimes per cubic metre—that is to say, from 7s. 6d. to 6s. 3d. per thousand, and from 30 to 20 centimes in the case of gas engines, &c. The Company, moreover, engages to distribute one-half of its profits when they exceed 38,000,000fr. (£1,520,000) to the consumers. In return for this the Company is to have its concession prolonged from December 31, 1905, to the end of 1930, and it is authorised to exploit any system of lighting and heating whatsoever, including, of course, "*the electric light and other applications of electricity.*" The receipts of the Gas Company for the first nine months of the present year exhibit a falling off of nearly 3 per cent., compared with those of the corresponding period last year. The figures for August and September of this year are still more remarkable when compared with those for the same months of 1889, showing, as they do, a diminution of respectively nearly 8 and 6 per cent.

The sub-stations of the Popp Company have come into operation within the last few days. Each of the 33 sub-stations contains a large battery of Laurent-Cély accumulators. The sub-stations are divided into groups, the sub-stations in each group being connected in series with a dynamo situated in an eccentric station. The charging dynamos give 70 amperes at a pressure of 3,000 volts. The cables are highly insulated, and are run in rectangular cast-iron troughs. The batteries are divided into halves, so that one half can be connected to the charging main, while the other is connected to the supply mains. The feeders from each sub-station join a network common to the whole system. The Popp Company has, it will thus be seen, renounced the idea of building compressed air sub-stations, and carries out its distribution on purely electrical lines.

In consequence of the fire at the Grand Café, to which you referred in your last issue, the Conseil Municipal has decreed that

Digitized by Google

electric lighting is a dangerous industry, and have submitted it to the police supervision usual under such circumstances.

The contracts for the various works connected with the erection of the new Paris Central Telephone Exchange were awarded on Saturday. On the same day the official decrees relating to interurban telephonic conversation was published. A unit of conversation is fixed, and the price varies according to distance. With a view of fostering the growth of "réseaux téléphoniques secondaires" (suburban systems) the urban rentals in the case of towns of not more than 25,000 inhabitants have been reduced to 150fs. per annum.

At the meeting of the Société Internationale des Électriciens on Wednesday last week, M. G. Dumont read a long Paper on the "Applications of Electricity to Railways." He recalled the fact that it was Cook who, in England, first made use of the needle telegraph to facilitate the working of a railway. He next described the various systems of electric signals and the various block systems, automatic or otherwise, employed in the chief countries of the world. M. Gaston Roux showed an indicator by which one is able to read directly in per cent. from an equally-divided scale the exact state of charge of an accumulator. The action of the apparatus, it is needless to say, is based on the variation of the density of the electrolyte.

## CORRESPONDENCE.

### THE WESTMINSTER ELECTRIC SUPPLY CORPORATION.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: With reference to your kind notice of the work of this Corporation in last week's *Electrician*, will you let me supply one omission, viz., that the whole of the architectural work for the three stations, which has been very heavy and important, has been carried out by Mr. C. Stanley Peach, of 8, John-street, Adelphi.—Yours, &c., A. H. W. Kennedy.

Victoria Mansions, Victoria-street, S.W., Nov. 7, 1890.

### A NEW EMPIRICAL FORMULA FOR THE AIR-SPACE OF DYNAMOS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: The following are the results of comparisons of a number of dynamos designed by me showing how the magnetic induction in dynamo-machines depends on the magnetising force:—

1. The total induction through the armature is proportional to the ratio of the magnetising force and the magnetic resistance (Kapp).

2. The magnetic resistance of iron of a given susceptibility is proportional to the ratio of length and cross-section of the path of induction (Kapp).

3. The resistance of air is proportional to the ratio of the length squared and the cross-section of the path (the Writer).

Hence, whilst the magnetic resistance between two parallel sides of a cube of iron is inversely proportional to the linear dimensions of the cube, *the resistance between two parallel sides of a cube of air is the same whatever be the dimensions of the cube.*

In dynamo-machines, with wrought-iron circuit, working at normal load, with 72,000 useful lines, C.-G.-S. per square inch in field magnet and 86,000 per square inch in armature core, if:—

$\beta$ = magnetic resistance of a cube of air.
$\gamma$ = " " " iron, the sides of which are 1in. long,
$m$ = total number of lines C.-G.-S. through armature,
F = magnetising force in ampère turns on field magnet,
Then I find:—

$$\beta = \cdot 0905$$
$$\gamma = \cdot 00294,$$

or, taking a kiloline (1,000 lines C.-G.-S.) as the unit of induction and denoting the total induction in kilolines by M:—

$$\beta = 90 \cdot 5$$
$$\gamma = 2 \cdot 94$$

$$\therefore M = \frac{F}{90 \cdot 5 \frac{\lambda^2}{\sigma} + 2 \cdot 94 \left( \frac{l_a}{s_a} + \frac{l_f}{s} \right)}$$

where $\lambda$, $l_a$, $l_f$ are the lengths and $\sigma$, $s_a$, $s_f$ the cross-sections of air space (total), armature, and field magnet core respectively, the unit of length in the last member under the line being 1in. $\gamma$ depends upon the susceptibility of the iron. With the densities used above, this is about the same in the charcoal discs in the armature as in the forgings of the magnets.

I hope to give figures proving my new theory in a short time.—Yours truly, F. V. Andersen.

November 10, 1890.

### LIFE OF GLOW LAMPS ON THE SERIES SYSTEM.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In the discussion on Mr. Bernstein's Paper on the Series System, read in the Institution of Electrical Engineers in 1886, Mr. Mordey expressed the opinion that lamps on a circuit of constant current must of necessity be shorter lived than lamps on a parallel circuit; the reason being that the resistance of lamps rises in course of time. If placed in parallel, they will then take less current, give less light, but have a considerable preservative power.

This view appears very plausible, and it will, therefore, be of interest to many readers to hear that a Bernstein lamp, which was placed on a circuit of constant current of 10 amperes in Niagara-in-London, has been in use more than three years every night except Sundays, and has already lasted more than 10,000 hours. During the present year it has been run twelve hours daily.

The system on which this lamp has been run is known as the Woods system of arc lighting, and is owned by the Fort Wayne Electric Company of Indiana.—Yours, &c.,

Niagara-in-London. Frank Lott,
November 7, 1890. Electrical Engineer-in-Charge.

## TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

Tenders Invited.—Sealed tenders will be received by the Municipal Commissioner for the City of Bombay up to 1 p.m. on Monday, the 16th February next, for experimental lighting by electricity of certain streets of the City of Bombay for a period of two years. Forms of tender and schedule of conditions, and a sketch of the portion of the city, showing the streets to be lighted, may, on payment of £1 sterling, be obtained from Messrs. E. W. and R. Oliver, 1, Corbet-court, Gracechurch-street, London, E.C., who will on application give any further information that may be required. Further particulars are given in our advertisement columns.

The Lane Fox Electrical Company (Limited).—This Company have this week issued a notice cautioning Electric Light Supply Companies against the unauthorised use of the system of electric lighting covered by the Lane Fox Patents, with special reference to Nos. 3,988** and 4,626, both of 1878. A complete list of licensees is announced as nearly ready, and further particulars will be found in our advertisement pages.

*Re* Magnus Volk.—We are informed that Mr. Bramwell, who was appointed trustee of the estate of Mr. Volk, has been removed, and a meeting was held yesterday at Brighton to appoint his successor. It is expected that a second dividend will shortly be announced.

Lighting at the Guildhall.—On the occasion of the Lord Mayor's Banquet, at the Guildhall, on the evening of the 10th inst., the hall was illuminated by about 500 incandescent lamps, artistically attached to the gasoliers above the tables, and the excellent effect produced was greatly admired. The installation was carried out at very short notice by the Brush Electrical Engineering Company, in whose district the Guildhall is situated.

Messrs. Davey, Paxman, and Co.—Removal Notice.—This firm have removed their London offices to larger and more convenient premises, No. 78, Queen Victoria-street, E.C. Telegrams intended for the London office should be addressed "Paxman, London," and the firm's London telephone number is 1697.

Messrs. Taylor, Tunnicliff, and Co.—This firm, who are extensively engaged in the manufacture of porcelain fittings for the electric lighting trade, have recently completed special machinery for tapping with a very fine thread the small holes in porcelain switches, cut-outs, ceiling roses, &c., thus enabling manufacturers

Digitized by Google

to fit these articles up with metal work without the objectionable metal nuts, &c., at the back of the fittings. This will supply a want much felt by electricians engaged in fitting up these goods. The metal nuts have hitherto been a fruitful source of short circuiting.

Messrs. J. D. F. Andrews and Co.—This firm have purchased the goodwill and assets of the firm of Messrs. White, Romanze, and Co., Kingsbury-road, Dalston; and 3 and 4, Great Winchester-street, E.C., who have been carrying on the manufacture of arc lamps, switches, &c., and also telephones, type-printing instruments, and electric bells, besides electric light contracts. Messrs. Andrews and Co. intend continuing all the manufactures hitherto carried on by the late firm, but they are about to remove the machinery from Dalston at an early date to more commodious premises. Mr. Fred. White, of the above firm, who is well known in connection with electric light and telephone work, has assumed the position of manager with Messrs. J. D. F. Andrews and Co.

Messrs. Arthur B. Gill and Co.—This Company have just completed the necessary alterations to their large and convenient show-rooms and stores at 36, Parliament-street, Westminster, S.W., where they are showing and storing all kinds of electrical goods and manufactures. A large stock of Henley cables and wires will also be kept.

Herr J. Obermaier.—This firm has recently built near the town of Nürnberg a large new factory for the manufacture of electric light, telegraph, telephone, and power transmission wires and cables. The firm is an old established one, having been in existence in Nürnberg over 15 years; and we understand that the large extension of premises is owing to a very considerable increase of business.

The Jerome Kidder Manufacturing Company.—We have received this Company's catalogue, which contains illustrated particulars and prices of their electro-surgical appliances. Over 100 appliances are illustrated.

## PATENT RECORD.

### APPLICATIONS FOR PATENTS.

Note.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

October 27, 1890.

17,112. F. Bosshardt. Manchester. An automatic apparatus for the control of torpedo batteries (J. de Petroff, France).

October 28, 1890.

17,181. H. J. Allison. London. Improved electric switch (J. A. K. McGregor, H. Wallach, and S. J. Wallach, United States).

17,247. M. W. Dewey. London. Improvements in electric apparatus for transmitting motion.

17,266. J. C. Fell. London. Improvements in electric railways (C. Richter, United States).

October 29, 1890.

17,277. R. Wotherspoon, Glasgow. An improved method of and apparatus for the electrical treatment of sewage, wines, oils, air, gases, and other fluids (H. Rowley, Australia).

17,308. C. W. Cox and F. Robinson. Liverpool. Improved switch for electric light.

17,309. C. W. Cox, F. Robinson, and W. H. Gritton. Liverpool. An improved method of lighting ship's side, mast-head, and signal lamps by electric light.

17,322. E. Hartmann and W. Braun. London. Improvements in telephones.

17,327. H. W. Miller. London. An improved electric meter.

### SPECIFICATIONS PUBLISHED.

1889.

15,733. Ducretet. Electrical signalling apparatus. (Price 8d.)
16,237. De Ferranti. Electrical mains. (Price 8d.)
17,819. Slatter & Rixon. Electric switches. (Price 8d.)
17,915. Gisborne (Keeley). Telegraph circuits. (Price 8d.)
18,350. Davies. Dynamo-electric machines. (Price 8d.)
18,604. Perry and Others. Measuring, &c., electric currents. (Price 6d.)
18,755. Reckenzaun. Secondary batteries. (Price 6d.)
19,011. Hopkinson. Dynamo-electric machines. (Price 8d.)
19,081. Wreden. Micro-telephonic apparatus for drivers. (Price 8d.)
19,190. Lovell and Lloyd. Induction coils, &c. (Price 6d.)
19,554. Von Dolivo-Dobrowolski and Others. Alternating-current generators. (Price 11d.)
19,555. Von Dolivo-Dobrowolski and Others. Electrical induction transformers. (Price 8d.)

## COMPANIES' MEETINGS.

### Western and Brazilian Telegraph Company (Limited).

The twentieth ordinary general meeting of this Company was held at Winchester House, Old Broad-street, yesterday, Mr. W. S. Andrews in the chair.

The SECRETARY (Mr. R. M. Cunningham) read the notice convening the meeting, and the minutes of the last meeting, which were approved and signed by the Chairman as correct. The report of the Directors was taken as read.

The CHAIRMAN: The outcome of our last half-year's working as compared with that of the corresponding period of the previous year is an improvement in the gross receipts. That is always a satisfactory fact. It is not a large improvement, but it is in the right direction. In the corresponding half-year of 1889 your revenue amounted to £86,556, and in the past half-year to £89,846, showing an increase of £3,290. The increase really in traffic is larger than that, because the revenue in the corresponding period a year ago was increased by a profit on exchange amounting to £2,482. This half-year there has not alone been no profit by exchange, but there has been a loss, therefore that £3,290 does not represent the increase that we have had in message work, because we have had to do message work to make up the two items I speak of—the £2,682 and the £730. Turning to the expenditure, the total amount under abstracts A, B, and C for the corresponding period of last year was £32,772, while for the last half-year it was £33,342, or an increase of £569. In analysing the figures under abstract A, the amount was £16,885 in the June half of 1889, whereas for the past half-year the amount was £17,320, or a total increase of £434; increases being under five heads and decreases under ten, the upshot being the figure I named. I will go further into these items if you like, though I do not know that it will be worth while, as the total is only the sum mentioned. I shall be happy to do so if you wish it. The next we come to is abstract B. There again the difference in the total is extremely small, the increase being only £220. I will go into that if you like, or I will not further deal with it; it is hardly worth while. Then with reference to abstract C, which deals with the London expenses, I know that you always like to look at them a little narrowly, but if you do you will only find in the total a decrease of £86, made up of various little items. This leaves the total increase under all these heads £569. In the balance-sheet you find that we have set aside this year an increased sum of £1,000 for depreciation of ships. You find there has been less cable used to the extent of £800, and that again, as the outcome of all these figures, your increase in revenue is £3,290, while your increase in expenses is £569, your balance brought down amounting to £49,337, against, in the corresponding period of last year, £47,451. That, therefore, is an increase in the balance of £1,886, which is of course satisfactory. To the £49,337 must be added £3,248 brought forward and £7,385 received in dividends from the Platino Company, making £59,970. Then deducting £13,220 paid for Debenture interest, £7,500 for renewal fund, and £5,880 for Debenture redemption fund, there is £33,370 left. The Directors recommend you to delare a dividend at the rate of 4 per cent. per annum, and to carry forward £5,751 to the current half-year. If you agree to our resolution for the dividend, we propose to make it payable to-morrow. That I think disposes of the financial aspect of this period, and you see that there has been nothing very eventful. It has been quite an ordinary state of affairs. That, however, does not hold quite good with respect to what I may call the political aspect of the period compared with the political aspect at the present time. No doubt you will remember that when we met twelve months ago we were in rather a "parlous" condition. The Brazilian Government had absolutely refused to permit us to lay the new cables, the putting down of which you had approved, and of course in face of that prohibition it was quite impossible for us to proceed. In other respects, too, the position out in Brazil was extremely unsatisfactory. That is about as mild as I can put it. You will remember that on that occasion we went very fully into the questions between us and the Government. We read to you all the points of the concessions. We read to you the communications that had passed, and, in fact, I think we kept back no single item of any kind. Well, since that period, immediately after our meeting—within 24 hours of it, I think—there was a change of Government in Brazil, and instead of having to deal with an Empire we had to treat with a Republic. I am glad to say that our experience, as you will have gathered from the paragraph in the report with respect to loops, was more satisfactory with the Republican Government than with the Imperial. We first tried to do all we could to obtain the support of the British Government. Lord Salisbury met us in a very fair spirit. He inquired very fully into everything; the result of his inquiries was in our favour, and we obtained the moral support of our Government. I believe that that has done us much benefit, because the Government has, of course, no direct interest in the increase or decrease of dividends of a private Company like ours. This fact must have been pretty well appreciated by the Government of Brazil, and it has done a great deal for us. Our representative out there was exceedingly accurate, able, and prudent, conducting the negotiations in such a way as to earn the satisfaction of the Board. Of course, with a great Empire like Brazil, neither the Company nor any Government could bring pressure to bear. If we could not have convinced the Government we could have done nothing; but, fortunately, we succeeded in convincing them. We relied on the strength of our case, the weight of our evidence, and the sense of justice of the Government, and, fortunately, the latter has proved favourable to us. They have seen that any step of this kind must redound, as it has already redounded, to the credit of the Government in the financial centres of the

Digitized by Google

world, and that it must also benefit the commerce of the country. These loops, I am pleased to say, were eventually authorised to be made. I do not propose to go into any further detail with respect to our relations with the Brazilian Government, except to say that they are decidedly more satisfactory than they were; but I think in drawing attention to the activity, prudence, and discretion, I think I may say, of the Board. I ought, with the approval of my colleagues, to make special mention of the valuable services of Major Wood, Managing Director, and of the activity and energy of our worthy Secretary. In fact, we have been able to pull through, and I think we have benefited ourselves a great deal. Of course you are not to suppose that the laying of these cables will produce an increased revenue. That was not the object. The object is, of course, to enable us to fulfil our concessional obligations more effectually, and at the same time safeguard the line against interruptions. Of course, the effect of that is that we do not sustain loss of revenue by interruptions, and to that extent there is a financial gain. In the same way you will remember that under our agreement with the Brazilian Company we were to forfeit a sum of £5,000 a year. Of course, you will not have to forfeit that; and altogether the results of our laying the loops will be beneficial for our service, and will tend, I think, to ensure the position and stability of the Company. There is a special question before us to-day, namely, the purchase of the undertaking of the Montevidean and Brazilian Company. Our position at present, as most of you will remember, is this—we have an agreement with the Platino Company and the Montevidean Company. The Montevidean part of it goes to this, that it constitutes a second charge upon our gross revenue, because we have to give that Company a proportion of our gross receipts subject only to our A Debentures. That is, of course, an unsatisfactory thing, and we have been desirous of getting rid of it for some time. In addition to that, moreover, the same motive which involved our arrangement with the Platino Company, which was carried out a year or two ago, and which, I may say, has operated most satisfactorily, and proved a very advantageous arrangement in all respects, prevailed in this case, namely, consolidation of management. We do not want—you will all readily see the inconvenience of it—an administration interposed between us and the end of our line. We want to be perfectly free. We want to have full and complete control of this undertaking. Now, of course, in considering this we had, besides looking at it from the working point of view, to consider the financial point; and though we thought it advisable to acquire this thing, we only thought it advisable to acquire it at a price. The price works out in this way. That the amount we are now paying this Company from our gross revenue will pay upon the amount of shares which we give to this Company as the purchase price of their entire undertaking just 5 per cent. I do not think that that is a bad arrangement. Of course that Company does not pay 5 per cent., as it has to provide for Debenture redemption and ordinary expenses of management; but the capital will work out in this way: The Debenture and share capital combined of the Montevidean Company amounts to £96,640. For this we pay in our fully paid-up shares, taken at par value, £79,500, and, as I said, the purchase price upon that shows 5 per cent. We thus get rid of a charge coming in between the A and B Debentures, and we substitute for that charge a body of gentlemen—shareholders in the Company—who will be in precisely the same position as all of you. They will depend upon the profits for their dividend. They will be with you in prosperity, I hope, exclusively. The agreement will be read to you presently, and, therefore, I will not further describe it. I will now move the following resolution:—

*"That the report and accounts for the half-year ended June 30, 1890, now submitted, be and the same are hereby approved and adopted, and that a dividend of 6s. per share, being at the rate of 4 per cent. (free of income tax) be and is hereby declared payable on the 15th inst."*

Mr. C. W. EARLE seconded the motion.

The CHAIRMAN: The report has been moved and seconded, but before I put it to the meeting I shall be happy, if the shareholders wish to ask any questions, to reply to them to the best of my ability.

Mr. COPPIN congratulated the Board on the improved condition in which the Company appeared to be owing to the way in which the Directors had conducted the business in the past six months, especially in connection with the negotiations for laying the loop lines. If there was any feature at all that was regrettable, it was the increased expenditure. He had imagined from their improved income that they would have had a little better dividend on the present occasion than 4 per cent. Still, he presumed that the same care had been bestowed on the expenditure which had generally marked the working of the Board, and he hoped that in the future they would try, as far as possible, to keep down the very large expenditure which they had had to put up with in the last two or three half-years. It was, he said, scarcely fair to compare the expenditure of the past half-year with that of the corresponding period of the previous year, because in the June half of 1889 they had some extraordinary expenses. One of the ships was laid up for some time, and that accounted for an expense of some £7,000 or £8,000, the expenditure of the first half of 1889 being brought up to £39,104 against £32,000 in the same period of 1888. Between the June half of 1888 and the same period this year he found that their expenses had increased by £7,500, while their income had increased by only £3,000. It was very difficult for shareholders to put their fingers on the different items; but he hoped that the Directors would remember in all their transactions, while maintaining the efficiency of the cables, to keep as far as possible within necessary expenditure, especially abroad. It was there that the expenses occurred. The home office expenses did not appear to increase at all. With regard to the proposed agreement with the Montevidean Company, he would like to hear from the Chairman whether this line—it was only a small section, he believed, and it was necessary that they should have the control of it—would increase their dividend. They were going to pay a price for the undertaking of the other Company, which the Chairman had told them represented 5 per cent. calculated on the amount they were now paying to the other Company. That 5 per cent. would be a fixed charge.

The CHAIRMAN: No.

Mr. COPPIN: It was not a guarantee, but they would be paying this rate.

The CHAIRMAN: I think I have not made myself clear. We purchased that undertaking for ordinary shares in our Company. On the shares that we pay for the purchase of that undertaking the amount which we now have to pay them from our gross receipts shows exactly 5 per cent. There is no fixed charge of any kind.

Mr. COPPIN said he understood this; but the amount this Company would have to pay for the right of running over the Montevidean Company's line would represent a dividend of 5 per cent. on the shares which they would give to that company. Then if the expenses of working the Montevidean line were in the same proportion as the expenses of working the other portion of the line, between 40 and 50 per cent.——

The CHAIRMAN: They will be *nil*. There will be no working expenses in respect of that.

Mr. COPPIN said that that cleared the point. He had been only anxious to know whether, in taking over this line, they were going to increase their expenses. This was all that he had to say, and he thought that, on the whole, the Directors and the shareholders were to be congratulated on the very improved condition of the affairs of the Company.

The CHAIRMAN: There are one or two observations which Mr. Coppin has very properly made which would have been dealt with by me but for the desire I felt not to take up too much of your time. I did mention the exchange as a thing that we had to earn by increased labour, which cost no labour at all when it was in our favour. But there is something else, which, no doubt, you will remember, for it is a fact which is far more important and grave in its incidence than the question of exchange, and that is the reduction of tariff. You will remember that some time back we made a very large reduction in the tariff. I have been extremely surprised to see the way in which it has recouped itself, owing to the peculiar state of things which has been prevailing in the Argentine Confederation and Brazil. We are actually earning more money with a considerably reduced tariff; but that involves something. It involves more work; and if I had gone on to explain these items, I should have told you that in addition to that difference in the exchange, and of gain and loss in exchange, we have had to make up the sum lost by the reduction in the tariff and the transmission of increased work; and what do you think that that work amounts to? To 26 per cent. An increase of 26 per cent. in the work of the Company, I need scarcely tell you, cannot be done for nothing. We have had to extend our hours of work; to apply a duplex in one part of our system where there was a bit of congestion, and that means double staff, double work, and double hours. We have had to open a new station at Chuy, and to do several other things. I think that shows pretty clearly that we have kept an eye on our expenses; and as to this general sheet respecting foreign expenses, Mr. Coppin says we spend our money abroad; but it is there where, I would equally observe, we earn our money, and therefore that is where we must spend it. With respect, however, to this matter, there were, as I have said already, five items in which there were increases of expenditure, and ten items in which there were decreases. That, I think, shows that where we can arrive at a decrease we do so. With respect to the ships, there, again, two or three things come in. The "Buccaneer," in the corresponding half of the previous year, was responsible for £3,200. You will remember that the "Buccaneer" was in commission instead of the "Norseman." The reason why there is a large increase in the expenses of the "Norseman" this year is that there has been no "Buccaneer," the "Norseman" having been at work the whole six months; and mark this, which is an important fact as showing the way in which we put our finger down upon expenses, that the great increase there has been in coal, which was £1,500 more. We did try—I daresay the shareholders may remember it—to send out coal on our own account, but the effect was that when we wanted coal anywhere else we could not get it. They said, "If you are coming out with your coal, we will 'salt' you when you have not any." We therefore had to pay the local price of the coal, which, as I said, has cost us this half-year £1,500 more. If it had not been for this increase of £1,500, there would have been a reduction instead of an increase in ships' expenses. Well, gentlemen, the report has been moved and seconded, and I will now put it. Having submitted the motion in the usual way, he declared it carried. Continuing, he moved the following resolution:—

*"That the agreement, dated November 3, 1890, between the Montevidean and Brazilian Telegraph Company and this Company for the acquisition by this Company of the undertaking of the said Montevidean Company be and the same is hereby approved and confirmed, and that the Board are authorised to carry the same into effect."*

The MANAGING DIRECTOR (Major Wood) seconded the motion.

Mr. BOMPAS afterwards read the proposed agreement between the two Companies. It stated that the shares which were to be issued to the Montevidean Company in payment for their undertaking were not to rank for dividend until after January 1st next.

Mr. COPPIN inquired whether the Directors had any information as to the condition of the line. Was it in fair condition?

The CHAIRMAN: We have to maintain it ourselves; we maintain it and work it. It is in excellent condition. He then put the motion, and having declared it carried, stated that there was no other business before the meeting, and he thanked them for their attendance.

A SHAREHOLDER proposed a cordial vote of thanks to the Chairman and Directors for the way in which the affairs of the Company had been managed and explained to them.

The motion was seconded, and carried unanimously.

The CHAIRMAN: I thank you very sincerely for the hearty way in which you have been good enough to receive and pass this vote.

The proceedings then terminated.

Digitized by Google

## The West India and Panama Telegraph Company (Limited).

The twenty-seventh ordinary general meeting of the members of the West India and Panama Telegraph Company, Limited (incorporated January 9. 1877), was held in Room 47, Winchester House, 50, Old Broad-street, on Wednesday, November 12th, to receive the report of the Directors and the accounts for the six months ended June 30, 1890, to declare dividends and to transact other businsss of the Company. Mr. C. W. Earle presided.

Mr. R. T. BROWN (the Secretary) read the notice calling the meeting and the minutes of the last meeting, which were confirmed and signed as a correct record.

The report of the Directors was taken as read.

The CHAIRMAN, in moving the adoption of the report and statement of account to June 30th, said that it was the most satisfactory one that the Directors had laid before the shareholders of the Company. However, at the best it could not be called a good account, and so long as the condition of the field in which they worked remained as it was now, he regretted to say that he did not see the possibility of their position becoming very brilliant. But still at the same time there were features that could only be regarded as satisfactory. The traffic receipts were slightly larger than they had been before, and the working expenses, outside the head of repairing expenses, were rather less than the average, and the net result of the half-year's operations was to give them the best outcome of any half-year that the Company had ever had. The cost of repairs of cables was rather in excess of the average; but that was a matter that compensated itself, because the more cable the Company were obliged to put into the system in repairs and renewals, the less they had to contribute in sovereigns to the reserve fund, which was calculated on the amount of depreciation that was supposed to be going on in the cables. He was glad to be able to say that he thought that they were now within reasonable distance of getting rid of the incubus that had weighed upon them for so long a period in the shape of arrears of interest on the Second Preference shares. The sum that they still owed on the Second Preference capital was £1. 8s. 6d. per share, amounting to a total of £6,653. He would like to call their attention to the fact that in the year 1884 the sum that they owed to the Preference shareholders was £65,000. He thought that under the circumstances the shareholders would be willing to admit that good progress had been made, considering the poor traffics that the Company had been in receipt of. As regards the Barbadoes and Demerara cables, the report informed the shareholders that they had settled the terms on which they would lay the new cables and the Barbadoes cable was laid, and they were now in progress of negotiation for a similar cable for duplicating the existing system between Demerara and Trinidad. They had felt it a wise policy to carry out the work for the duplicate connection of these two colonies; but at the same time, he wished to point out that the increased outlay was not to open up any new traffic, as it was simply a duplication of cables which were already in existence, but still there was the probability that they would save something in the course of the year by preventing the communication being interrupted, and the consequent loss of traffic and also loss of subsidy. The position as regarded Demerara would, he believed, be almost immediately settled. The Directors had had a telegram yesterday saying that certain features in the proposed Act to which they made objection had been removed, and they would probably in a short time receive the text of that Act, and then, if they were perfectly satisfied, they would proceed with the laying of the 300 miles of cable between Trinidad and Demerara. In order to replace the cable used out of stock in laying the St. Vincent and Barbadoes cable, they had brought the ship "Grappler" home, and she was now in the Thames repairing and being thoroughly overhauled preparatory to taking in the cable which was ready for her at Messrs. Siemens Bros. and Co.'s works. The alterations and repairs to the ship now being carried out would render her valuable to the Company, and efficient for a long period to come. Referring to the recent Telegraph Conference at Paris, he stated that it was attended by himself, accompanied by Mr. Brown (the Secretary), on behalf of the West India and Panama Company. They were in Paris for a month, and they had several interviews with the Spanish authorities and with the French authorities as to the position of their relations in the West Indies, and he thought that in many instances the result of their attending that Conference would be found to be beneficial to the Company. While himself and Mr. Brown were in Paris they were fortunate in being able to obtain the assistance and the advice of Sir James Anderson, Mr. Andrews, and Mr. Ford (Directors of the Company), who happened to be in Paris at the time representing other telegraphic companies. With reference to the traffic receipts of this Company for the current half-year, they were certainly good, and he really began to have the hope that better things were coming for this Company as well as for the West Indies. Still, at the same time, he must not neglect to caution the shareholders against running away with the idea, because there were improved prospects before the Company, that they were going to step at once into a perfect El Dorado in the West Indies. It was one of the poorest fields that he knew of for telegraphic services. The receipts per mile were only half the average of those of other trans-oceanic cable companies. He, therefore, begged the shareholders not to expect that they were going to jump into dividends at once, because they were told at the last meeting they had shortly to face the likelihood of the loss of the Martinique subsidy, and in five years' time the Guadeloupe subsidy would expire. Therefore, again, he deprecated in the strongest terms any exaggerated idea as to the prosperity that the Company was likely to get which might run up the shares to a price that would be bound ultimately to disappoint those new shareholders who might come in at the high price. He did not know that he had anything further to add. He would be happy to reply to any questions that any shareholder desired to ask, and he begged to move:—

"*That the Directors' report and accounts to June 30, 1890, submitted to this meeting be, and the same are hereby, received and adopted, and that, as recommended by the Board, a payment of 6s. per share on the First Preference shares (being dividend for the six months ended June 30, 1890), and £3 per share on account of arrears of dividend on the Second Preference shares be, and the same is hereby, declared.*"

Mr. FORD seconded the motion.

Mr. LUCK: After the somewhat depressing address of the Chairman, I hardly like to ask the question as to whether he thinks there is any likelihood that next half-year the ordinary shareholders—the 88,321 ordinary shares—will receive a dividend?

Mr. GRIFFITH characterised the report as certainly one of the most satisfactory that had been presented to the shareholders of that Company. He was glad that the careful management of the Directors had proved successful in piloting the Company through the troubled sea into somewhat quieter waters for the future. The report had been so clearly explained by the Chairman, and was also so explicit itself, that it hardly called for any further remark, but there was just one point upon which he would like to offer an observation, and that was the smallness of the amount of interest that they got upon their investments. They certainly did very wisely in keeping a good reserve fund invested in sound securities, but he must say that the sum of £3,177 interest on those investments was very small. If they had gone in for the "despised Goschens" they would, he thought, have got a little more, and at the same time, although these investments were very sound and good, a little more security.

Mr. SAUNDERS said that he would like to remark that his opinion coincided with that of the gentleman who had last spoken, that they ought to get more for the money that was invested, and formed the reserve fund. He made out that they only got about 2¼ per cent. return interest on the money.

The CHAIRMAN: £3. 16s. per cent. is the average interest on the investments.

Mr. SAUNDERS: I do not make it out that.

The CHAIRMAN: The figures in the accounts are for the half-year.

Mr. SAUNDERS: Oh, yes! of course.

The CHAIRMAN, in reply to the various other remarks, said that as to the first question as to what prospect there was for the payment next year of a dividend on the ordinary shares, that was a problem that he would prefer for the shareholders to solve for themselves. He had told them that the arrears of interest on the Second Preference shares was now only between £6,000 and £7,000, then they had to pay the interest on the First Preference shares, and in addition they had to provide what was necessary for the expense of repairs, renewals, &c., in the half-year, and they would then find out if they had any sum still available for the payment of dividend on the ordinary shares.

Mr. FORD remarked that it had to be borne in mind that before they could pay anything to the ordinary shareholders they had to find the money for the payment of the then current half-year's dividend on Second Preference shares also.

Mr. LUCK said that he hoped that they might expect that there was a possibility of a payment to the ordinary shareholders at the next meeting.

Mr. FORD said that the answer would be easier to give if the shareholders could tell the Directors what amount they would be put to for repairs and renewals. That was the element of uncertainty that had to be faced in any calculation as an important factor.

The CHAIRMAN said that of course the possibility of the ordinary shareholders getting a return was far greater now that the arrears of interest on the Second Preference shares had been virtually wiped off. As to the question of interest, that he thought had been already explained. He did not consider that £3,000 odd for the half-year could be regarded as bad, looking at the high-class securities that they held.

The resolution was then put to the meeting and unanimously carried.

The CHAIRMAN stated that that was the whole business of the day, and it only remained for him to thank the shareholders for their attendance.

Mr. GRIFFITH moved a very hearty vote of thanks to the Chairman and Directors of the Company for their past services through trying and difficult times. He remarked that they were much indebted to them for the manner in which they had wiped off the arrears, and he expressed the hope that they would carry on equally good management in the future, now that brighter days seemed dawning for the Company. He thought they deserved a hearty vote of encouragement.

Mr. FISON seconded.

The motion was carried.

The CHAIRMAN, on behalf of himself and colleagues, briefly responded, and promised a continuance of their efforts in the Company's interest.

The meeting then separated.

## The Metropolitan Electric Supply Company (Limited).

The third ordinary general meeting of this Company was held on Friday, November 7th, at Winchester House, Old Broad-street, under the presidency of Sir John Pender, K.C.M.G.

The SECRETARY (Mr. E. Cunliffe Owen) read the notice convening the meeting, and the report of the Directors was taken as read.

The CHAIRMAN then said:—The report will have explained to you our reasons for calling you together to-day. Under the Electric Lighting Act it is provided that companies with statutory powers must present their yearly accounts, made up to December 31st, to the Board of Trade not later than March 25th in the year following. You will remember that our Company was formed in the autumn of 1888, and we naturally made up our first year's accounts to September 30, 1889, and our general meeting was held to confirm these accounts in December last. The Board of Trade

Digitized by Google

having intimated that they expected us in future to comply with the statutory requirements above referred to, we have found it necessary to alter the period of our financial year, which will therefore end in future on the last day of December. We shall, therefore, call you together again in the spring, for the purpose of submitting to you our accounts, and our meetings will henceforth be held in the beginning instead of at the end of the year. I am very glad indeed to meet you today, for I am anxious to place before you such information as will enable you to share with the Directors the confidence which they feel with regard to the position and prospects of the Company. It has always been my policy as Chairman of other companies that the greater we could strengthen the confidence between the shareholders and Directors the more smooth would our proceedings be, and the more satisfactorily would the business be conducted. When we last had the pleasure of meeting you I stated that we were supplying current for 15,000 lights to 58 customers. We are now supplying current for 40,000 lights to 300 customers. You will observe the great increase in the lights and the increase in the number of our customers, but you can well conceive what an enormous number of customers we have yet left to supply. It is one of the great features of our prospects at the present moment that we have such a wide field before us, and I hope I shall be able to satisfy you before I sit down that that field we are likely to occupy with considerable benefit to all concerned. I may state that this number of lights is largely in excess of that supplied by any other company in the United Kingdom, and that it is equal to about one-third of the total number supplied in London by public companies. I am informed by our manager that we hold contracts for a further 10,000 lights, and that there are many more applicants who are negotiating with us for the supply; indeed, I may say that it has been our experience that the number of applications grows steadily with and in proportion to our number of customers. I have in my hand a table, showing the monthly increase of our lighting during the present year, which will give you some idea of the steady and assured growth of our business. I will also read to you a few testimonials which we have received expressing entire satisfaction at the supply which we give. That is a further important point. I daresay you have all heard of complaints about the electric light—that it has been uncertain, irregular, and so forth. We have had nothing but complimentary letters from our varied customers, which give, after all, the best assurance of their number being rapidly increased. The testimonials it is well that I should read, because they are important. This is from Mr. Augustus Harris, of Drury Lane Theatre:—

Theatre Royal, Drury Lane, April 21, 1890.

My Dear Sir,—I have no hesitation in affirming that the Electric Light supplied by your Company, "The Metropolitan," is, and has been, in every way satisfactory, both as to quality and regularity.—Yours faithfully, Augustus Harris.

E. S. Claremont, Esq.

From George Edwardes, Esq., Gaiety Theatre.

Gaiety Theatre, Strand, April 21, 1890.

Gentlemen,—In reply to your inquiry, the light you have been supplying is extremely satisfactory. There is not the slightest fault to find with it, the current being regular and the light brilliant.—Yours truly,

Geo. Edwardes.

The Metropolitan Electric Supply Company (Limited).

From E. Kennedy, Esq., Exeter Hall.

Exeter Hall, Strand, May 9, 1890.

Dear Sir,—I am pleased to inform you that the installation of the electric light at the Central Young Men's Christian Association has proved a complete success. We are very pleased both with the continuity and the quality of your supply, and I shall be at all times pleased to afford any persons bearing your card an opportunity of viewing the light.

I am, dear Sir, urs faithfully,

(Signed) E. Kennedy, General Secretary.

E. S. Claremont, Esq.

From C. G. Compton, Esq., Garrick Theatre.

Garrick Theatre, April 21, 1890.

Dear Sir,—I beg to state that the lighting of this Theatre is in every way satisfactory, both as to purity and regularity.—Yours faithfully,

C. G. Compton.

To the Manager of the Metropolitan Electric Supply Company (Limited).

From Messrs. Hampton and Sons, Pall Mall East.

Pall Mall East, April 19, 1890.

Dear Sir,—We have much pleasure in stating that the lighting of our premises upon the Low-tension System is most satisfactory, the whole 640 lamps giving a good steady light. We heartily congratulate you upon its success.—We are, dear Sir, yours faithfully, Hampton and Sons.

E. S. Claremont, Esq., The Metropolitan Electric Supply Company.

And I am just reminded by one of our Directors, a great personal friend of Mr. Hare, that that gentleman has given us a testimonial. Mr. Hare's statement is this: "I feel when I leave the theatre at night quite a different man from what I used to be when we had the gas. I find that I am now in a pure atmosphere, and I can do my work better." You see, gentlemen, that even from a sanitary point of view electricity is immensely beneficial. I have not given you private testimonials, but the testimonials which we have received from theatres and large establishments, where it is so important that the light should not only be steady but pure; and I think this evidence of what we are doing is a very striking indication of what we may expect in the future. I am now going to show you the increase of our lights. The total number of lights supplied on March 1st was 16,702; April 1st, 19,134; May 1st, 21,388; June 1st, 22,991; July 1st, 28,595; August 1st, 30,711; September 1st, 33,642; October 1st, 35,209; and on November 6th, 40,033. You will observe that we have passed through the summer with a very fair average. We have been rising up to a point which is very considerable, and before I see you next spring, I expect to see at least 10,000 more lights added. All this, I am sure you will agree with me, is satisfactory as to the progress of the Company. A glance at the maps which we have prepared will show you the magnitude of our operations. You will notice the supply stations—Whitehall, Sardinia-street, Rathbone-place, and Manchester-square—together with the vast system of underground mains that has been carried out. Upwards of forty miles of mains have been already laid, and we roughly estimate that to complete our system at least double this quantity will be required. That will give you some idea of the work that has to be done, and the time that is required to do it. The following statistics on the subject of our areas may be of interest as showing their magnitude and importance:—Acreage, 3,105; houses, 45,451; rateable value, £4,500,000. The report states that we have obtained powers over Paddington. This district adjoins our other areas, and, therefore, will form part of our general system. We have obtained an advantageous site on the canal bank, and are about to commence active works; and while the Paddington station is being constructed, we shall be able to supply from Manchester-square as much lighting as we can lay the mains for in the Paddington district. I may here observe that we have no intention of applying for further districts at the present time. We do not consider that we should be justified with our present issue of capital in incurring further responsibility and liability. We are satisfied that our present areas are amply sufficient both in size and importance to take up all our energies at the present moment, and we believe that it is conducive to the interests equally of shareholders and consumers that we should develop the resources we have already acquired. Now our capital at the present moment is £500,000. When I was examined before the Board of Trade Inspector who was appointed to inquire into the general electric lighting of London I stated that I should not be satisfied as Chairman of this Company until our capital became at least two millions sterling. I hold precisely the same opinion to-day. I believe that it will be so successful and so remunerative that we shall gradually extend our system until we have got at least a couple of millions of money invested in it. I will now describe to you in as few words as possible the present condition of our supply stations. Our Whitehall station has caused us a certain amount of disappointment, owing to the fact that the large block of buildings called Whitehall Court, which it was originally constructed to light, and which we were under contract to supply, has not been occupied quite so speedily as we might have wished. There has therefore been some delay in the Whitehall station being as productive as at one time we expected it would be. We thought it would be immediately productive; but I am glad to say that these chambers are now beginning to attract considerable attention, and probably before I meet you again I shall be able to report that a considerable number of them are being lighted from the Whitehall station. We are also negotiating for the supply of current to other buildings in the neighbourhood. I may mention that this station has 710 horse power. It is supplying 4,177 lights, and it is capable of supplying 8,000 lights. The next station is Sardinia-street. We have every reason to be most satisfied with the working of this very important station. I informed you at our last meeting that we had given an order to double its capacity. This contract has been carried out, the machinery is now in working order, and we are ready to cope with any demand on it that may arise. We have at this moment 19,500 lights running from this station, and I may state that we have here a plant of 3,000 horse-power equal to supplying 50,000 lights. The demand is increasing, and now that we are in the winter it is increasing at rather a rapid rate, so much so that lately we have not been canvassing, but are only taking up the work that is brought to us, and there are a great many applications for extending the light. The next station which I shall refer to is Rathbone-place. I have already informed you of the circumstances which led us to purchase and develop the small station which has existed for some time on this site. The new machinery which we ordered some time ago is now fast approaching completion. Indeed, it would have been finished before now had it not been for many serious difficulties which have now, I am glad to say, been successfully overcome. These difficulties were of a mixed character. In the first place, I daresay you know that if a man has got a house alongside any electric installation, his belief is that he ought to make some claim against the Company. We have had injunctions threatened without number, but all of them in Rathbone-place have been overcome. The other day our landlord of Rathbone-place died, and his property was brought to the hammer. I went to the sale after consulting the Directors, and we bought his interest in the property. The advantage of purchasing this site is that it gives us control over the property. In the second place, it gives us something like 8 or 9, probably 10 per cent. We shall be able to get the money for a great deal less, so that at the end of 21 years, instead of, as according to our late lease, requiring to pay double rent, we shall be able at the end of that time to stand without any rent at all. I think that that must be satisfactory to the shareholders for another reason—that it has given you a tangible security; and not only is it a security, but it has enabled you to work the station at a much lower expense. At Rathbone-place station the horse-power is 1,200, and the total capacity in lights when finished will be 21,000. The next station is Manchester-square. To this station we attach the very greatest importance. It is situated in the midst of the wealthy parish of Marylebone, and promises to be one of the most lucrative stations in our districts. You may remember that at the last meeting I informed you we had made advantageous terms with the London Electric Supply Corporation, by which we took over from them their existing network of mains in the Marylebone district. We were thus enabled to supply from this station the whole of the then existing demand as soon as our machinery was ready to run. By this means,

Digitized by Google

although the machinery has only been at work for a period of four months, we are now supplying 11,000 lights. The total capacity of this station will be 35,000 lights, its horse power being 2,000. You will remember that the Directors have always laid very great stress upon the communication by trunk mains between one station and another. By this means we shall always be able to cope with any sudden demand in any one of our districts, and should any accident arise, the load of one station could at once be transferred to another station. One great point that we originally insisted on was that we were not going to be speculative, that we would let others experiment, and that we should reap the result of their experiments. At the present moment, though we have all these different installations, we can unite them together and make one powerful combination at any moment. That is a very important feature in this Company's business. The laying of our mains has taken a considerable time to effect, and I am sure you will realise that we have had to encounter many difficulties in the course of our works. Anyone walking about the streets of London will see constantly interruptions to the traffic owing to these works, and you can well conceive the difficulties we have in those neighbourhoods where we have to interfere with the traffic. Shopkeepers complain—everyone complains—and it is not a pleasant task to keep things quite smooth. But still, we have been able to keep on fair terms with everybody, and we are pursuing our work steadily and successfully. I may state that the whole of these works are being executed by our own men under the superintendence of our engineering staff, and I need scarcely say that this is a far more economical method than that of employing contractors. These works have necessarily brought us into frequent contact with the Local Authorities and with the County Council, and I should like to take this opportunity of expressing publicly our appreciation of the kindness and courtesy now shown to us by the officials of these bodies. Turning to our financial position, I would remind you that owing to the circumstances under which we have called you together we have no audited statement to submit; we have, however, gone very carefully into the matter, and I have no doubt that it will be satisfactory for you to hear that even with the necessarily small amount of our revenue at the close of last year and the commencement of this, we have every reason to believe that we have more than paid our way, and that we have made a small profit in the short time that we have been at work, and that profit I may say has been made upon something like 30,000 lights. We are very pleased to be able to make this statement for the following reason, which we are anxious that you should carefully bear in mind. Our working expenses in the past, and even at present, are with few exceptions the same to all intents and purposes as they will be when we are giving our present maximum supply of 114,000 lights. That is a very important point—that the staff employed in the production of 40,000 lights is far larger in proportion than that which will be required to conduct our full out-turn of 114,000 lights. When I state to you that we have made a small profit on the out-turn of 30,000 lights, it does not require a great amount of imagination to see that it must be a very good business if we can conduct 114,000 lights with a comparatively small increase in working expenses. Of course there will be an increased consumption of coal. Incidentally to that I may mention that in consulting our experts, it is calculated that, not including the current expenses of general management, but the cost of coal and of working the machinery, we shall be able to produce electricity at the central station for about 3½d. per unit, as far as we can now see. That is the most satisfactory point, I think, yet ascertained in regard to the experience of working the electric light. If we can prove, as I hope, when I see you three or four months hence, when we shall have had three months' winter's lighting, that all that I have said now is borne out, I think I shall be able to congratulate you on having made an investment in a very sound and prosperous concern. As you know, we get 7½d. per unit, and there is a very considerable margin between 3½d. and 7½d. to allow for our other expenses. You may naturally ask, why should we spend so much at the present time upon the staff? Well, ours is a new business. We have thought it advisable to afford an opportunity to our engineering staff to gain the experience necessary to cope with this business by appointing one of sufficient size when the business is small, and thus giving it the means of becoming familiarised with the special requirements of our systems by the time that we are working at a maximum capacity. With the present large growth of business over what it was six months ago, and with an assurance of a continuous and steady increase from the present time, we believe that we are perfectly justified in stating as we do in the Report that we look forward to a satisfactory dividend being earned during the ensuing year. I have heard some people say that a dividend might have been expected during the present year; I think this is a little unreasonable, inasmuch as the Company has only been founded for little more than two years, and has only been in possession of its Parliamentary powers for little more than one year. During this time the works which I have endeavoured to describe to you have had to be executed, and already we are able to announce that with an average output during the present year of, say, 25,000 lights, and with our working expenses, as I have already endeavoured to show you, almost as heavy as they will ever be, we have run at a small profit. It does not, therefore, take much power of calculation to see, as I have said, that there is a very fine field before us. I do not think I have omitted anything that I ought to have said. I may mention that at the different stations we have 6,710 horse-power capable of supplying 114,000 lights. I may state that if 30,000 lights give us a small profit, the difference between 30,000 and 114,000—that is to say, if the increase is conducted with only the additional cost of coal—will give, as you may calculate for yourselves, a very considerable income out of the large additional number of lights. I do not like to promise or to prophecy much; but when I stated to you just now that this undertaking must grow to be a very large one, I speak now with a great deal more confidence than I could have done in its earlier days. We have many gentlemen round this table, but one of our number is absent on account of ill-health—Sir Geo. Elliott. He entirely concurs in the views which I have expressed to you. When I look back to our first days I think we did a little bit of prophecy too, but I must say that all our prophecies were realised, and I believe that the statements I have made to-day will be realised in the future of the Metropolitan Electric Supply Company. With these remarks I beg to thank you for being present, and to move—

"*That the report of the Directors submitted to this meeting be and is hereby received and adopted.*"

If any gentleman wishes to put any questions to me I shall be only too happy to answer them to the best of my ability before putting the motion.

Alderman Sir ROBERT N. FOWLER, Bart., M.P.: I beg to second the motion, and I need not add anything to what the Chairman has said.

A SHAREHOLDER asked whether the 30,000 lights and £30,000 were the same thing.

The CHAIRMAN: Not necessarily. We are selling our electricity now by meters, and therefore we must have a year's experience to see how the consumption works out before we can give any definite answer.

Another SHAREHOLDER wished to know whether the Fleet-street newspaper offices were lighted by these lights, because this seemed to be rather important.

The CHAIRMAN said that these offices were not in the Company's district. Fleet-street was in the City.

The SHAREHOLDER failed to see that the City had done anything in connection with the lighting.

The CHAIRMAN said that the City authorities seemed to know, or thought they did, a great deal more than other people about what the lighting could be done for. It was a sort of rule and thumb with them. They thought that it ought to be done for so much, and the Company were not prepared to enter into a bargain with them.

PATENT

SILICIUM BRONZE AND SILICIUM COPPER WIRE.

The best for overhead Telephone and Telegraph Lines,

AND ALL ELECTRICAL PURPOSES.

Hard Drawn High Conductivity Copper Wire.

ROLLED AND DRAWN PHOSPHOR BRONZE.

PHOSPHOR BRONZE — VULCAN — PHOSPHOR — DURO METAL

PHOSPHOR BRONZE BEARINGS, BUSHES, AND OTHER PARTS OF ELECTRICAL MACHINERY.

SOLE PROPRIETORS of the British, Indian and Colonial Patents,

THE PHOSPHOR BRONZE COMPANY (Limited),

87, Sumner Street, Southwark, London, S.E.

WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

Digitized by Google

A SHAREHOLDER asked whether they were making arrangements to supply motive power as well as light.

The CHAIRMAN said that the demand for light, which was their primary object, was such at the present time that until this demand was satisfied they had no time to turn their attention to the supply of motive power.

Mr. GILES, M.P., understood the Chairman to say that they were increasing their district by adding Paddington to it, and that they were already supplying over 40,000 lights, which was more than any other company supplied. Did that mean that they were more forward in the completion of their work than other companies, or that other companies had not districts which would require such a large supply? The Chairman had also said that their capital was £500,000, and that he would not be satisfied until it was two millions. Did this mean that they were going to issue new shares fairly soon?

The CHAIRMAN replied that the capital was £500,000, and that they had certain installations now, but they would not put down new ones until he could satisfy them that those they were now working were paying a handsome profit. The moment they could prove that their system was a success mechanically, electrically, and financially, he would call on the shareholders, and he expected they would be glad to join with them in pushing ahead and adding another half-million to the capital. They would not do it all at once.

Mr. GILES had, he said, asked a question at the last meeting with regard to their progress and that of other companies.

The CHAIRMAN: It is not for me to criticise what other companies are doing. I said when I first addressed you that we were not a speculative Company—that we should take the best system that existed and that we should take advantage of any improvements that came out. I think I may say, perhaps, that we have managed our capital more prudently than other people, and that we have got more for it than they have. As to Waterloo Wharf, we are at present utilising that station as a store. It is on the Thames, and it is very useful in every way for that purpose. But we have a plant in existence that we intended to put down there. There is a good field there, but we are not going to occupy it until we satisfy that the field we have occupied is productive. I think I have answered you pretty fully, and I have, I think, satisfied you, although some people have been complaining that they have been getting no dividend. While we were spending money to create all these installations which are now beginning to bear fruit it was not possible for us to pay you a dividend. The same can be said of a cotton mill, or of a steamer, as Mr. Giles will know. You cannot begin to pay a dividend on a steamer until it is floated and earning money; so it is with us. Our installations are now nearly completed, and are earning money, and our lights are being taken up very rapidly. When I meet you again I believe I shall be able to announce something satisfactory to you in the way of dividend.

He then put the resolution, which was carried unanimously.

Mr. GILES proposed the re-election as Directors of Sir James Anderson, Mr. J. Spencer Balfour, M.P., and Sir George Elliott, Bart., M.P.

A SHAREHOLDER seconded the resolution, which was agreed to *nem. con.*

Messrs. Deloitte, Dever, Griffiths and Co. were afterwards appointed auditors for the ensuing year.

The CHAIRMAN wished to say, before separating, that nothing would please the Directors more than that the shareholders should visit the various installations and see what had been accomplished by the Company.

A vote of thanks was then passed to the Chairman and Directors, and

The CHAIRMAN, in acknowledging the compliment, said that the greater the confidence between the Board and the shareholders the more prosperous their business would become, and he hoped that this was the beginning of meetings at which they would always have occasion to congratulate one another.

The proceedings then terminated.

## NEW COMPANIES REGISTERED.

**ELECTRICAL SUPPLIES AND FITTINGS COMPANY (LIMITED).**—Registered by Wilson, Bristows and Carpmael, 1, Copthall-buildings, E.C., with a capital of £20,000 in £5 shares. Object, to carry on the business of electricians and mechanical engineers. The first subscribers are:—G. L. A. Rooke, J. A. Roxburgh, J. Whitehead, T. B. Arundell, W. L. Madgen, N. G. Bingham, and G. S. Butler. There shall not be less than three nor more than nine directors. The first to be appointed by the subscribers to the memorandum of association. Qualification, £200. Remuneration, £500 and one-tenth of net profits after 8 per cent. dividend, with the proviso that the whole remuneration of the board shall not exceed £1,000, the same to be divisible.

## CITY NOTES, &c.

**BRAZILIAN SUBMARINE TELEGRAPH COMPANY.**—The receipts of this Company for the week ended November 7th amounted to £5,112.

**THE KELVINSIDE ELECTRICITY COMPANY (LIMITED).**—This Company is this week inviting subscriptions for a second issue of capital, making the capital of the Company £50,000, in 50,000 shares of £1 each. This is payable 2s. 6d. on application, 2s. 6d. on allotment, and the balance, as required, in calls not exceeding 5s., at intervals of not less than three months. The prospectus states that the Company is established to supply electricity for illuminating and other purposes in the district of Kelvinside, the principal residential suburb of Glasgow, and was incorporated in 1889 under the Companies' Acts, with a capital of £10,000, and proceeded with an application to the Board of Trade for a Provisional Order under the Electric Lighting Acts to enable them to supply electricity for lighting purposes, both public and private, in Kelvinside, and bounded by the Burghs of Partick, Hillhead, and Maryhill, and by the Counties of Dunbarton and Renfrew. That Provisional Order was granted by the Board of Trade, and the Bill to confirm it received the Royal Assent on August 14 last. This is the only Company which has powers to supply electricity under the Electric Lighting Acts for the above-mentioned district of Kelvinside. Intending investors are asked to note that the Company have come to an agreement with the Corporation of Glasgow whereby the Corporation, in any Bill to be promoted by them for the annexation of the Kelvinside district to Glasgow, have agreed to insert a clause undertaking not to compete with this Company in the supply of electricity to that district. At the request of the local authority, and in order to efficiently supply the district, the Directors have resolved to increase the capital of the Company from £10,000 to £50,000. There are no unusual engineering difficulties to be overcome in supplying the district. An estimate of the capital outlay and income, which accompanies the prospectus, has been prepared by the electrical engineers of the Company, and it shows that the capital outlay for plant required for a full installation of 30,000 glow lamps will amount to £40,000; but they also give the cost for a first installation of 10,000 glow lamps as amounting to £16,000, the plant for this first installation being put down with a view to its economical extension to the full capacity. None of the shares have been underwritten, and no promotion money has been or will be paid other than the usual brokerage to stockbrokers. The preliminary expenses will be charged against capital. Prospectus and forms of application may be obtained from the Bankers, Brokers, Solicitors, and at the offices of the Company, which are set out on page xvi. of our advertisements.

**MONTEVIDEAN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).**—An extraordinary general meeting of this Company will be held at the offices, Langthorn House, Copthall-avenue, London, E.C., on Tuesday, the 25th inst., at 11.30, when resolutions will be proposed,—That the Company be voluntarily wound up; that Mr. George Fraser, F.C.A., be appointed the liquidator to conduct such winding up; that the Company's undertaking be sold and transferred to the Western and Brazilian Telegraph Company (Limited); and others rendered necessary if the foregoing are carried. We may mention that a meeting of the Western and Brazilian Company was held yesterday (Thursday). A report of the proceedings appears in our present issue.

**SWAN UNITED ELECTRIC LIGHT COMPANY.**—At the meeting of the shareholders of this company, which is to be held on the 25th inst., the Directors will recommend a dividend of 10 per cent. for the year ended September 30th.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY.**—The traffic receipts of this Company for the week ending November 7, 1890, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £3,979.


THE NON-CONDUCTOR OF ELECTRICITY.

WAREHOUSE.

VULCANISED FIBRE,
PATENTED.

This new material is supplied in two qualities, Flexible and Hard.

The FLEXIBLE is a substitute for Leather, Rubber, Gutta Percha, &c., and is extensively used by Brass Founders, Axle Makers, Hydraulic, Sanitary, and other Engineers, Pump Makers, Carriage Builders, &c.

It makes the best Hot and Cold Water Packings, and for Axle Washers of all kinds it is unequalled.

The HARD is a substitute for Metals, Hard Wood, Ivory, Vulcanite, Ebonite, &c., and is a good Insulator.

Sold in sheets, 5ft. 6in. by 3ft. 6in., varying in thickness from 1-50in. to 1in.

FLEXIBLE, 2/- per lb.; HARD, 2/3 per lb.

FACTORY.

MOSSES & MITCHELL, 70, Chiswell-st., London, E.C.


Digitized by Google

# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Divi-dend. | Name. | Previous Week's Price, Nov. 5. | Price Wednesday, Nov. 12. | Rate per Cent. Yielded. £ s. d. | Dividend Due. | Business Done During Week Ending Nov. 12. Highest | Lowest. |
|---|---|---|---|---|---|---|---|---|---|
| | | | **TELEGRAPHS.** | | | | | | |
| 1,381,380 | Stock | 15/0 | Anglo-American | 48¾ 49¼ | 49 50 | 5 15 0 | Jan., Apr., July, Oct. | 48¾ | .. |
| 2,809,310 | Stock | 30/0 | Do. Preferred | 84½ 85½ | 85 86 | 6 13 9 | " " | 85¼ | 85½ |
| 2,809,310 | Stock | .. | Do. Deferred | 13 13½ | 13 13¼ | .. | .. | 13⅜ | 13 |
| 25 ,000 | £100 | 4% | African Direct, 4 per Cent. Debentures | 99 102 | 99 102 | 3 18 5 | January and July .. | 99½ | .. |
| 130,000 | 10 | 3/0 | Brazilian Submarine | 11¼ 11¾ | 11¼ 11¾ | 5 10 8 | Mar., June, Oct., Dec. | 11 5/16 | 11½ |
| 84,500 | 100 | 5% | Do. 5 per Cent. Bonds | 101 103 | 101 103 | 4 17 1 | January and July .. | .. | .. |
| 75,000 | 100 | [illegible] | Do. 5 per Cent. Bonds (2nd Series) | 104 108 | 104 108 | 4 12 7 | June and December | 108 | .. |
| $7,216,000 | $100 | .. | Commercial Cables | 102 104 | 102 104 | 5 15 5 | April and October .. | .. | .. |
| £16,000 | £10 | 8/0 | Cuba Submarine | 11½ 12 | 11½ 12 | 7 1 8 | February and August | 11⅝ | .. |
| 6,000 | 10 | 10% | Do. Preference 10% | 17 18 | 17 18 | 5 11 1 | " " | .. | .. |
| 12,931 | 5 | 2/4½ | Direct Spanish (£4 paid) | 3¾ 4¼ | 3¾ 4¼ | 5 12 11 | April and October.. | 4 | 3¾ |
| 6,000 | 5 | 10% | Do. Preference 10% | 8½ 9½ | 8½ 9½ | 5 5 3 | " " | .. | .. |
| 60,710 | 20 | 3/6 | Direct United States | 10¼ 10¾ | 10 10½ | 6 16 7 | Jan., Apr., July, Oct. | 10⅜ | 10¼ |
| 400,000 | 10 | 2/6 | Eastern | 13¾ 14 | 13⅜ 13¾ | 4 13 8 | " " | 13 15/16 | 13 11/16 |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference | 14¾ 15¼ | 14¾ 15¼ | 3 18 8 | " " | 15⅛ | 14⅞ |
| 1,200,000 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock | 103 106 | 103 106 | 3 15 6 | May and November | 104½ | 103 |
| 200,000 | £100 | 5% | Do. 5 per Cent. Debentures, 1899 | 106 109 | 106 109 | 4 11 9 | February & August | .. | .. |
| 250,000 | 10 | 2/6 | Eastern Extension | 14 14½ | 13¾ 14¼ | 4 19 1 | Jan., Apr., July, Oct. | 14¼ | 13 15/16 |
| 320,000 | 100 | 6% | Do. 6 per Cent. Debentures, 1891 | 100 102 | 100 102 | 5 17 8 | February & August | .. | .. |
| 91,800 | 100 | 5% | Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900 | 102 105 | 102 105 | 4 15 3 | January and July .. | .. | .. |
| 145,300 | 100 | 5% | Eastern & S. African 5 per Cent. Mor. Deb., 1900 | 101 104 | 101 104 | 4 16 2 | " " | .. | .. |
| 180,227 | 10 | 1/9 | Globe Telegraph and Trust | 8¾ 9 | 8¾ 8⅞ | 5 9 10 | Jan., Apr., July, Oct. | 8 13/16 | 8⅝ |
| 180,042 | 10 | 6% | Do. 6 per Cent. Preference | 14¼ 14¾ | 14¼ 14¾ | 4 2 1 | " " | 14⅝ | 14⅜ |
| 150,000 | 10 | 5/0 | Great Northern | 15¾ 16¼ | 15¾ 16¼ | 4 12 4 | Jan., April, and July | .. | .. |
| 15,000 | 100 | 5% | Do. 5 per Cent. Debentures, 1881 | 101 104 | 101 104 | 4 16 2 | January and July .. | 101¾ | .. |
| 230,000 | 100 | 5% | Do. 5 per Cent. Debentures, 1883 | 104 107 | 104 107 | 4 13 6 | March & September | 105 | .. |
| 17,000 | 25 | 37/6 | Indo-European | 36 37 | 35 37 | 6 15 2 | May and November | 36¼ | 35¾ |
| 38,348 | 10 | 4/0 | London Platino-Brazilian | 6½ 7½ | 6½ 7½ | 5 6 8 | " " | .. | .. |
| 100,000 | 100 | 6% | Do. 6 per Cent. Debentures | 105 108 | 105 108 | 5 11 1 | March & September | .. | .. |
| 9,000 | 8 | 4/0 | Reuter's | 8¼ 8¾ | 8¼ 8¾ | 5 14 4 | April and October.. | 8⅝ | .. |
| 3,381 | £100 Cert. | 6% | Submarine Cables Trust ....x April Coupon, 1890 | 110 114 | 110 114 | 5 5 3 | " " | .. | .. |
| 15,609 | £10 | 6/6 | West African | 8½ 9½ | 8½ 9½ | 5 5 3 | January and July .. | .. | .. |
| 290,000 | 100 | 5% | Do. 5 per Cent. Debentures | 98 101 | 98 101 | 4 19 0 | March & September | 99¾ | 99 |
| 30,000 | 10 | 3/0 | West Coast of America | 4 5 | 4 5 | 10 0 0 | January and July .. | 4¼ | 4 |
| 150,000 | 100 | 8% | Do. Debentures 8% | 102 107 | 102 107 | 7 9 7 | June and December | 105 | 104½ |
| 88,321 | 10 | Nil. | West India and Panama | 3 3½ | 3½ 3¾ | .. | .. | 3 5/16 | 3¼ |
| 34,563 | 10 | 6/0 | Do. 1st Preference 6% | 11½ 12 | 11½ 12 | 5 0 0 | May and November | 11 13/16 | 11⅝ |
| 4,669 | 10 | 27/6 | Do. 6 p. c. 2nd Pref. | 14 15 | 14 15 | 4 0 0 | " " | .. | .. |
| 64,174 | 15 | 6/0 | Western and Brazilian | 11 11½ | 11 11½ | 5 4 3 | " " | 11⅜ | 11¼ |
| 27,873 | 7½ | 1/6 | Do. 5 per Cent. Cumulative Preferred | 6¾ 7 | 6⅝ 6¾ | .. | — | 7 | 6 11/16 |
| 27,873 | 7½ | 4/6 | Do. 5 per Cent. Deferred | 4½ 5 | 4½ 5 | .. | .. | .. | .. |
| 200,000 | 100 | 6% | Do. 6 per Cent. Debs., Series "A" | 103 106 | 103 106 | 5 13 2 | February & August | .. | .. |
| 250,000 | 100 | 6% | Do. 6 per Cent. Mort. Debs., Series "B" | 103 106 | 103 106 | 5 13 2 | " " | .. | .. |
| $1,336,000 | $1,000 | 7% | Western Union 7 per Cent. 1st Mortgage | 120 125 | 120 125 | 5 12 0 | May and November | .. | .. |
| £175,100 | £100 | 6% | Do. 6 per Cent. Sterling Bonds | 99 103 | 99 103 | 5 16 6 | March & September | .. | .. |
| | | | **TELEPHONES.** | | | | | | |
| 224,850 | 14/0 | 0/5¾ | Consolidated Telephone Const. & Maintenance. | ⅛ ⅜ | ⅛ ⅜ | .. | May and November | .. | .. |
| 220,000 | £1 | .. | Oriental (11s. paid) | ⅛ ⅜ | ⅛ ⅜ | 4 8 3 | Yearly | .. | .. |
| 433,984 | 5 | 3/0 | National | 4¼ 4¾ | 4¼ 4¾ | 6 17 2 | June and December | 4 7/16 | 4 |
| 15,000 | 10 | 6/0 | Do. 6 per Cent. Cumulative 1st Pref. | 12 12½ | 12 12½ | 4 16 0 | " " | 12¼ | .. |
| 15,000 | 10 | 4/9¾ | Do. 6 per Cent. Cumulative 2nd Pref. | 9½ 10½ | 9½ 10½ | 5 14 3 | " " | .. | .. |
| 209,750 | 1 | .. | South of England, Ordinary | ⅛ ⅜ | ⅛ ⅜ | .. | .. | .. | .. |
| 20,000 | 5 | 2/0 | Do. 6 per Cent. Cumulative Pf. (£3 10s. pd) | 2½ 3 | 2½ 3 | .. | .. | .. | .. |
| 58,000 | 5 | 1/0 | United River Plate | 3 4 | 3 4 | .. | January and July .. | .. | .. |
| 146,128 | Stock | .. | Do. 5 per Cent. Debenture Stock | 90 94 | 90 94 | 5 6 5 | .. | .. | .. |
| 3,200 | 100 | .. | Do. 7 per Cent. Debentures | .. | .. | .. | .. | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | |
| 200,000 | £5 | .. | London Electric Supply | 2⅝ 2⅞ | 2⅝ 2⅞ | .. | .. | .. | .. |
| 43,900 | 10 | .. | Metropolitan Electric Supply (£8 paid) | 5 5½ | 5½ 6 | .. | .. | 5 11/16 | 5⅝ |
| 42,853 | 5 | .. | Westminster Electric Supply (£3 paid) | 2½ 3 | 2½ 3 | .. | .. | 2⅝ | 2 9/16 |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | |
| 63,416 | 3 | .. | Brush Electrical Engineering | 1¼ 1¾ | 1¼ 1¾ | .. | .. | 1¾ | — |
| 63,416 | 2 | 0/10 | Do. 6 per Cent. Preference | 1½ 2 | 1½ 2 | 6 0 0 | June and December | 1 13/16 | — |
| 20,000 | 5 | .. | Crompton and Co., 7 per Cent. Pref. Shares | 5¼ 5¾ | 5¼ 5¾ | 6 1 9 | January and July .. | .. | .. |
| 17,139 | 5 | .. | Edison and Swan United | .. | .. | .. | .. | .. | .. |
| 45,000 | 10 | .. | Electric Construction | 8 8½ | 7¾ 8¼ | .. | .. | 8¼ | .. |
| 70,000 | 2 | 10/0 | Elmore's Patent Copper Depositing | 5 5½ | 4½ 4¾ | .. | .. | 5 | 4 7/16 |
| 20,000 | 5 | .. | Fowler-Waring Cables (£4 paid) | 2½ 3½ | 2½ 3½ | .. | .. | .. | .. |
| 41,600 | 10 | 10/0 | India Rubber, Gutta Percha & Telegraph Works | 18 19 | 18 19 | 5 5 3 | February & August | 18½ | .. |
| 200,000 | 100 | 4½% | Do. 4½ per Cent. Debentures, 1896 | 100 102 | 100 102 | 4 8 3 | March & September | .. | .. |
| 78,949 | 5 | 6% | Swan United (£3. 10s. paid) | 5 5½ | 5 5½ | 3 16 5 | May and November | 5¼ | 5 |
| 37,350 | 12 | 12/0 | Telegraph Construction and Maintenance | 43 45 | 43 45 | 5 6 8 | March and July..... | 45 | 44 |
| 150,000 | 100 | 5% | Do. 5 per Cent. Bonds, red. 1894 | 100 102 | 100 102 | 4 18 0 | January and July .. | .. | .. |


# JABLOCHKOFF'S DISTRIBUTION PATENT

(BEING A PATENT FOR "PRODUCING AND DIVIDING ELECTRIC LIGHT," No. 1996 of 1877.)

## THE ELECTRICAL ENGINEERING CORPORATION, LIMITED,

(STATTER'S) Are Proprietors of the above Patent, and Warn the Public against Infringement. (UNITED)

*The following are Licensees:—*

Brush Electrical Engineering Company, Limited.
Crompton & Co., Limited.
S. Z. de Ferranti.—London Electric Supply Corporation, Limited.
W. T. Goolden & Co.
Hammond & Co.

Wilson Hartnell.
Johnson & Phillips.
Laurence, Paris & Scott, Limited.
Malder Brothers & Co.
Paterson & Cooper.
Ernest Scott & Co.
Siemens Brothers & Co., Limited.

3, Prince's Mansions, Victoria Street, Westminster.

PERCY E. SCRUTTON, *Secretary.*


Digitized by Google

# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 653.—Vol. XXVI. FRIDAY, NOVEMBER 21, 1890. Price Fourpence.

## NOTES.

After many minor mishaps, which have been occasioned by the inadequate accommodation at the Grosvenor Gallery Station, a most unfortunate accident occurred there last week. The generating machinery was being dismantled, the station was being used as a transformer centre, and a bank of transformers was temporarily erected in the only available place over the boilers and under the water-tank. This place was very dry, and was enclosed by a tarred wooden partition.

At 6.30 last Saturday morning a man who had been in the service of the company for three years, and who was well acquainted with the connections and switches, attempted to change on to a fresh set of transformers so that the others might be free for workmen coming in at 7 o'clock to finish connecting, and it was in trying to carry out this operation that he started an arc at the plug switch. This evidently frightened the man, and he *withdrew* the plug. A 5,000 volt arc was the result, and this set the temporary woodwork and temporary india-rubber covered wires in connection with the plug switches on fire, and in half-an-hour the place was burnt out. A breaking switch was close at hand by which this circuit could have been cut off, and at the end of the room was a main switch by which the whole station would have been disconnected from the Deptford mains. At Deptford, the first intimation received was a drop in the transformed volts to 50; the driver on seeing this immediately shut down. Although it would have been possible to have resumed running almost immediately, it was considered advisable to wait until the engine-room had been cleared out, when the transformers will be placed there. It is expected that the supply will re-commence at the end of this week or early next week. This deplorable accident cannot be said to have arisen from the system employed, but was, in the first place, due to the man losing his head; and, in the second place, to switches, which were of a temporary nature, and capable of being set on fire by an accident. The room itself was fire-proof, so that the damage was limited to the contents, namely, converters and temporary gear erected for distribution purposes. Had the appliances been fire-proof the only result would have been a badly burned switch on a single distributing circuit.

The Grosvenor Gallery Station will form one of four transformer sub-stations, the others being at Trafalgar-square, Victoria, and Blackfriars. The work of generation and of distribution thus stopped had been proceeding with highly satisfactory results. The load has been considerably higher than that which was generated at the Grosvenor Gallery, but both the coal bill and the wages have been reduced to about one-half. The arrangements for parallel running are now complete, and the huge dynamos are without any difficulty run together, keeping each other rigidly in step. So perfect is the synchronism that when the dynamos were running at the Grosvenor Station, they were thrown on to the same mains as those at Deptford, and both contributed their yield of energy to the circuit. The older pattern of transformers which have been in use at the station are being replaced by an improved pattern, in which the drop in pressure is only one per cent.

To discuss with justice and pertinence a paper which contains so much new information, and one recording so much work as that which was presented by Prof. Ayrton to the Institution of Electrical Engineers last week, it is at least necessary that the audience should hear the paper read, or have a printed copy before them. The nature of the subject and the time precluded the former, and we regret that we are unable to present the latter to our readers in this issue. The "authorised abstract" of the discussion, which we hold over until the paper itself is published, contains a very meagre reference to two points in Mr. Crompton's remarks, and we are indebted to him for the following information about the proof-plate, and the irreducible sulphate.

The proof-plate for use with accumulators consists of a small accumulator plate kept charged in a separate cell. A fully charged positive proof plate is used to test the negatives of a discharged cell, and a fully charged negative proof to test the positives of a discharged cell. If when a cell is discharged the full volts are found between its positive and a proof negative, then the negatives are said to have run down, or are deficient in capacity, and *vice versa*. The period of discharge during which sulphate is formed, and the position in which it is formed, has a great deal to do with its reducibility; and this has, Mr. Crompton thinks, no doubt given rise to the belief that there are two kinds of sulphate, one of them irreducible. If a current is still passed through a cell, of which the negative plates have run down, in the same direction (owing to it being coupled in series with other cells), there comes a time when there is no longer any electrical stress in the electrolyte. Under these conditions ordinary chemical

Digitized by Google

affinities come into play. The positive plate becomes sulphated from mere contact with the electrolyte, that is to say, at the outer surfaces. This sulphate may not be in electrical contact with the lead backing, and consequently can never be reduced. It only gets pushed off, and falls down to the bottom of the cells. The ordinary sulphate is probably formed at the inner boundaries—that is to say, between the active material and the lead backing—and is consequently in electrical contact with the backing, and is easily reduced during charge.

---

MR. TESLA favours us this week with a valuable letter describing his views on the losses which occur in transformers. His communication is particularly important, as the different points of this intricate subject are explained at some length in order to avoid the possibility of misconception. Statements made about magnetomotive force are apt to be misleading unless very explicitly made, as the analogy between the magnetic and electric circuits is liable to incline us to regard the former in too simple a way. Electric currents are easy to deal with because, as MR. CROMPTON recently observed, they can be canalized or confined to definite channels, while the flux of magnetic lines of force can take place through all known substances, and in consequence all magnetic circuits are very complex. Both electromotive and magnetomotive forces are in general located in a particular part of the circuit to which they refer, in the former case they are to be found in the battery or dynamo, and in the latter in the magnetising coils. When, however, we attempt to distribute the potential around the circuit, a difference between the two cases is at once manifest; for whereas with the electric circuit owing to its simplicity, it is easy to see how the volts are distributed, the magnetic circuit is much harder to deal with owing to the great number of the branch currents. For this reason it appears better to avoid the use of the term magnetomotive force per unit length.

---

THE remarks made by Mr. TESLA about the constancy of the magnetomotive force for different loads on the secondary seem especially suggestive. It is, in fact, not difficult to see that with transformers which regulate well at constant potential, the hysteresis and eddy current losses must be practically the same for all currents. The volts induced in the secondary circuit cannot differ much from the pressure at the terminals, since the resistance of the secondary coil of all ordinary transformers is negligibly small. The number of volts induced in the secondary, and hence the flux of lines in the magnetic circuit of every transformer regulating for constant pressure, must thus be independent of the load. It follows that the hysteresis and other losses are constant as regards the load, and must therefore be the same as when the secondary circuit is open. The same remark applies to the resultant exciting current due to the combined action of the primary and secondary coils; and it thus becomes a simple and definite problem to determine the relation which connects the magnitude of the primary and secondary currents with the difference of phase which must exist between them, so that the effective ampere turns may be independent of the load.

THE methods of measuring the impedance and self-induction of alternate-current apparatus, described by Mr. STEINMETZ in this issue, are worthy of attention, since they need but the ordinary testing implements at hand in the factory or dynamo room, and no particular skill is required to carry them out. Ballistic galvanometer methods are quite unsuitable for such measurements, since this instrument is unfitted for use in factories, and is not in general sufficiently sensitive. Moreover, the results obtained by using steady or transient currents are seldom applicable for alternate current work when iron is present in the coils tested. In the methods described, alternate currents of the usual frequencies are passed through the apparatus under examination, and the coefficient is deduced from the readings of an ammeter and Cardew voltmeter. There is no special novelty in the process, as it is but a slight modification of an old method of JOUBERT'S, which has hitherto received very little of the notice it deserves. The manner in which the formulæ have been obtained, and the practical shape in which they have been put, is, however, important, and the experimental examples given will render the application of the methods clear. The process for finding the self-induction of choking coils and other inductive resistances appears to be excellent, but the method for determining the inductive constants of measuring instruments seems of little practical value. The formula given is seen to be a complicated expression involving five quantities, each of which has to be observed, and an error in any one of which will seriously affect the result. The values so obtained for the self-induction cannot be relied on, even if the ammeters and voltmeters used read as accurately as Mr. STEINMETZ'S numbers appear to claim. Instruments which read a current of ·3478 amperes, correct to the last figure, are too rare as yet to "have come into general use" in the factory. With ordinary instruments the second figure is always uncertain, and under these circumstances the results by this method obtained could not be trusted.

---

WE are glad to learn that the Central London Railway Company, nothing daunted by the rejection of their scheme last session by the Select Committee of the House of Lords, propose to renew the attack. Few districts of London are more completely isolated, so far as concerns direct railway communication with the City, than Bayswater, and the proposed line, apart from any benefits it may confer on the inhabitants of that quarter, will be a distinct public improvement, since it can hardly fail to divert a large proportion of the omnibus traffic at present encumbering Oxford-street to routes less busy, and where electricity does not compete. We trust that by the time the Company's Bill again comes before the Parliamentary inquisitors, the success of the City and South London line will have discounted the dismal forebodings of landowners, shopowners, and bishops

---

ANOTHER Bill which is to be re-introduced this Session is the London Overhead Wires Bill, by which powers to remove, register, inspect, and regulate overhead wires in the Metropolis is conferred upon the London County Council. Now that practically nothing but statutory electric lighting is being carried on in

Digitized by Google

London, the Bill of the County Council would appear at first sight to be aimed at the National Telephone Company; but since power is also asked "to provide for the attachment of overhead wires to houses or buildings, and the carrying of wires over land and buildings in certain cases where it is necessary for the extension of telephonic communications, and to provide for determining and assessing the compensation to be paid to the owners or occupiers of the houses, buildings, or land in respect thereof," there is, apparently, nobody left but the Postmaster-General for the Council to fall foul of. However, whether or not there is any immediate necessity for a London Overhead Wires Bill, it is but right that some such powers of regulation and inspection should be conferred on the Municipal Authorities.

**Personal.**—Lord Rayleigh has been appointed an honorary member of the Bavarian Royal Academy of Science.

**Harrogate.**—At the last meeting of the Town Council it was decided to light the whole of the town by electricity.

**Leeds.**—The Leeds County Council have decided to allow a trial of some Thomson-Houston electric cars on the Roundhay Park tramway.

**Institution of Electrical Engineers.**—No students' meeting will be held as advertised. On the 5th proximo Mr. Garret will read a paper on "Search-Light work."

**National Telephone Company.**—This Company announces that the trunk line between London, Manchester, Liverpool, and Birmingham, is now open to the public.

**Stockport.**—The Corporation have given notice of their intention to apply for an Electric Lighting Provisional Order. The gas works are under the management of the Corporation.

**Bombay.**—The Bombay Municipality has called for tenders, up to February 16, 1891, for the experimental lighting by electricity of certain streets in the city for a period of two years.

**Indian Telegraph Department.**—The Government of India has sanctioned an expenditure of one and a-half lakhs for the repair of the overland telegraph line to Persia, the insulation of which is defective.

**Southport.**—The Corporation have given the usual notices of their intention to promote in Parliament next Session a Provisional Order empowering them to supply electricity for lighting and other purposes.

**The Elektricitats Zeitung.**—This paper, which has recently passed into the hands of Herr Arthur Wilke, will in future appear three times instead of twice weekly, and the editor announces that he will endeavour shortly to bring it out daily.

**"Darkest England and the Way Out."**—The staff and men in the dynamo department of Messrs. Goolden & Co.'s works resolved to raise a subscription to aid General Booth's scheme. The sum of six guineas was in a few hours collected, and forwarded last Saturday to General Booth.

**A New Use for the Telephone.**—The latest application of the telephone is to place the wards of the City Hospital, New York, and the reception-rooms in telephonic communication, so that patients suffering from infectious maladies may safely communicate with their visitors.

**Gelatinous Electrolyte for Storage Batteries—A Correction.**—On p. 47 of our last issue it was stated that "during the last months *The Electrician* twice mentioned the 'gelatinous electrolyte' (August 12th and September 10th)." These dates should be July 11th, p. 253; and April 25th, p. 213.

**The Board of Trade Overhead Wire Rules.**—We understand that Mr. Crompton has laid the whole case of the action of the Board of Trade with regard to overhead rules before the General Council of the London Chamber of Commerce, and it has been decided to write a strong letter to the Board of Trade requesting them to receive a deputation on the subject.

**Newcastle-on-Tyne.**—On Wednesday afternoon last week, between twelve and one, a puff of smoke was observed to issue from a junction-box of the Newcastle-upon-Tyne Electric Supply Company's mains (the same one that blew off a few days previous). Nothing further happened to this box, but the covers of two other boxes in the locality almost immediately blew off. No one was injured.

**Madame Tussaud and Sons.**—This popular Gallery has recently been provided with a well-arranged plant for supplying its own electric light. The work has been carried out by Messrs. Drake and Gorham, Mr. Kapp acting as consulting engineer. The lighting was inaugurated on Wednesday last, and will, no doubt, prove to be very valuable to the proprietors on account of its cleanliness as well as comfort.

**A Chair of Industrial Electricity.**—The Minister of Commerce has just created, at the Conservatoire of Arts and Sciences, a chair of industrial electricity, and the Académie des Sciences was invited to present a list of candidates for the new chair. There were three candidates for the post, MM. Marcel Deprez, Hospitalier, and Mercadier, and the President of the Republic, upon the recommendation of the Académie des Sciences, nominated M. Marcel Deprez.

**Edinburgh Exhibition.**—Judgment was given last week in the Second Division of the Court of Session, as to the winding up of the association. Lord Young, in giving the opinion of the Court, said: We have considered this case, and we are all of opinion that the voluntary liquidation which is going on just now is lawful, and that there are no sufficient reasons why we should interfere with it by putting the association under another form of liquidation and another liquidator.

**Electric Traction.**—The Hammersmith Vestry, at its meeting last night, unanimously agreed to the proposal of the West Metropolitan Tramway Company to work the line from the Uxbridge-road Station to Kew, a distance of three miles, by the Lineff system of electrical traction. Reports by Mr. W. H. Preece, chief electrician to the Post Office, Mr. Gisbert Kapp, C.E., and Prof. Robinson, approving of the Lineff system, were laid before the Vestry. It is understood that the work will be commenced without delay.

**Old Students' Association.**—A Cinderella Dance will be held at the Westminster Town Hall, on Friday, December 12th. Tickets, 3s. 6d. each, may be obtained from Miss Walter, 38, Woodbury-Grove, Finsbury Park, N.; Dr. W. E. Sumpner, Central Institution, South Kensington; H. B. Bourne, 41, Priory-road, Bedford Park, W.; or any other of the members of the committee, or from Reginald J. Jones, Hon. Sec., care of Messrs. Woodhouse and Rawson United (Limited), 88, Queen Victoria-street, London, E.C. The number of tickets being strictly limited, early application is desirable.

**Bath.**—At a meeting of the Town Council last week a report by the Electric Lighting Committee was read. Mr. Sturges advocated an independent inspection by a leading electrician. He also stated that the Board of Trade insisted on inserting a paragraph in Mr. Massingham's licence that he should not be compelled to sell at the end of seven years if he wanted an extension. Mr. Massingham was perfectly willing not to have such a clause, but the Board of Trade said he should have it. It was decided that as the question at issue with the Board of Trade was not pressing it should be deferred, and it was unanimously decided to have the works inspected by an expert.

**Institution of Electrical Engineers.**—The *conversazione* given on Wednesday evening last in the Galleries of the Royal Institute of Painters in Water Colours by the President and Mrs. John Hopkinson was of a very successful character. The attendance was unusually large, over 1,000 being present, and the additional room afforded by making use of Prince's Hall was, in consequence, greatly appreciated. Amongst those present were Sir Richard Webster, M.P., Sir James Anderson, Sir James Douglass, Sir Douglas Galton, Sir Albert Cappel, Sir Henry Mance, Sir David Salomons, Bart., Prof. Perry, Prof. Ayrton, Prof. Silvanus Thompson, Mr. C. E. Spagnoletti, Prof.

Digitized by Google

G. C. Foster, Major-General C. E. Webber, Colonel Sir Charles Wilson, Sir G. Barclay Bruce, Mr. Latimer Clark, Sir Benjamin Baker, Sir Frederick Pollock, Dr. Coleman Sellers, Prof. W. D. Niven, Mr. John Aird, M.P., Prof. J. W. Groves, Rt. Hon. Sir Edward Fry, Prof. J. Thomson, F.R.S., Dr. J. H. Gladstone, F.R.S., Sir F. Abel, Mr. J. W. Swan, &c., &c.

**The Northfleet Series Tramway.**—The technical and commercial merits of the series system of electrical traction, as exemplified at Northfleet, having been ascertained from the operation of the line for the last eighteen months, it has been decided to discontinue running. We are informed by the Electrical Engineering Corporation that the line, as is well known, was for demonstrative purposes only, and that, in their opinion, its object having now been attained, they see no further reason for incurring the large expense necessitated by the smallness of the local traffic, and the heavy rental and charges imposed by the Gravesend, Rosherville, and Northfleet Tramway Co., through whom the Parliamentary powers were obtained. Careful accounts have been kept of the cost of running for the last six months, and from these, when audited, the actual cost of motive power on the series system will be made public. To this, we hope, will be added a report upon the degree of success which has been attained.

**Electric Railroading at Buffalo, N.Y.**—The following figures with regard to the passengers carried by the Park electric system of the Buffalo Street Railroad Company may prove of interest. There are four cars running on this branch, which is about one and three-quarter miles in length. On July 16th 17,000 passengers were carried; July 27th, 11,000; August 25th, 10,000. This road is equipped upon the Edison system, and has been in operation now for about fifteen months. The largest load ever carried was a little over twenty thousand, the occasion being a picnic, and the time being two days after the road commenced operation in July, 1889. Only three motor cars were in service on that day, and this remains the greatest record ever made by that number of cars.

**Telephone Extensions in Devonshire.**—A few months ago the Western Counties and South Wales Telephone Company were approached by the Port of Plymouth Chamber of Commerce with a view to establishing a signal station on Rame Head for reporting by telephone to Plymouth all vessels passing up or down Channel or entering the port, as well as casualties and other shipping news of interest. The Company have so far met the wishes of the Chamber that the connection with Rame Head is almost completed, and, provided that arrangements can be made with the Admiralty, the station will be in working order in a few weeks. The Company have now a connection with the Plymouth post-office, whereby subscribers can, in arrangement with the Company, transmit and receive their telegrams by telephone without the inconvenience and delay of sending them by hand.

**Royal Society.**—The following papers were down for reading at the Royal Society, on Thursday, Professor J. V. Jones "On the Determination of the Specific Resistance of Mercury in Absolute Measure." Dr. Hopkinson, F.R.S., "Magnetism and Recalescence."—The following is the list of names recommended by the President and Council of the Royal Society for election into the council for the year 1891: President, Sir William Thomson; treasurer, John Evans; secretaries, Prof. Michael Foster and Lord Rayleigh; foreign secretary, Archibald Geikie; other members of the council, Prof. W. E. Ayrton, W. E. M. Christie, Prof. W. Boyd Dawkins, J. W. L. Glaisher, D.Sc., Hugo Müller, Prof. Alfred Newton, Sir William Roberts, M.D., W. Chandler Roberts-Austen, Prof. E. A. Schäfer, Sir George Gabriel Stokes, Lieut.-Gen. Richard Strachey, R.E., Prof. J. J. Thomson, Prof. T. E. Thorpe, Sir William Turner, M.D., Prof. S. Howard Vynes, and Gen. J. T. Walker, C.B.

**The Life and Price of Glow Lamps.**—A correspondent points out that before being able to attach any practical value to Mr. Lott's statement in our last issue, it is necessary to have figures as to the watts per candle-power that this lamp required initially and after burning 10,000 hours. It is quite practicable for either a series or multiple glow lamp to burn considerably over 10,000 hours if he always kept a low efficiency, say, of 5 watts per candle-power and below. If the particular lamp mentioned by Mr. Lott began at, say, 3 watts per candle-power, and after 10,000 hours even went up to 4 watts per candle-power, then this denoted an excellent result. Our correspondent adds, with reference to our note on the price of lamps, that he is supplying lamps (made within 300 miles of London) at the still lower price of 1s. 7d., fitted and delivered free, and there is still every prospect of lowering this price in the near future.

**St. Martin's Vestry v. Gordon.**—This case, which was an appeal from the decision of the Divisional Court, was heard before Appeal Court I. on Monday this week. Mr. Gordon is the proprietor of the Hotel Métropole, and the question raised was whether the vestry were bound, under the Metropolis Local Management Act, 1885, to remove, in the ordinary course, the clinkers and other refuse produced in the furnaces erected in the hotel for the purpose of supplying the electric lighting, &c., of the hotel. The vestry contended that the clinkers were the "refuse of a trade" within the meaning of the Act, and therefore that they were not bound to remove them without payment of a reasonable sum for so doing. The Divisional Court held that the clinkers were not the refuse of a trade, and that the vestry were bound to remove them without payment. The Appeal Court dismissed the appeal, the Court being of opinion that in no case could "ashes" be held to be the "refuse of a trade."

**Reduction of Telephone Rates.**—The National Telephone Company has intimated to the subscribers to the Liverpool and Birkenhead exchanges that the rate of annual subscription will be reduced on and after January 1, 1891, from £15 to £10 for a connection within the customary radius. The trunk line tariff will, after January 1, 1891, be revised, the charges for three minutes' conversation being as under, to exchange subscribers only, no reduction being made to non-subscribers:—For any distance not exceeding 25 miles, 3d; over 25 miles and not exceeding 50, 6d.; over 50 miles and not exceeding 75, 9d.; over 75 miles and not exceeding 100, 1s.; over 100 miles and not exceeding 125, 1s. 6d.; over 125 miles and not exceeding 150, 2s.; over 150 miles and not exceeding 175, 2s. 6d.; over 175 miles and not exceeding 200, 3s. The National Telephone Company has also intimated that on and after January 1st next, local subscriptions will be reduced at Newcastle from £12 to £10, also that the trunk line tariff will also be considerably reduced on and after the date named.

**The Candle-power Classification of Arc Lamps.**—With a view of demonstrating the meaningless nature of the present commercial candle-power classification of arc lamps, M. Hospitalier publishes in a recent issue of *l'Electricien* the nominal illuminating power of arc lamps by different makers, but taking the same current. The following are some of the figures reduced to English candles contained in M. Hospitalier's table:—

| Amps. | Sautter-Lemonnier. | Fontaine | Cance (Globe). | Schuckert. | Cr'mpt'n | Latimer-Clark. | Ball. | By Tischendorffer's Formula. |
|---|---|---|---|---|---|---|---|---|
| 5 | 350 | 500 | 300 | ... | 500 | 400 | ... | ... |
| 8 | ... | 1,000 | 450 | 1,250 | 1,000 | ... | 1,600 | 1,250 |
| 10 | ... | ... | Breguet 700 | 1,750 | 1,400 | 1,500 | 2,000 | 1,780 |
| 12 | ... | ... | ... | 2,500 | ... | ... | ... | 2,375 |
| 13 | 1,500 | ... | ... | ... | ... | ... | ... | ... |
| 14 | ... | ... | ... | ... | ... | ... | ... | 2,930 |
| 15 | ... | 2,000 | ... | ... | ... | 3,000 | ... | ... |
| 20 | ... | ... | 1,500 | 5,000 | 4,000 | ... | ... | 5,375 |

**Hydro-Electric Installation at Antwerp.**—At the time when various schemes for the electric lighting of Brussels were under consideration (see *Electrician*, October 11 and November 1, 1889), M. Van Rysselberghe produced a plan, which was much discussed, for distributing power by hydraulic pressure to turbines placed in the basements of the buildings to be lighted, the turbines being coupled direct to the spindle of the dynamos In this connection the following description of a miniature installation laid down by M. Van Rysselberghe on this plan at Antwerp may be of interest. The installation is situated at the hydraulic station connected with the Antwerp dock-locks, and cranes and water at 40 atmospheres pressure is obtainable. The turbine devised by M. Van Rysselberghe is of the "hydrau-

Digitized by Google

lic tourniquet" description, and is coupled direct to a four-pole Victoria machine, the spindle of which is vertical. At full load 7 electrical horse-power are given out by the dynamo for every 16 horse-power supplied to the hydraulic motor. The speed is kept very constant at 650 revolutions by an automatic governor which regulates the admission of water. The hydraulic motor consumes three litres of water per 16 horse-power per second, and as the price of it is ·1d. per cubic metre, the cost of the horse-power hour at the dynamo terminals is about 2d. The dynamo supplies current to the four arcs and 150 incandescents employed in lighting the hydraulic station.

**A Novel Form of Measuring Instrument.**—In a recent issue of *La Lumière Electrique*, M. F. Leconte gives a brief account of some experiments carried out by him at the Liége University with a view of testing a curious form of electrical measuring instrument. M. Leconte's idea is to make a pile of circular iron discs, interposing some springy substance, between each disc, and to place this pile inside a solenoid. When the solenoid is traversed by a current, the pile of discs tends to contract owing to the formation of unlike magnetic poles at the opposing surfaces of the discs. This contraction is resisted by the springs, and by means of a suitable magnifying device the movement of a pointer along a suitably graduated scale enables one to read off the volts or the amperes. M. Leconte employed discs ranging in number from 18 to 60, in diameter (1mm. = 40 mils) from 20mm. to 65mm., and in thickness from ·2mm. to 8mm. Amongst the substances employed as springs were watch-spring steel, blotting paper, packing paper, ordinary paper, flannel and black indiarubber. The tendency of the discs to move sideways was checked by punching holes through them and slipping them over vertical glass rods. The sensitiveness of such an apparatus can be increased either by adding to the number of the discs, augmenting their surface, or by providing the solenoid with a core of iron wire. M. Leconte gives curves of the scale readings obtained with a voltmeter arranged with 18 cast-iron discs, 8mm. thick, and 65mm. in diameter, and provided first with indiarubber springs and then with steel springs. The curve in the first case was fairly regular between 27 and 53 volts, with steel springs the curve was very irregular, with indiarubber springs the deviation of the scale index was only 18mm. for 57 volts, and the actual contraction of the column of discs was only 2mm.; with steel springs the index deviation was only 8mm. for 50 volts.

**Electricity in the Service of the Chicago Fire Underwriters.**—Several months ago the inspection department of the Chicago Fire Underwriters' Association, says the *Western Electrician*, decided to establish a test department for the purpose of experimenting with automatic sprinkling apparatus. As in making the experiments it would be necessary to employ a convenient and easily-handled heating apparatus, and also to have a well-lighted room and a small power plant, it was decided to use electricity as a heating agent as well as for furnishing light and power. Arrangements were therefore made to construct an electric heater to be operated by current from the Edison Company's 220-volt circuit. The pipe sprinkler runs into a zinc-lined water-tight apartment. At the centre is the electric heating device, a metallic box, measuring 12 by 12 by 12in. The switch to control the current is on the outside of the apartment. The heater, when in operation, takes on an average 16 amperes. In the ceiling, with its bulb set just above the sprinkler on the end of the pipe, is a mercurial thermometer which will indicate a temperature from freezing point to 465 degrees. This instrument is so arranged that its indications may be read on the outside of the apartment. The room is well lighted by incandescent lamps, and small windows in the side of the rooms permit a close observation of the action of the sprinkler. When a sprinkler is to be tested it is only necessary to attach it to the end of the pipe, and by means of the cords to hoist the heater until it incloses the sprinkler. Current is then turned on until the temperature rises to the point at which the sprinkler opens. After this the heater is lowered and the form of the water jets may then be closely observed. A temperature of 221 degrees at the sprinkler has been attained through the use of the method, and a higher degree of heat could be obtained. The sprinklers, however, are designed to open at about 155 degrees.

**The Lubrication of Steam Engines.**—The following is extracted from an interesting article on this subject which appeared in a recent issue of the *Engineer*: Engineers very commonly pay scant attention to the cost of oil used in lubricating steam engines. They regard it as an insignificant item. Even those who pay for the oil take small pains to ascertain whether they are paying more than need be paid. The results of an inquiry into the question of oil bills in any district would, we venture to say, give highly startling results. Not long since we were shown an American engine of the horizontal high speed type. It was indicating about 13 or 14 horse-power. Coal was very cheap, and we were told that the cost of fuel was as nearly as might be 1s. 6d. a day. The oil bill was 3s. 6d. a day, or more than twice the cost of coal. In another instance we found an engine indicating about 1,500 horse-power and using 120 gallons of oil per week. A marine engine, triple expansion, of the same power gets on with 20 gallons a week. Again, we find in some cases that oil costing 2s. 6d. a gallon is used; in others, for just the same class of work, about 9d. a gallon is paid. It will readily be seen that a lavish use of oil at 2s. a gallon runs into a great deal of money. It is high time, we think, that more attention was given to this subject than has hitherto been devoted to it by users of steam machinery. The chief causes of excessive oil consumption are —says our contemporary—firstly, that engineers or drivers in charge of engines care nothing about oil waste; secondly, badly designed or badly kept engines; thirdly, unsuitable oil; fourthly, running in dusty places; fifthly, defective lubricating apparatus.

**Experiments on Electrical Oscillations.**—Professor John Trowbridge and W. C. Sabine, of Harvard University, have, says the *Electrical World*, recently been experimenting on electrical oscillations, and their results are interesting. The fundamental experiment consisted in obtaining a rapidly oscillating discharge from a Leyden jar and photographing the oscillations by making the spark fall on a revolving mirror. In reasoning on the mode of electrical oscillations in dielectrics, it occurred to the authors that the particular dielectric medium must influence the result obtained. The condensers employed were concentric cylinders of zinc, of which the capacity could be quite readily computed. The condenser was furnished with a discharging circuit about 50 feet in length, and was charged by a Holtz machine. The revolving mirror was spinning on a horizontal axis at the speed of 3,000 revolutions per minute. The period of the oscillations was, approximately, two or three millionths of a second. Glass Leyden jars were tested in addition to the air condensers. With the air condenser there was found a singular variation in the times of successive oscillations. It might have been expected that glass would be much more likely to show such variations. On the contrary, the periods of the discharges from the glass condenser were extraordinarily regular, while those in the air showed decided discrepancies from the theoretical time of oscillation as determined from the capacity of the condensers and the self-induction of the circuit. With small air condensers the variations were more marked than with large. According to the authors the reason the phenomenon was not observed in glass was because the period of recovery from a strain in that dielectric is too long to show itself during the enormously rapid oscillations with which the experiments were tried. The conclusion reached was, that, in the first place, the electrical oscillations in air show a certain periodicity in their lengths, due to the incomplete recovery of the air from the electrical strain. It also appears that there is a certain amount of the energy of the discharge spent in overcoming the dielectric viscosity of the air, just as a certain amount of energy is spent in hysteresis in a magnet. A further experiment was tried by the authors with a view of testing the effect of an intense magnetic field on these electric waves. The results, however, were indecisive. We may mention that these conclusions were criticised at the recent meeting of the British Association by Dr. Oliver Lodge, who pointed out that the capacity of the leads was able to produce results very similar to those observed.

Digitized by Google

## AN IDEAL PHYSICAL LABORATORY FOR A COLLEGE.

BY PROF. OLIVER LODGE.

(*Concluded from page* 33.)

Coming nearer to the details of internal arrangement of the block-plan, published last week, we may as well consider each of the main blocks separately, considering them as something like 40ft. cubes.

### The Students' Laboratory.

Take first the students' laboratory. The ground floor, as being steadiest, should accommodate the senior or second and third year students. Benches round the walls under the windows, with a gap here and there to give direct access to wall itself, and tables in the middle of the room, some fixed and very steady, others movable so as to leave either a clear space or to enlarge the fixed tables at pleasure, seem the main fittings wanted (Fig. 4). The non-window wall would be left free for fixtures and wall apparatus generally. Every bench and table 3ft. high and, say, 2½ft. broad. All the fixed ones to be provided with gas and water and electricity, and several of them with exhaust or vacuum pipes, compressed air, steam, temperature and pressure regulators, small turbines or other motors, and fume chamber ventilation. Galvanometers and lamps and scales on wall brackets.

The junior students' laboratory on the first floor would contain simple tables placed so as to get a good view of a slightly raised lecturer's or demonstrator's table, whence the student could be instructed what to do every now and then (Fig. 5). Each table might have a gallows frame along its middle, for the purpose of supporting things conveniently.

Above this, again, there might be another floor partitioned off lightly into rooms of various size, to accommodate a limited number of advanced students engaged in research, and each provided with a key to lock up the contents of their respective rooms (Fig. 6). By means of benches supported by very substantial brackets from the walls, without touching the floor, very fair steadiness can be obtained; though, of course, for anything demanding a high degree of rigidity, the ground floor is more suitable. Still, there are contrivances for securing steadiness on an elevated floor, and these are mentioned in connection with the research laboratory.

### The Electrical Laboratory.

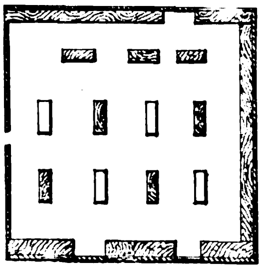
The electro-technical department is also mainly a students' laboratory, and may be considered next. The ground floor is to hold the heavy apparatus, say three or four experimental direct-current dynamos, a couple of alternating machines with their exciters, dynamometers, speed varying gearing, &c.; the shafting being driven either by an engine on the spot, or preferably by a large dynamo used as a motor, and supplied with current by a similar machine driven from a steam-engine in the neighbouring engineering department, where there will naturally be steam always up. This plan will save the danger and trouble of a local boiler, or the inconvenience which gas-engines present when used for experimental purposes; and it would besides give the students some experience of fairly large-scale transmission of power and of the tests to be made at both sending and receiving ends. The storage battery would be established in a well-lighted, well-ventilated, partitioned off, central compartment, whence groups of wires would lead to switchboards in various parts of the building. Various engine room meters would be provided on the ground floor; but the more delicate and elaborate testing instruments, Thomson meters, and such like, together with transformers, lamps, and experimental devices of all sorts, would be accommodated on the first floor above. On an upper floor, again, I should propose a telegraphic laboratory, with artificial cables and a syphon recorder, in addition to the more refined kinds of apparatus in use on land lines, and the ordinary electrical fittings of a laboratory. An experimental land line, with specially arranged resistance and leakage, and with a variety of faults to be introduced by the demonstrator and detected by the student, could also be planned.

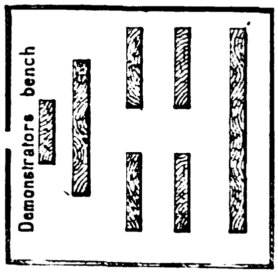
### The Theatre.

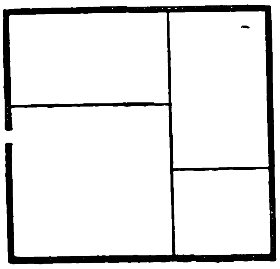
Not much need be said about the theatre. It should be a lofty room, say about 30ft. high, with a large lecture table plentifully supplied with every convenience already mentioned as desirable for some of the senior students' work benches, and likewise containing a large tank with plate glass front, a mercury trough, strips let into it for supplying current from a storage battery, with switchboard to vary the number of cells connected, and so on. Diagram frames, lantern screen, fume chamber, wall slates, &c., go without saying. An oxygen tank, easily controlled by water taps and supplying the gas to various parts of the table for local oxy-coal-gas lamps, is also useful. So is an electric lantern conveniently situated and always ready. For exhibiting lantern slides I prefer a translucent screen of small size (about a yard square), on which strong illumination is thrown by a short-focussed lens from behind. The room need not be darkened, only shaded from direct sunshine. I have been accustomed to show lantern slides in this fashion for some years and find it extremely convenient. To darken a room so that students cannot take notes or see the blackboard and other diagrams is a very unsatisfactory plan. Stray light *behind* a translucent screen is to be avoided, but stray light in front penetrates it, and does no particular harm. It is necessary with such a screen to point the light towards the middle of the audience, and persons very much on one side will lose some light; but there is usually no practical difficulty in securing plenty for all. Even to a large audience a brightly-illuminated small picture is often quite as effective as a large dim one. The size of the room, however, must, of course, be taken into account, and the amount of darkness necessary varies accordingly.

The best place for artificial light at night is frequently near the back of the audience; it illuminates their books then without glaring into their eyes. The table, blackboard, and diagrams, can be illuminated from above by screened lamps under the control of the lecturer's assistant. Near the top of the room an experimental gallery, with slotted uprights to its baluster for suspending things from, and for helping the performance of various lofty experiments, is a valuable addition. The best place for the outgoing ventilation shafts is probably near the back of the ceiling, fresh air entering from under the lecture table on the lecturer's side, its temperature and volume being under control, so that the foul air can be drawn away from the lecture table, which for some experiments it is desirable to protect from the damp of an audience.

In addition to the main lecture theatre, a class-room for exercises and more mathematical work is essential, especially as the illustrated lectures involve a good deal of preparation, and the lecture theatre is therefore not always available for





Students' Laboratory.

Fig. 4.—Ground Floor, for Senior Students. Fig. 5.—First Floor, for Junior Students. Fig. 6.—Second Floor, for Advanced Students.

the multitude of classes that have to be held. A floor high up, above the theatre, seems the place where such a classroom must be placed, though a lower position would have been preferable.

THE RESEARCH LABORATORY.

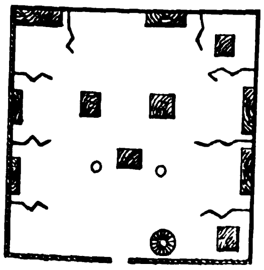
Now we come to the place where the Professor carries on his own private work, and the endowment of which usually constitutes the inducement to associate himself with a college at all. There may be many differences of opinion as to what is best for a research laboratory. Some may prefer a set of small rooms, others one large room. My own inclination leads me strongly in the latter direction; I have found one large room by far the best plan. Of the block called "research laboratory," the ground floor is the principal portion; it, in fact, constitutes the laboratory, with a supplementary floor high up, and a couple of galleries in between. A large lofty room has great advantages; it is inconvenient to be cramped in any dimension.

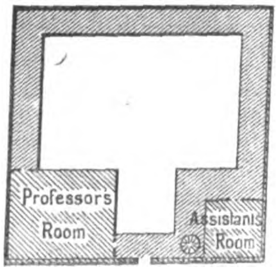
A large amount of unoccupied wall space is left in this laboratory for the accommodation of tall mercury gauges, suspended wires, long tubes, and a multitude of other things conveniently fixed and reared against a wall. Slotted poles, or "Willis's posts," of considerable height, fixed against a wall with a space large enough for the hand to clamp special iron brackets (supplied by Rigg, of Chester) to them, I find excessively convenient for supporting things firmly. Similar, but shorter, slotted posts are useful also in the students' laboratory, above several of the side benches. They are unobtrusive when not wanted, and they often save the necessity for inconvenient retort stands and other holders standing unsteadily about. To get at these carpentered up; but to make it still easier I propose a set of folding screens, 8 or 10ft. high, hinged and shutting up into the wall like shutters when not in use, but able to be drawn out so as to make a stall or little room, which can then be secured with a padlock if desired (Fig. 7).

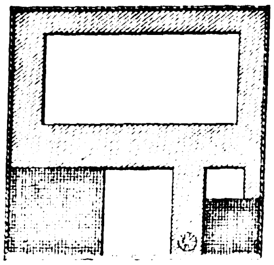
Every window throughout the building ought to be provided with obscure blinds, and those in the theatre and research laboratory ought to be thoroughly opaque, so that complete darkness can be secured when wanted; but when only local darkness or considerable shade is needed, the partitions already spoken of enable it to be obtained with little more than a black cloth thrown over their top.

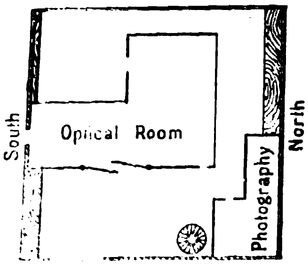
The main difference between the research laboratory and the senior students' laboratory is that, whereas in the latter all manner of appliances are located in permanent positions, water pumps, turbines, gas furnaces, sand-baths, steam-heaters, gas cooking stoves, and the like; in the research laboratory permanent fixtures are few: things are to be brought from the museum and rigged up in the most convenient position for the particular investigations going on, and when they are done with after a few years they can be dismantled and moved elsewhere, or else stored until they are wanted again. The difference may be emphasised thus:—A student is to be moved to the apparatus adapted to the particular experiment given him to do during the next few days or weeks. Apparatus is to be moved to the person engaged in research and established in some semi-permanent manner for the year or two during which the investigation lasts.

Although a lofty room is needed for some experiments, it is not necessary to have it equally free all over, and accordingly








RESEARCH LABORATORY.

Fig. 7.—Ground Floor. Fig. 8.—Twelve feet up, Private Rooms and Main Gallery. Fig. 9.—Twenty-four feet up, Upper Gallery. Fig. 10.—Top Floor.

poles, gauges, and other appliances, the two galleries are available. The poles penetrate the galleries, leaving a clear space a foot or so square round them; but the galleries are five feet broad, and accordingly there is plenty of room to pass. Short library ladders in each gallery permit every point of the entire wall to be readily accessible. The front uprights of the gallery, both here and in the lecture theatre, are also slotted for hanging things from brackets for experiments going on below.

The tables in the research laboratory will most of them be movable, there must always be plenty of ordinary wooden tables standing about, but a few masonry piers built direct on the rock beneath, which is not to be cut away but if necessary levelled up by concrete to within a foot or so of the boarded floor, are provided here and there; and more can be put down temporarily wherever wanted. A spiral staircase and a couple of pillars for supporting some rooms above are also shown on the plan. These pillars should not be iron or faience or anything ornamental, but should be simple baulks of timber, so that things can be easily attached to them. The walls, also, it is very pleasant to have substantially wood-panelled up to a certain height, so that screws, hooks, &c., &c., can be immediately put in at any place without the trouble of plugging. The water and gas pipes, and the electric wires, should not be hidden away, but should be readily accessible along their whole length, so that they can be tapped at any convenient place, in addition to the fixed stop-cocks provided.

Although a large lofty room is favourable for many experiments, yet there are occasions when it is desirable to enclose something or to partition it off from the laboratory for a month or two; for instance, an experiment which needs a long time for its development. Such partition can always be lightly at about 12ft. elevation I propose to place the professors and the chief assistants' private rooms, as shown in Fig. 8. The professor thus gets the benefit of plenty of outside light, and also a window for supervision of the laboratory, without encroaching on any of the valuable ground floor space. The five-foot gallery, and the window sills in the thick walls, allow space for sundry small experiments to be going on at this level. The walls of the entire building should be very thick and substantial. Above, again, and close to the ceiling, is a mere assistants' gallery for suspending things and for getting to the top of any wall fixtures at that height (Fig. 9).

The upper floor may be regarded as mainly an optical laboratory, heliostat window on the south front opening into the principal dark room. It is suggested that this should be lightly partitioned off from the rest of the space so as to virtually leave several other rooms for working in; and there will be a supplementary dark room with a long wall bench on the north side for photographic purposes. Two ordinary doors into the optical room are shown in Fig. 10, and one pair of large doors for only occasional use, *e.g.*, for introducing large apparatus, and for letting in plenty of light for cleaning, &c.; but ordinarily to be closed and their chinks clothed over. The defect of such an optical room is that steadiness is difficult to secure, and yet for many optical experiments it is vital. A wall bench is not altogether convenient, and probably the best plan is to utilise the anvil principle, and support the bench on a great mass of iron bedded on indiarubber, or even (as Michelson does) floating on mercury. A pair of girders can always be made to support it independently of the floor. The optical room, as planned, is a mere expedient for securing local darkness, and its shape should be alterable

Digitized by Google

without much difficulty. If spectroscopic work is to be done, a rectangle and sliding bar for mounting a Rowland grating will, of course, be provided. Although sunlight is arranged for in connection with spectroscopy and other subjects where its use is essential, an arc lamp will also be provided for the numerous occasions when the sun is not visible.

### The Annexes.

Three of the angle rooms shown in Fig. 3, page 32 of last issue, will be passage-rooms, with a door at each end, and with plenty of side light in front. A long bench will run along under the window of each, and there can be a store-cupboard or chest of drawers at the back of each. The workshop can have a shaft driven from the electro-technical department; the store room is to contain chemicals and materials, wire, rod, tube, sheet, &c. The room labelled desk room will have to be mainly occupied by the entrance; and, in fact, if it can be made into both entrance and main staircase, its space will be exhausted.

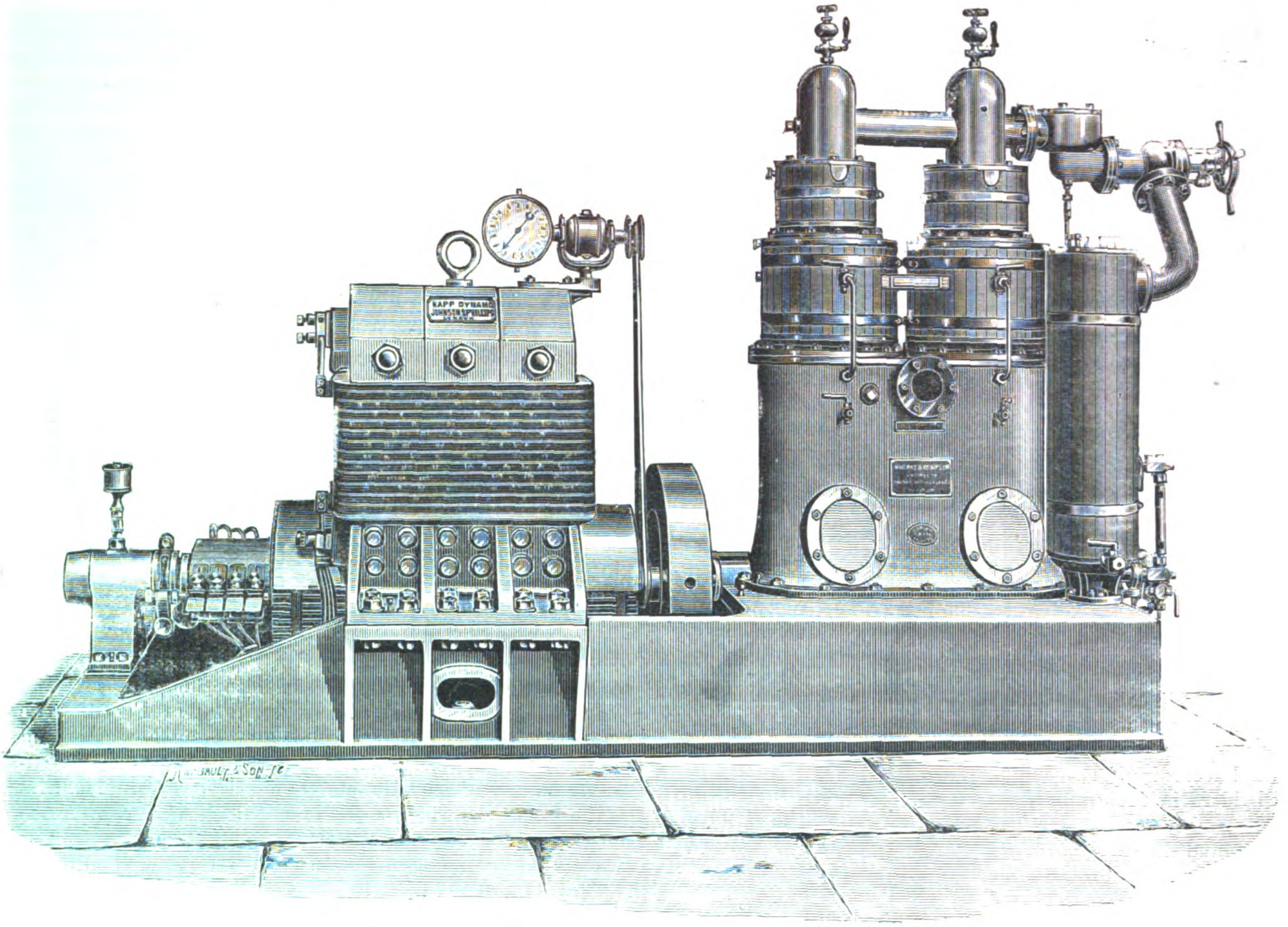
propose to leave the centre comparatively free from permanent fixtures. Beneath the centre of the dome there might be a railed-off pit leading down into the basement excavated under the central hall for uniform temperature operations.

### Basement.

As to the basement, it need not be lighted from the outer air at all. It should be well drained, whitewashed, and lighted by incandescent lamps, with a central arc light for making it more wholesome by occasional artificial sunlight.

### Astronomical Annexe.

A water tower with spiral staircase and clear central space has been spoken of as a suitable annexe. Another may very well be a small astronomical, magnetic, and meteorological observatory. A transit instrument, a clock, and an equatoreal with photographic and spectroscopic appliances, are the fittings suitable to the astronomical room; and the meteorological in-



Kapp-Willans Combination 50 kilowatts.

### The Central Hall.

The central space remains to be considered (Fig. 3). Doors will open out from it direct into each of the four main blocks, both on the ground and on the first floors, the first floor doors being connected by a wide gallery running all round it at the appropriate height. All round the walls, up to this gallery, will be the apparatus cases; and some pieces of large apparatus can stand about near the middle of the floor. Side lights at each corner begin at the height of the gallery and continue to the roof, which will probably be dome-shaped with a central lantern, and perhaps a small gallery round the lantern.

I did propose a central tower resting on columns and arches, but it may be better to keep the centre of the hall under the dome, free, and to erect a tower on a separate basis. A tower with a cistern for delivering water of a high uniform pressure is certainly useful, but it can very likely be obtained in connection with some adjacent building. The large space of the hall may be occasionally useful for experiment, and hence I should

struments may vary with the interest the professor or students take in the collection of data. A few inexpensive recording instruments would undoubtedly be instructive, and a student will commonly be found able and willing to look after them.

## TEST OF A WILLANS-KAPP COMBINATION.

For the lighting of the new Birmingham post-office there will be required three 50-kilowatt steam dynamos, and these sets have been supplied by Messrs. Willans and Robinson, who have obtained the dynamos from Messrs. Johnson & Phillips. As the engine-makers undertook the contract on a guaranteed consumption of steam per unit output, careful efficiency tests were made, and we give below a summary of the result.

The tests were carried out by passing the exhaust steam through a surface condenser, and weighing the water in the

Digitized by Google

manner described in Mr. Willans' classical paper on non-condensing steam-engine trials, *Proc.* Inst. C.E., Vol. xciii. The intervals of time given in the tests refer to the time taken to pass 100lb. of steam through the engine.

The dynamo is of the inverted type, as usual with this make. The armature is drum-wound, having a resistance of ·00527 ohms when warm. It contains 102 conductors, and a 51-part commutator. The resistance of the shunt is 17 ohms, and that of the main ·002 ohms. The volts are 112; the full current 456. The average indicated horse-power during the trial was 79·7, and the average output from the dynamo terminals was 447·2 amperes, at 112 volts pressure, making an average of 50·1 kilowatts, or 67·2 electrical horse-power. The mechanical efficiency of the set is therefore $\frac{67 \cdot 2}{79 \cdot 7} = 84 \cdot 25$ per cent. The consumption of steam per indicated horse-power is remarkably low.

*Consumption Trial.*

Steam pressure 120 lbs. No. 982. For Birmingham P.O.
Engine No. 982. Barometer 30·3 falling. Date, August 8, 1890.

| Weight in lbs. Water collected. | Time. hrs. | Time. min. | Time. sec. | 100lb. interval. min. | 100lb. interval. sec. | Amperes. | Volts. |
|---|---|---|---|---|---|---|---|
| 4420 | 3 | 36 | 15 | | | 450* | Volts constant at 112 throughout trial. |
| 4520 | 3 | 39 | 34 | 3 | 19 | 452 | |
| 4620 | 3 | 43 | 53 | 3 | 19 | 440 | |
| 4720 | 3 | 46 | 13 | 3 | 20 | 448 | |
| 4820 | 3 | 49 | 34 | 3 | 21 | 454 | |
| 5020 | 3 | 56 | 11 | 3 | 18·5 | 443 | |
| 5120 | 3 | 59 | 34 | 3 | 22 | 450 | |

(Six other similar readings follow.)

*Voltmeter, Evershed, 643, checked by Siemens' small dynamometer. Ammeter, Siemens, 2477

Water per hour = 1803lb.
Add 4lb.

Total water = 1807
Total kilowatts = 50·09
Water per kilowatt hour = 36·08lb.
" " indicated horse-power, 22·55lb.
" " electrical " " 26·91b.

## THE CENTRAL STATIONS OF THE METROPOLITAN ELECTRIC SUPPLY COMPANY.

BY DR. J. A. FLEMING, M.A.

*(Continued from page 9.)*

### THE MANCHESTER-SQUARE STATION.

This central electric supply station ranks next in order as regards degree of completeness after Sardinia-street. Like this last-named station, Manchester-square is an alternate transformer station, supplying distributed transformers placed on customers' premises by means of an underground system of primary conductors. The site on which the station stands was formerly a mews, and the first sod was turned on August 12, 1889, in the commencement of the station which has been erected on that place. The station may be described as capable, when in full operation, of an electrical output of a million watts. Hence it can supply an actual demand of 30,000 30-watt lamps, or is equal to supporting 50,000 such lamps wired. The station buildings are substantial brick buildings, which have been laid out with great skill to economise to the utmost the space at disposal.

The architectural work here, as well as that of the Sardinia-street station, was carried out by Mr. Robert Walker, F.R.I.B.A., and the engineering construction and design of the station has been done by Mr. J. E. H. Gordon. The dynamo room (Fig. 11) contains a set of 10 generating units, each composed of a 200 horse-power Willans triple expansion engine, working under a pressure of 200lb. of steam, combined on the same bed-plate with, and driving direct an Elwell-Parker alternator, having an output of 100 kilowatts.

The engines work at a speed of 355 revolutions per minute, and require 200lb. pressure of steam. The Elwell-Parker dynamo coupled to it has already been described in detail. (*See Electrician*, November 7, 1890, p. 15, Vol. 26.)

The dynamos at Manchester-square have 36 magnet poles on the revolving field magnets and 36 coils in the stationary armature, and, accordingly, there are about 12,000 alternations per minute in the resulting current, or a frequency of 100. The exciting current employed is a current of 28 to 34 amperes at a pressure of 100 volts. Each dynamo-bearing is provided with arrangements for circulating cold water through the hollow bearings in case of heating.

These dynamos furnish a current of 100 amperes at full load, under a pressure of 1,000 volts. To excite this battery of 10 alternators there are four exciters by Elwell-Parker, which are the ordinary shunt machines, each driven by a triple-expansion direct-coupled 60 horse-power Willans engine at a speed of 475 per minute. Two of these exciters are equal to doing the whole work of exciting the 10 alternators, and the fields of the alternators are, as usual, joined in parallel across the poles of the alternators. The arrangements for preventing the transmission of vibration from these engines and dynamos to the ground around are very perfect.

In preparing the foundations for each engine and dynamo, the ground was first excavated for a depth of 10 or 12ft., and a pit formed (*see* Fig. 12) in which was made a solid floor of

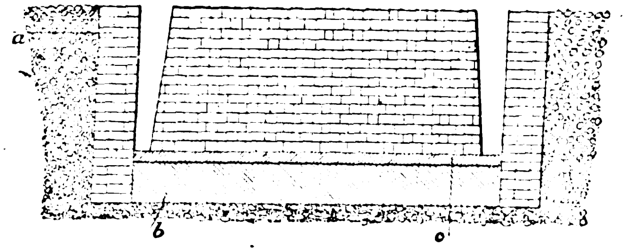



FIG. 12.—Manchester-square Station. Sectional view of the method of arranging the foundations so as to prevent vibration. *a* Retaining wall. *b* Sub-base. *c* Lead and felt.

concrete, and the sides built up. On this floor of concrete was laid a thick sheet of felt, and then one of lead, and on this was built up a block or table of brick. On this table are fixed and bolted the bed-plate of the engine and dynamo. It has been thus found possible to quench all vibration and prevent the communication of thump to the walls of the building and to the ground around. Entering the boiler-house (*see* Figs. 13 and 14) we find a battery of nine Babcock and Wilcox tubular boilers, each capable of evaporating 6,000lb. of water per hour. The consumption of all the engines when at full load will be 40,000lb. of water per hour. The arrangement by which large steam pipes are avoided is worth notice. Over each pair of boilers is a wide pipe or drum, and from each drum proceed steam pipes to two engines. All the drums are connected by equalising pipes, and as a result there is no steam pipe other than these drums which is larger than five inches in diameter, and the difficulties with large bends and joints thus avoided. The steam stop-valves which shut off each boiler are made with an outside screw thread, and a gunmetal female screw having a longitudinal slot through which oil can be squirted through the thread to prevent sticking. Each boiler has two feeds, one hot and one cold; so that if the hot feed fails from any cause the cold feed can be supplied. In blowing off the hot water from the boiler there is an arrangement by which cold water is mixed with the hot, so as to reduce it below a temperature of 212deg. when it enters the drains, or else the result of "blowing off" would be to fill all the drains of the surrounding neighbourhood with steam. A water tank is provided which will contain twelve hours' supply of water; but water can also be taken direct from the water mains. The coal

Digitized by Google

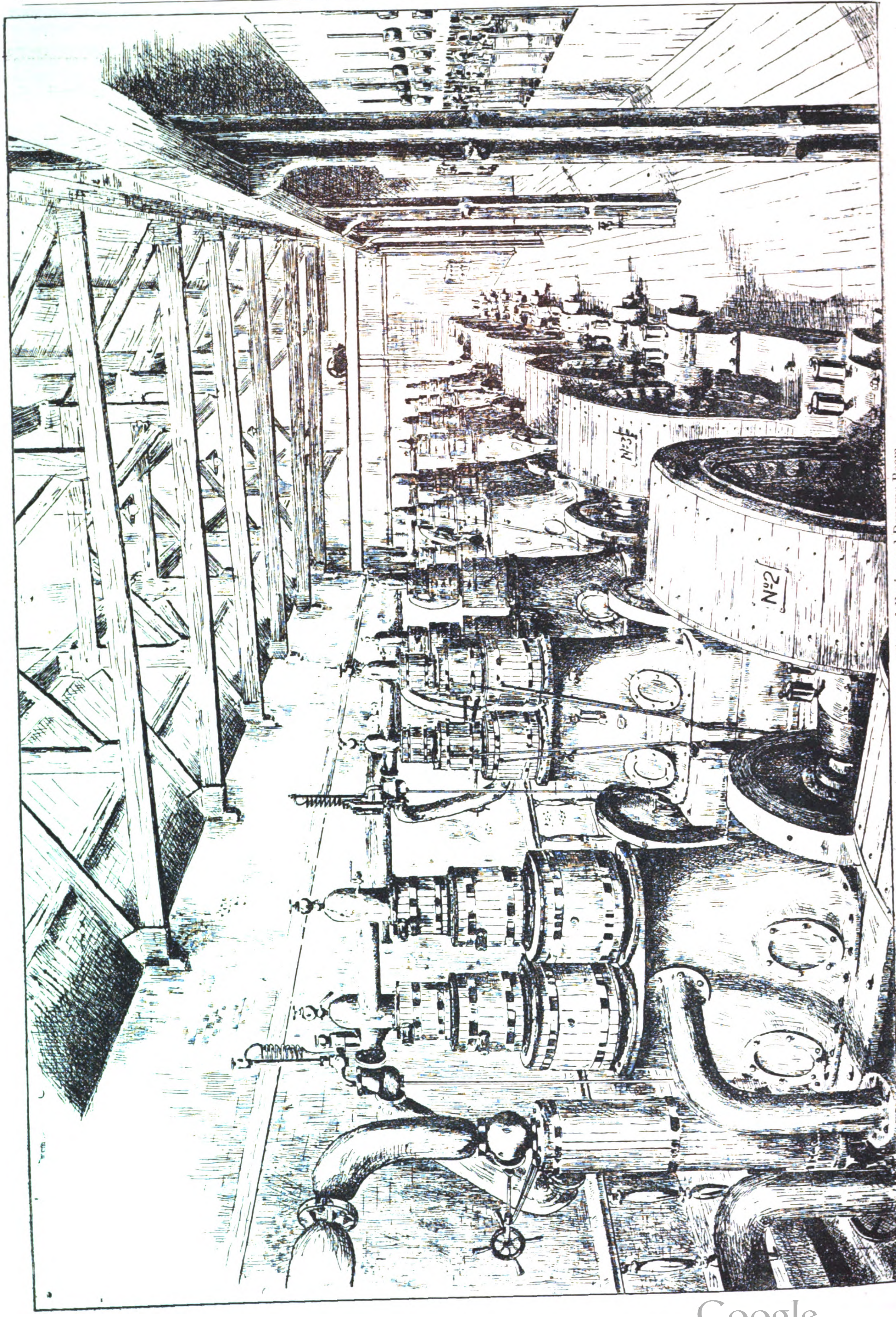



Fig. 11.—Manchester Square Station.—View of Engine and Dynamo Room.

Digitized by Google

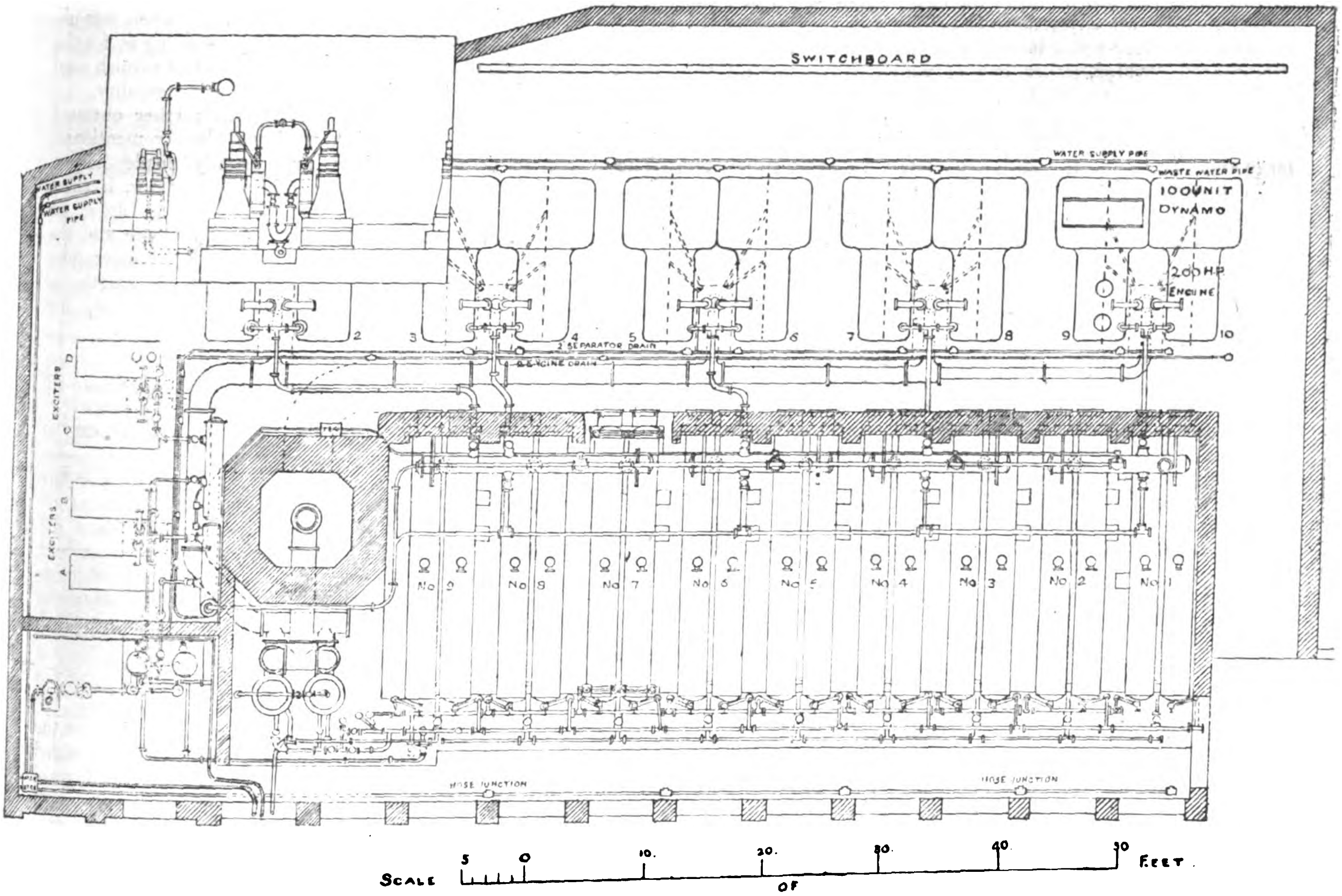



Fig. 13.—Manchester Square Station.—Plan

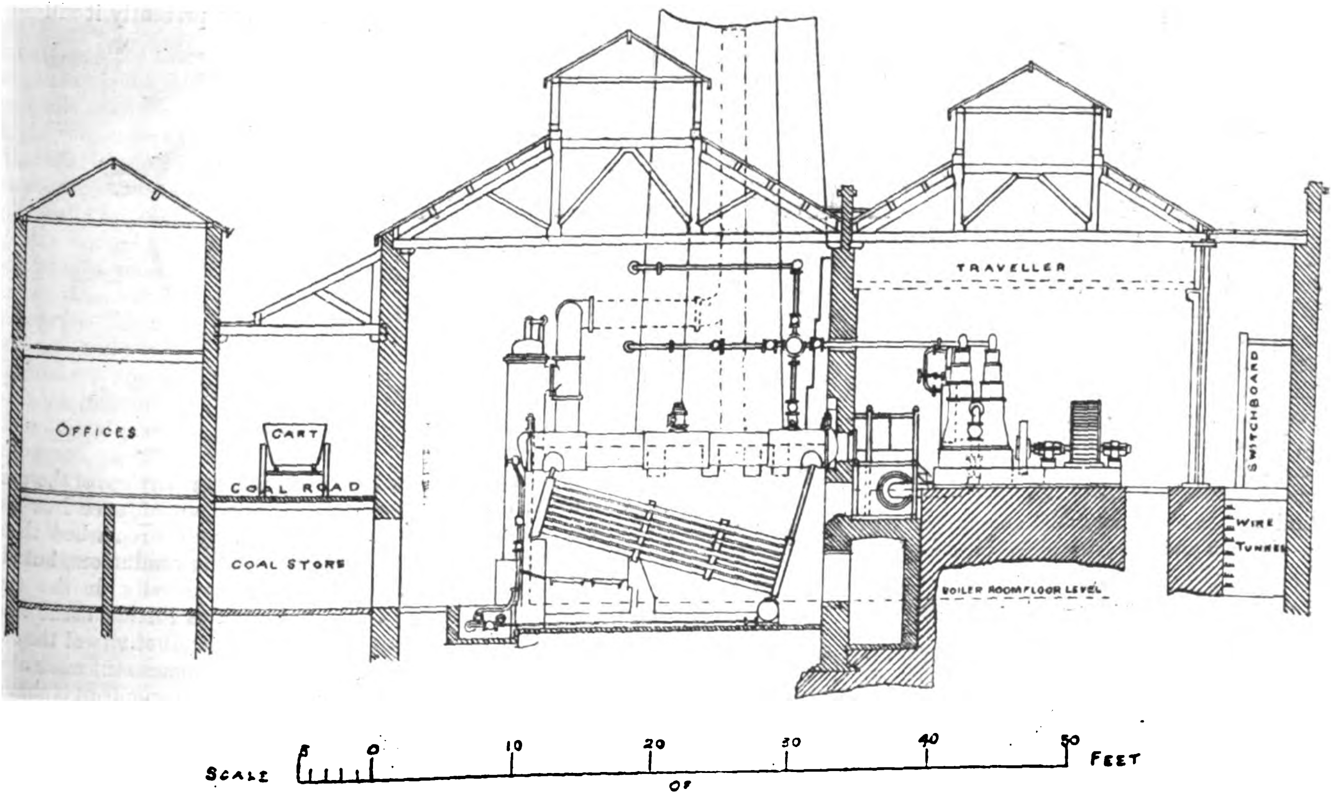



Fig. 14.—Manchester Square Station.—Section and Elevation.

Digitized by Google

store has a capacity for 300 tons of coal, and the coal waggons arriving from the street shoots the coal directly down into the bunkers, which are adjacent to the stoke holes. Hard by the boilers are the feed-water heaters and the pumps. Two Owen's pumps are provided, either one of which will pump all the water required for the boilers. The exhaust steam from the engines passes into an exhaust pipe, which is 15in. in diameter at one end and widens to 25in. in diameter at the other. The large end opens into the chimney shaft. In order to prevent the exhaust steam from mixing with the smoke, this exhaust steam pipe is continued right up the chimney, being supported centrally right throughout its length by rings built into the brickwork, and which preserve it in position whilst permitting free expansion and contraction.

The shaft itself is 8ft. square inside at the bottom and 10ft. square inside at the top, and cased outside with white glazed bricks. The central exhaust steam-pipe is 26in. in diameter. The shaft is surmounted by a cast-iron chimney cap weighing 26 tons. This arrangement, which is due to Mr. Gordon, has the effect of abolishing the nuisance resulting from condensed steam and soot in the neighbourhood of the station. The exhaust steam not being contaminated with products of combustion dissolves quickly in the air. Adjoining the station is a house for the engineering staff, and when in full work the work will be arranged in three watches of eight hours each, and two watches on Sundays.

The whole of the station buildings are solidly built of brick, and lined with white glazed brick, like Sardinia-street.

*(To be continued.)*

## DRUM ARMATURE WINDING.

BY F. M. WEYMOUTH.

*(Continued from page 39.)*

Foucault currents may, however, be stopped by another method, also included in one of Mr. James Swinburne's patents, by which any twist in compound bars is rendered unnecessary. This applies in cases where it is possible to connect up the component parts of two bars of a coil, separately, and in such a manner that the tendency to these currents in each bar shall oppose that in the other. This is achieved in the manner indicated diagrammatically in Fig. 8. The pulley end of the armature is here shown, and one coil, each bar of which is composed of four strips laid edgeways. The strips of the one bar must then be connected to those in the other bar, separately, in the manner represented. The coil is, in fact, split into so many parallel planes. To understand this, we may imagine the coil to be revolving in the field in the direction indicated by the curved arrow. The upper pole-piece is north, and the lower south. The magnetic lines of force will thus be running from N to S, and will be most dense at the trailing horns, $a$ $a$. As rotation takes place it will be seen that both bars are approaching dense portions of the field, and the lines of force are running through both bars in the same direction, that is, toward S. Hence, as viewed from some point in the same plane as the coil, on one side, but outside the armature, the eddy current would circulate in each bar in the same direction; or, as seen from S, in the same direction as the hands of a watch. Thus, at the sides $w$ and $x$ of the two bars, the current would approach; while at the sides $y$ and $z$ it would recede, as indicated by the small arrows. The opposition of the two tendencies is at once obvious. The union of the strips in each bar at the commutator is, of course, of no consequence. The explanation can also be put in terms somewhat as follows:—Whereas the volts of $w$ $z$ may be greater or less than $y$ $x$, the sum of the volts of $y$ $z$ will about equal the sum of the volts of $w$ $x$. Hence no current will flow

In all cases, it may be mentioned, the bars, whether solid or compound, may be wound with cotton or silk tape and varnish for insulation. Solid bars are sometimes left bare, in sulated from one another by air gaps, and from the core by Willesden or Manilla paper, or other material, and varnish. They will, of course, be more liable to damage when left uncovered; but with compound bars the tape winding is, for the most part, necessary to maintain their shape. The varnish used is commonly shellac, though some makers use a speciality.

The heating of the bars should be still further obviated by efficient ventilation, a point we have already mentioned. The cores of large machines are usually made hollow. When revolving, the long lugs of the commutator, if there are any, act as centrifugal fan blades, and draw air through the hollow between the interior of the core and the spindle, and so assist to keep down the temperature. Some makers leave gaps in the core along its length, so that air from the interior may fly outwards, and help not

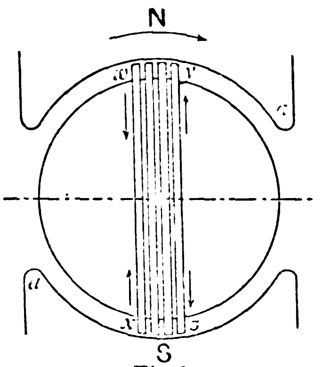


Fig. 8.

only to keep the core cool, but also the conductor bars on the periphery, and the pole-pieces. The bars will also draw air round after them, and so ventilate themselves. One of the advantages of the Hopkinson dynamo is thus here illustrated (Fig. 3, reproduced) since, owing to the fact that the horns stand away from the armature, air is more easily drawn down between it and the pole-pieces, and thus can be more effective in keeping the bars cool than when throttled and wire-drawn, as it were, by the closeness of the horns to the armature. The whole question of ventilation is not one to be passed over as inconsiderable. A phenomenon showing the effect of thorough ventilation may be observed when a dynamo stops after a run. The end winding, owing to its complete exposure, and revolving in a thorough draught, may feel cool to the hand at first; but presently it will become

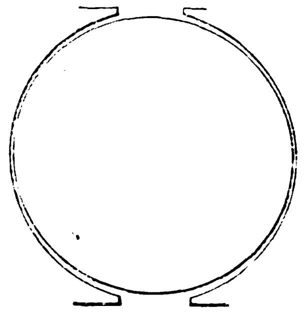


Fig. 3.

warm, owing to the heat from the interior portions of the winding and armature creeping out. This shows at once how great a difference ventilation makes. It may be remarked that not only does heat tend to generate in the conductors, but also in the iron core and the pole-pieces, especially in the trailing horns of the latter. Hence, when it is further borne in mind that a high temperature reduces the conductivity of the copper, the desirability of good ventilation becomes still more obvious. In fact, other things being equal, a greater output is obtainable from a well-ventilated machine than from one not ventilated. When a machine is run very hot, energy is wasted in the dissipation of the heat, as already pointed out in an earlier passage. Some makers supply auxiliary fans, or air propellers, especially for the purpose of creating a draught through a machine as it

Digitized by Google

runs. But, on the other hand, though thorough ventilation may keep the bars cool, there is yet, perhaps, some degree of falsity in the theory of this method of procedure. Heat is abstracted, and so energy lost, just as when the bars are allowed to heat—though it may be not so much, owing to the lesser resistance of the cool bars—beside the loss of power involved in driving a fan when one is used. Only by good ventilation the heat is drawn off more quickly, and the bars are kept cool, and at their normal conductivity. Hence, as already intimated, the size and therefore the first cost of a well-ventilated machine for a given output should be less than for one not ventilated. In some machines ventilation is further assisted by the magnets being formed of bars, with interstices between them, through which air may pass in and out of the field. A practical limit, however, to heating is the ability of the various materials used for insulation to endure a high temperature without perishing, or losing their insulating qualities. To this limit no doubt machines are sometimes run.

We may now proceed to describe some of the different methods in which heavy current windings are constructed, having special regard to the arrangement of the cross connections at the ends of the armature. It will be noted that a bar being the reverse of flexible, it cannot be dealt with as a mere wire. To have to bend it would be a matter of considerable trouble. Hence special means have to be adopted at the drum ends. These consist principally, though not in all cases, of separate lengths of metal. These are used to form a connection between the ends of two opposing bars forming the two sides of a

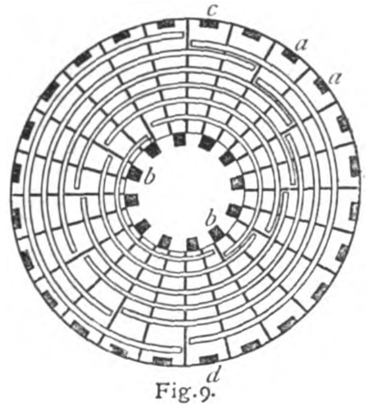



Fig. 9.

coil, and are united thereto by soldering, screwing, or both. As we have already pointed out, in armatures for heavy currents there is generally only one, or, at the most, but two turns per section. If high volts are required, the machine must be made larger, or the field stronger, or the speed increased, or all three. Matters are thus much simplified. It is, of course, not mechanically impossible to have more turns per section. But the extra complications involved, combined with many other disadvantages, render the idea in ordinary cases inadmissible.

Among the earliest of these methods brought out, is one patented by Edison. This is illustrated in Fig. 9, which shows an end view of an armature. The rectangular black dots *a a* are the parallel conductor bar ends. Each of these is let into and jointed to the periphery of a flat radial insulated metal plate, as shown. The radial plates of two bar ends desired to be connected up, such as *c* and *d*, are then united by a circular bar, as shown, jointed to each, but insulated from the other bars and plates. An electrical connection is thus carried round from one side to the other. It will be understood, in accordance with some of our preliminary remarks, that this sketch merely represents the principles of mechanical construction involved, and does not necessarily represent any one actual design. It is probable that the bars in Edison's early machines were connected up in the manner, though not in the order here shown. The parallel conductors here are bare, and, it will be observed, are a long way apart. This method is practicable indeed for a winding of a few sections only. Though each end of the armature is thus connected up, yet at the commutator end, which is here given, alternate radial plates are projected further inwards than the remainder, as shown in solid black at *b b*. These projections are each united to a commutator segment. Besides the drawback already intimated, this end winding has the further fault of not being symmetrical. Hence, a perfect balance and equality of resistance in the coils become often impossible. Some new arrangement thus becomes desirable.

*(To be continued.)*

## ON THE POTENTIAL DIFFERENCE BETWEEN TWO DILUTE SOLUTIONS IN CONTACT.*

BY MAX PLANCK.

The author, as well as W. Nernst, has already published a treatise on the calculation of the potential difference when the two fluids in contact are solutions of the same electrolyte at different degrees of concentration. He now shows how the same may be accomplished when two different solutions are used.

If $\phi$ denotes the potential, the constant $\epsilon$ the electrical charge of a monovalent + ion, the constant R the osmotic pressure of an ion occupying unit volume, $\xi$ a constant depending on the concentration and the mobility of the ions, then the required potential difference is—

$$\phi_2 - \phi_1 = \frac{R}{\epsilon} \log \xi.$$

When the calculation is based on the assumption of a complete dissociation, the calculated value will never correspond exactly with that observed. The limiting value which the potential difference approaches as the solutions are diluted may, however, be obtained. The calculated differences of potential are not independent of the time, for two solutions in contact are never in a state of equilibrium, diffusion taking place until the mixing is complete. For many solutions a constant value for the potential difference cannot be determined, though by a comparison of theory with practice a nearly constant difference may be arrived at.

The investigation of the general case when the ion is multivalent presents considerable difficulty, but it is found that if $n$ is the valency of the ion,

$$\phi_2 - \phi_1 = \frac{R}{n\epsilon} \log \xi$$

$n$ times less than when the ion is monovalent.

## MEETINGS OF SCIENTIFIC SOCIETIES, &c.

**FRIDAY, November 21st.**

THE JUNIOR ENGINEERING SOCIETY.

*8 p.m.* Presidential Address: "Electro-magnetic Mechanisms," by Prof. SILVANUS THOMPSON, D.Sc.

**MONDAY, November 24th.**

SOCIETY OF ARTS.

*8 p.m.* Cantor Lecture. 1. "Gaseous Illuminants," by Prof. VIVIAN B. LEWES.

**TUESDAY, November 25th.**

INSTITUTION OF CIVIL ENGINEERS.

*8 p.m.* Ordinary Meeting. Paper to be read: "The Vibratory Movements of Locomotives," by Prof. JOHN MILNE, F.R.S., and JOHN McDONALD.

ROYAL VICTORIA HALL.

*8.30 p.m.* Lecture: "The New Divisions of Africa," by HILLIARD ATTERIDGE.

**WEDNESDAY, November 26th.**

SOCIETY OF ARTS.

*8. p.m.* Ordinary Meeting. Paper to be read: "Physical Tests in Competitive Examinations," by FRANCIS GALTON, F.R.S.

**THURSDAY, November 27th.**

INSTITUTION OF ELECTRICAL ENGINEERS.

*8 p.m.* Ordinary General Meeting. Adjourned discussion on the following papers: "The Efficiency of Secondary Cells," "On the Chemistry of Secondary Cells," by Prof. W. E. AYRTON, F.R.S., C. G. LAMB, B.Sc., and E. W. SMITH.

**FRIDAY, November 28th.**

PHYSICAL SOCIETY.

*5 p.m.* Papers to be read: "Notes on Secondary Batteries," by DR. GLADSTONE and W. HIBBERT; "An Illustration of Ewing's Theorem of Induced Magnetism," by Prof. S. P. THOMPSON, D.Sc.

* Wiedemann's *Annalen*, Vol. XL., No. 8.

Digitized by Google

# The Electrician.

**Published every Friday, Price Fourpence; Post Free, Fourpence Halfpenny.**
**Editorial, Publishing, and Printing Offices:**
**SALISBURY COURT, FLEET ST., LONDON, E.C.**
*Telephone No. 2714. Telegrams:* "ELECTRICIAN NEWSPAPER, LONDON."

*All Letters relating to Subscriptions, Advertisements and other business matters should be addressed to the Publisher,* "THE ELECTRICIAN," *Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to* "THE ELECTRICIAN" *Printing and Publishing Company, Limited, and be crossed* "Coutts and Co." *All other letters to be addressed to the Editor.*

*All letters intended for insertion in* "THE ELECTRICIAN," *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

"THE ELECTRICIAN" *is published every Friday morning, in time for the morning mails. Subscribers should receive their copies by the first post on Friday morning.*

"THE ELECTRICIAN" *is on sale at the railway bookstalls throughout the Kingdom on Friday morning, and can be obtained of all Booksellers and Newsvendors; or direct from the Publishing Offices as above.*

*New Volumes of* "THE ELECTRICIAN" *commence in May and November.*

## SUBSCRIPTION RATES.

The rates for Subscriptions to "THE ELECTRICIAN" are as follows:—

| | 3 months. s. d. | 6 months. s. d. | 12 months. s. d. |
|---|---|---|---|
| For the United Kingdom | 5 0 | 10 0 | 19 6 |
| For Foreign Parts and Colonies:— Within Postal Union | 6 6 | 12 6 | 24 0 |
| Aden Borneo, Ceylon, China, India, Japan, Java, Labuan, Mozambique, New Caledonia, Persia, Philippine Islands, Siam, Transvaal, and Zanzibar | 7 6 | 14 6 | 28 0 |



## TO ADVERTISERS.

"THE ELECTRICIAN" *offers exceptional advantages to Advertisers.* **It has by far the largest circulation of any English Electrical paper, and circulates all over the World.**

*Particulars relating to Advertisements will be promptly forwarded on application to the Offices as above,*

TRADE ADVERTISEMENTS *intended for the current issue must reach the Offices not later than First Post on Thursday morning. Renewals of expiring advertisement orders and alterations to standing adv rtisements should be in the Publisher's hands by Wednesday at latest. No alteration can be made in Wrapper advertisements after Wednesday evening.*

SMALL PREPAID ADVERTISEMENTS *(for Rates see page xvii.) are accepted up to 4 p.m. on Thursday.*

## TECHNICAL PRINTING.

"THE ELECTRICIAN" PRINTING AND PUBLISHING COMPANY (LIMITED) *inform Electricians, Electric Light Engineers, &c., that they make a specialty of Technical Printing, and have a large Staff thoroughly acquainted with Electro-Technology. They can, therefore, promise Accuracy and Despatch in the Printing of Electro-Technical Literature, &c.*

## "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. (Royal 8vo.)

*Early in each year is issued* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. *The* DIRECTORY *was established in 1883, and the 1890 Edition consisted of about 850 pages of printed matter. The names and addresses of all persons engaged in the Electrical Industries at home and abroad may be relied upon as accurate. Useful Tables and Electrical Formulæ, and information specially compiled for this work are given, together with popularly-written Biographical Notices of the leading Electricians, Electrical Engineers, &c., accompanied in many cases by Portraits.*

*Orders for the 1890 issue should be forwarded* AT ONCE *to the Publishing Offices, Salisbury-court, Fleet-street, London, E.C.*

*The 1891 Edition is now preparing, and New Names, &c., can now be received.*

## ELECTRICAL BOOKS AND PUBLICATIONS.

*All Books, Newspapers, and other publications, dealing with Electrical and kindred subjects, can be ordered direct of* "THE ELECTRICIAN" *Printing and Publishing Company, who are proprietors of the well-known* "ELECTRICIAN" *Series of Standard Electrical Works, and are agents for all the leading publishing houses at home and abroad.*


## CONTENTS OF THE CURRENT NUMBER.


NOTES ... 61
An Ideal Physical Laboratory for a College. By Prof. Oliver Lodge. Illustrated. Concluded ... 65
Test of a Willans-Kapp Combination. Illustrated ... 68
The Central Stations of the Metropolitan Electric Supply Company. By Dr. J. A. Fleming. Illustrated. Continued ... 69
Drum Armature Winding. By F. M. Weymouth. Illustrated Continued ... 72
On the Potential Difference between Two Dilute Solutions in Contact. By Max Plank. 73
Meetings of Scientific Societies. 73
THE TRANSFER OF ENERGY BY THE ETHER ... 74
Magnetism in Iron and other Metals. XXXV. By Prof. J. A. Ewing, F.R.S. Illustrated. Continued ... 75
Electro-Magnetic Radiation. By Prof. A. L. Kimball, Ph.D. Illustrated. Concluded ... 77
Some Practical Methods for the Determination of Inductive Resistances and Self-Induction of Alternate-Current Instruments. By C. Steinmetz ... 79
Testing the Centrality of Cable Cores. By Paul le Goaziou. 80
Edison Underground Work in Boston. By A. C. Shaw. Illus. 82
The Electro-Magnet. By Prof. Silvanus P. Thompson, D.Sc., B.A., M.I.E.E. Illus. Continued ... 82
Electrolysis of Aluminium Fluoride. By M. Adolphe Minet. 87
The Most Favourable Position for an Electric Light Central Station. By Dr. A. Föppl... 88
German Notes ... 88
CORRESPONDENCE—
The Transmission of Energy—Oliver J. Lodge ... 88
Losses in Transformers—Nikola Tesla ... 88
A New Empirical Formula for the Air Space of Dynamos—H. Ravenshaw ... 90
Prof. Kimball and Electricity—James Johnstone ... 90
The Cologne Electric Light Cables—Société d'Exploration des Cables Elettriques 90
The Electrolytic Preparation of Bleaching Agents—E. Andreoli ... 90
Trade Notes and Notices ... 91
COMPANIES' MEETINGS, &c.—
Eastern Extension, Australasia and China Telegraph Company (Limited) ... 92
Swan United Electric Light Company (Limited) ... 93
City Notes, &c. ... 93


## THE TRANSFER OF ENERGY BY THE ETHER.

IT is with some satisfaction that we find Dr. OLIVER LODGE reminding us in our correspondence columns that energy is a definite thing. In these days of fashionable philosophy and amateur metaphysics, there are many who would sweep away the very foundations of physical science. Writers who do not know the difference between power and force endeavour by their wordy artifices to deny the existence of matter, and give us instead incoherent rigmaroles about phenomena and concepts. If they would keep such discussions for themselves and their followers we should have no cause of complaint, but they thrust their theories before those who are concerned with the action of energy on matter; in fact, before engineers and students of physics. They deny, as mere assumptions, the continuity of energy, the continuity of space, and, indeed, of everything but their own arguments. The modern metaphysician finds no room for energy in his scheme of the foundation of things. Energy is asserted by some to be a mere product of force into distance, and force is only an inference from the motion itself, and is measured solely by the effect for which it is postulated as a cause. Even if it be allowed that force is the product of acceleration into mass, our idealists tell us that mass is but another name for inertia, and this is known and measured solely by the amount of force communicated to a given body in order to produce in it a determinate rate of acceleration. "There are only two Things going," says Mr. OLIVER HEAVISIDE in *The Electrician* Vol. XVIII., p. 211, "Matter and Energy. Nothing else is a thing at all; all the rest are Moonshine, considered as Things. The transfer of energy is a fact well known to all, even when we put the statement in such a form that the energy seems to lose its thinginess, by calling it the transfer of the power of doing work."

Digitized by Google

If matter and energy are the only things, what then is electricity? It has been hastily asserted that electricity is a form of energy or a mode of motion, and such statements are still to be found in elementary works; but a moment's reflection will show that the product of electricity into voltage gives power, or the rate at which energy is transferred. Is it then matter? No experiments have yet shown that electricity by itself and without connection with dielectrics exhibits the smallest indication of inertia, nor is it affected by gravitation. Professor KIMBALL's statement, at which Mr. JAMES JOHNSTONE rejoices, that electricity is a substance, is not sufficiently explicit; he immediately disclaims "the idea that like ordinary matter it has weight."

It is quite far enough to go, to allow, with Dr. OLIVER LODGE, that "whenever we perceive that a thing is produced in precisely equal and opposite amounts, so that what one body gains another loses, it is convenient and most simple to consider the thing not as generated in the one body and destroyed in the other, but as simply transferred. Electricity in this respect behaves just like a substance." But so much can be said for heat. The admirable thermodynamic work of CARNOT, the grandfather of the President of the French Republic, was founded entirely upon the assumption that heat behaved just like a substance; the error which he made was to go a step further, and, in accordance with the state of science of his day, to consider it *to be* a substance. This led him to imagine that the work of a steam engine is done at the expense of the fall of temperature, and that the energy of a certain quantity of heat in a hot body is greater than when it exists in a cooler body. We know now that the energy is the same, but it is less available. CARNOT's principle enables us to define efficiency; it has given us the second law of thermodynamics, and, as Sir WILLIAM THOMSON pointed out twenty-four years ago, it leads us to the most scientific way of defining temperature. If the two fluid or the one fluid language will enable us thus to state electrical theorems in a clear manner, we are in no way committed. And if, carefully distinguishing between the flow of electricity and the flow of electric energy, we agree to talk of electricity as material, since it behaves as a substance, great facility for expression and for the description of phenomena in simple terms is thus afforded us. But in doing this we need not go so far as Prof. KIMBALL, and demand a something which is not matter, but which may be called a substance. Modern science, while it attributes "thinginess" to matter and energy alone, fills all space with a *tertium quid*—the ether. The researches of HERTZ have been said to be the *experimenta crucis* which once and for all prove the actual existence of ether. But in the present state of the vortical theory of matter, and in view of a possible demand for a primordial fluid, it is more safe for the present to be content with the investigation of its properties, and to leave too definite ontological assertions for future philosophers. The property which the experiments of HERTZ have brought into such prominence—the propagation of electrical disturbances in time as well as in space—establishes the ether as the medium for the transfer of energy.

This brings us back, then, not necessarily to electricity—which is but a name for the agent which appears to underlie a certain group of phenomena, just as caloric was a very useful name, and was used to connote a similar agent which was supposed to appear and disappear by transference from one body to another—but to the transference of energy. If we could learn something about the mode of transfer, the nature of the strain to which the ether is subjected; or if strain be too definite a term, the displacement which is produced; or if we could find some good experimental grounds for the view that electricity is a disturbance which is measured quantitatively by the excess of the ether in a given space over the normal quantity, it would appear that we might ere long be able to drop the word electricity as indicating an entity, and retain it only in such indispensable terms as electrification and other derivatives.

The difficulty of introducing electricity as a substance, though not as matter, has caused some to think of the ether as being of a dual nature, which can be sheared into two constituents; others, following the one fluid theory, take ether simply as identical, as far as substance is concerned, with ether. We hope that before long the ether will be relieved of some of the many duties which are thrust upon it. How much more is to be expected of it? Its density is not allowed to exceed $10^{-18}$, and its rigidity is an equally inconceivable order. The most flimsy comet whisking round the sun feels it not, and if only we had a theory for gravitation we should probably exact another responsibility—the instantaneous transmission of stresses of enormous magnitude. It is said to be sometimes bound to the gross matter which it continuously pervades, and with some irony it is said to be otherwise free. By a convention rarely admitted with candour, its specific inductive capacity is unity, while at the same time the permeability is also said to be of unit value. As Dr. OLIVER LODGE remarks, both these conventions cannot be true; no one has the least right to suppose either true, and, in our opinion, no convention has ever given rise to such dire confusion, generating two discordant sets of units, and setting up the bewildering idea that an ohm is a velocity. Let us retain the ether as a patient overworked beast of burden, and let us determine its constants in absolute measure at our earliest possible convenience; but if the idea of transference of energy by its agency will answer the purpose, let us avoid splitting it up into one or more electricities, and let the very term electricity pass with epicycles, caloric, and many other once useful ideas, into the dignified repose of ancient history.

## MAGNETISM IN IRON AND OTHER METALS.*—XXXV.

BY PROF. J. A. EWING, F.R.S.

(*Continued from page 7.*)

§ 127.—**Effects of Applying Longitudinal Pull to Magnetised Iron.**— In the experiments described above the pull was applied before magnetisation began, and was then left constant. It remains to describe what is observed when the pull is varied while the magnetising force is kept constant. If there were no hysteresis, we should obtain in this way curves similar to those of Figs. 104 or 107. In consequence of hysteresis the changes of magnetism that are actually produced by changing the load, though maintaining a general similarity to these curves, differ from them in two important respects. In the first place, the *initial* effects which are observed when we first begin to change the stress are in general very great, and are to be distinguished from the effects obtained after a cycle of stress changes has been repeated once or twice. These initial effects of applying stress resemble those that are produced by vibration, although the process of loading may be conducted in such a way that no actual vibration takes place. They proceed, as the molecular theory to be discussed later indicates, from a condition of molecular instability; and they do not disappear when the stress is removed. Thus, when we begin to load for the first time an iron wire, to which a magnetising force has been applied, we find that the first loads are associated with an increase of magnetism, which may be so great as to increase the whole quantity ten-fold. Moreover, if a load has been hanging from

* All rights are reserved.

Digitized by Google

the wire while the magnetising force was being applied, we find that on beginning to remove it an increase of induced magnetism takes place. Again, if we are dealing with residual magnetism, the first effect of changing the load after the magnetising force has been removed (whether by way of increasing or decreasing the load) is in general to largely reduce the amount of the residue. It is only after applying and removing any load several times that the magnetic effects of the stress changes become cyclic; that is to say, after several repetitions of the operation, the magnetism will be found to alter from one to another of two definite values when the load is put on and when it is taken off. But even then the effects of hysteresis are manifest; for any intermediate value of the load is found to be associated with very different values of the magnetism during loading and during unloading. These features are well seen when we examine curves drawn to show the change

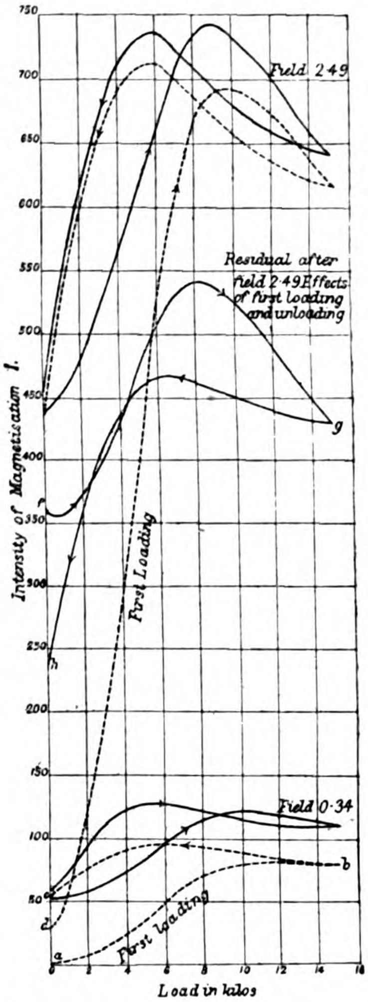



FIG. 108.—Effects of applying Pull to Magnetised Iron.

of magnetism in relation to the change of load, of which the following figures (108 and 109) are examples.* They refer to an iron wire, hardened by previous stretching beyond its elastic limit, of such a size that each kilo. of load corresponds to a stress of about 2·3 kilos. per sq. mm. The cycle of stress consisted in applying and removing 15 kilos.

Beginning at the bottom of Fig. 108, at the point marked *a*, we have the wire, free from any load and previously demagnetised by reversals, exposed to a magnetising force of 0·34 C.-G.-S. In this state there was very little magnetisation. Then loads were applied, and the effects of the first application and removal are shown by the dotted lines *a b c*. The full lines immediately above them show the effects of the *second* application and removal of load, by which time the magnetic changes had become nearly cyclic. It is clear that in the first loading we have to deal with a progressive augmentation of magnetism superposed on cyclic changes of the character shown by subsequent cycles of loading—that is to say, we have an initial effect superposed on the cyclic effect.

Next, the wire was demagnetised, and then a stronger field (2·49 C.-G.-S.) was applied, while there was no load. The effects of the first loading in this field were enormous; they

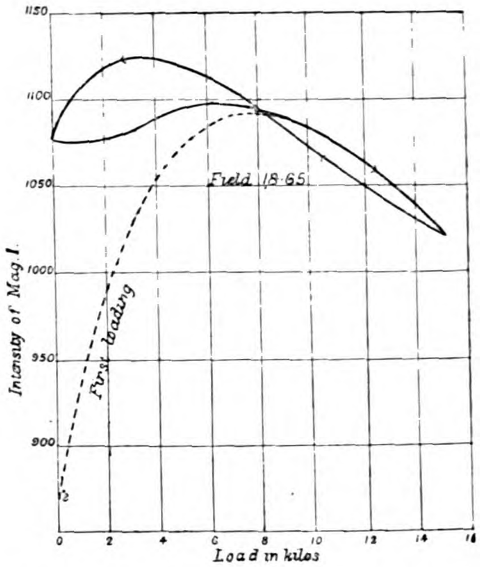



FIG. 109.—Effects of applying Pull to Strongly Magnetised Iron.

are shown by the dotted line which starts from the point *d* in the figure. Here, again, a repetition of the process of loading and unloading brought the magnetic changes into a nearly cyclic state, which is shown by the full lines at the top of the figure.

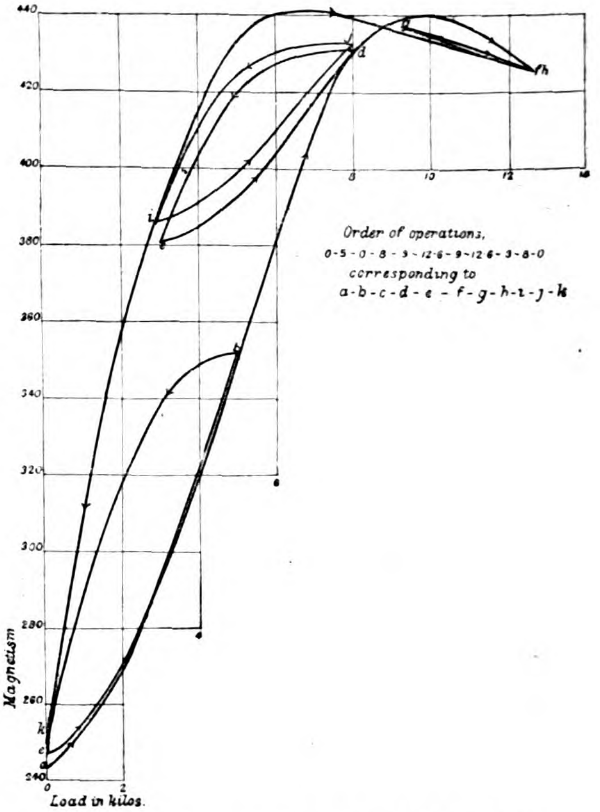



FIG. 110.—Effects of Pull on a Stretched Iron Wire.

Next, a stronger field still (18·65 C.-G.-S.) was applied (Fig. 109). The curve for first loading still shows a considerable permanent augmentation of magnetism; but a cyclic state is reached sooner than in weaker magnetic fields. In still stronger magnetic fields the curves become more and more

* *Phil. Trans.* 1885, plate 63, p. 603.

Digitized by Google

flattened down into a form in which the application of load causes a diminution of magnetism throughout.

Finally, to show how the residual magnetism is affected by change of stress, the residue left after applying a field of 2·49 and subjecting the wire to loads in that field, was made the subject of the experiment shown by the lines *f*, *g*, *h*, in Fig. 108. These curves show how (starting from the point *f*) the residual magnetism suffered changes due to loading and unloading, which may best be described as a progressive decrease of magnetism superposed upon cyclic changes of the same character as those which are shown in previous figures. If we repeat the cycles of load on a piece in which there is only residual magnetism, we find, in fact, cyclic changes of the same general kind as those that are found when a magnetising force is in action.

§ 128. **Hysteresis in the Effects of Stress.**—The hysteresis of magnetism with respect to changes of load, which is clearly exhibited by these curves, is static in character. That is to say, it does not depend on the time-rate at which loads are applied nor on the intervals which are allowed to elapse before readings of the magnetisation are taken. After any condition of load is reached, the magnetism does not change with the lapse of time, except possibly to a very insignificant extent.

During each loading, after a cyclic condition has been established, the magnetism is at first increased; but a maximum is passed as more load is added, and later additions of load reduce the magnetism. A similar maximum is seen during unloading; but owing to hysteresis the maximum comes at different loads in the two cases; each maximum is shifted, through hysteresis, to a later place in the operation than it would otherwise have. Another manifestation of hysteresis is seen in the easy gradient with which each curve begins, as the process of loading is changed to that of unloading, or *vice versâ*. In a weak field the initial gradient of each curve is so small that the curve appears to set out tangent to the line of loads.

Fig. 110 may be referred to in further illustration of the presence of hysteresis in changes of magnetism caused by changes of load.* It shows the effect of superposing on a principal cycle of stress changes several minor cycles, in each of which hysteresis is very apparent. The order in which the loads were applied was this:—0, 5, 0, 8, 3, 12·6, 9, 12·6, 3, 8, 0. The wire dealt with here had been hardened by stretching, and hung in a constant field the force of which was 0·34 C.-G.-S.

*(To be continued.)*

*Phil. Trans.*, 1885, p. 582.

## ELECTRO-MAGNETIC RADIATION.

BY PROF. A. L. KIMBALL, PH.D.

*(Concluded from page 35.)*

*The Experimental Study of Electro-Magnetic Waves.*

It has been known for many years that these electrical oscillations existed, but it remained for Prof. Hertz to show how the electrical waves given off from such a conductor might be detected and studied. The method of which he was the discoverer depends on what may be called *electrical resonance.*

It was discovered by Hertz that if two electrical conductors are taken of such sizes and shapes that the time of electrical oscillation in the one is the same as in the other, that when strong electrical vibrations are set up in one the other will also have an electric disturbance sympathetically excited. It is by making use of this fact that he was able to demonstrate the existence of electro magnetic waves and to measure wave lengths.

It will be well to examine briefly how some of the more important results have been demonstrated. Hertz apparatus involved what we shall call the vibrator and the resonator. In his earlier experiments the vibrator consisted of two sheets of tin, A and B (Fig. 3), about a foot square, provided with knobs and separated by a small gap C. These plates were connected one with each pole of a powerful induction coil D. The resonator (Fig. 4) was simply a hoop of wire, in which there was left a gap, the terminals being made of little knobs, whose distance apart could be accurately adjusted by means of a micrometer screw.

When the induction coil was made to act, the plates A B where charged and discharged by sparks across the gap C.

The resonator E was made of such a size and shape that the period of electrical vibrations in it might be the same as in the vibrator, and the adjustment was finally made by changing the sizes of the knobs until the best effect was obtained.

But how can it be established that these effects are really due to waves, and how can the wave lengths be measured? The characteristic phenomenon by which the existence of waves is recognised is *interference.* That is, two waves may come together in such a way that one shall exactly neutralise the effect of the other, or by slightly changing their relative *phases* they may re-inforce each other. In case of water waves, for example, if two sets of waves are coming from separate points, there will be certain points where the crests of the two sets of waves will arrive simultaneously; these will be points of great disturbance; there will be other points where the crests of one set of waves will arrive at the same instant as the troughs of the other sets of waves; these will be points of minimum distribution, for one set of waves will largely or entirely neutralise the effect of the other set. These are what are known as *interference* effects, and it is by these interference effects in case of light that it is known to be a wave motion, and that the wave lengths are measured. It at once became a point of peculiar interest to discover whether such effects could not be demonstrated in case of electro-magnetic waves, and the discovery of these interference effects by Hertz established beyond all question the existence of electro-magnetic waves.

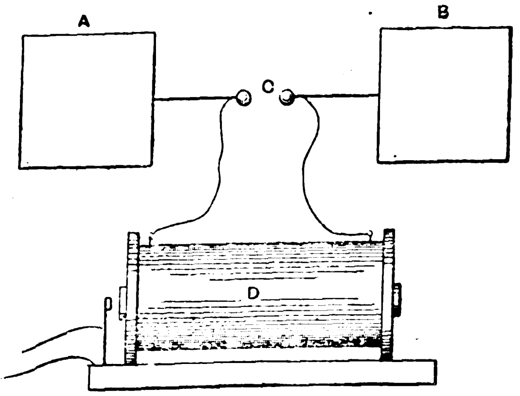



Fig. 3.

In one experiment the vibrator sending out the waves was placed directly opposite, and at a distance of 40 feet from a wall which had been covered with sheet metal, and so was a good reflector. The reflected waves meeting those coming directly from the vibrator gave rise to interference, producing what are analogous to the nodes and loops set up when a sounding tuning fork is held in front of a reflecting wall.

In an electro-magnetic wave there are two elements to be considered—the electric currents and the magnetic inductors; and, thinking of it again, according to the mechanical analogy previously discussed, it is evident that the one will be a maximum when the other is a minimum.

In an ordinary sound wave the points of rarefaction and condensation are places when the air particles are moving with greatest *velocity*, while midway between them where the density of the air in the wave is normal, the *displacement* of the air particles from their equilibrium positions is greatest. When a sound wave is reflected from a hard surface, a node or point of rest of the air particles is found at the surface, another such node or point of rest is found at a distance of one-half a wave length from the reflecting surface by the interference of the advancing with the reflected wave, and between these two nodes there is what is called a loop or a point where the motion of the air particles is a maximum, and so on, we find nodes and loops succeeding each other in regular order, the distance between two successive nodes being half the length of the wave. But while the nodes are places of minimum motion they are

Digitized by Google

points where the change in density of the air is a maximum. So in the case of electro-magnetic waves when reflected from the surface of a conductor; at that surface the changes in magnetic induction will be a maximum, while the changes in the electric displacement will be a minimum; a half wave length from the conducting surface this will be changed; there will be no magnetic induction, while the changes in the electric displacement will be a maximum, and so on alternately, thus constituting electro-magnetic nodes and loops. In Fig. 5 the state of things near the reflecting wall in Hertz's experiment is represented, the distances being indicated in metres on the scale at the bottom of the diagram. The vibrator sending out the wave is supposed to be off at the right, with its axis vertical and parallel to the paper, so that in the waves represented electric displacements are up and down in the plane of the paper, while the magnetic lines of induction are perpendicular to the paper.

If at some point on the line from the vibrator perpendicular to the reflecting surface the circle of wire used as a resonator is placed with its plane parallel to the reflecting surface, and with the spark gap neither at the top nor bottom, but at one side, the effect observed will be wholly independent of the magnetic lines of force, since none of them will go through the circle, and since in that position the electric displacements are the same at all points of the circle, the effect will depend only on the intensity of the changes in the displacements; the circle may therefore be used in this way to compare the intensities of the displacement currents at different points. On performing the experiment in this way Hertz found that there was scarcely any sparking when the resonator was near the wall, but that it increased in intensity on carrying it away, reaching a maximum at B, then diminished again to a minimum at C, and finally

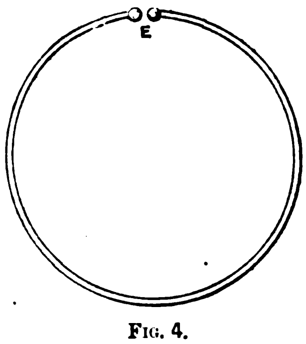



Fig. 4.

increased as the circle was moved toward D; the periodicity could not be traced farther, owing to the preponderance of the direct waves as the vibrator was approached more nearly. This experiment indicated that the electric displacement was a minimum at the wall, a maximum at the distance B, again a minimum at C, &c., indicating that the distance from B to C was one-quarter of a wave length. In this way the length of the wave was found to be 9·3 metres. It will be noticed that in the diagram (Fig. 5) the distance from B to the wall is rather less than from B to C. This is due to the fact that the point at the reflecting surface is not exactly a node, owing to the surface not being a perfect conductor, so that there were slight displacement currents even close to the reflector. That this is the true explanation of the observed phenomena was further shown by determining in a similar way the points where the changes in the magnetic intensity were a maximum. For this purpose the resonator or circle is held with its plane vertical and perpendicular to the reflecting plane, or just as represented in positions I., II., III., IV. in the diagram, except that the spark gap was at the top or bottom instead of at the side, as in the case indicated. In this position of the circle the electric displacements, being up and down, have scarcely any influence in causing sparking to take place at the gap; but the magnetic lines of force, being at right angles to the coil, pass through it, and hence changes in the magnetic induction at the point where the circle is placed, give rise to electromotive forces acting around the circle and causing sparks to leap the gap. In this position, therefore, the greatest sparking will be observed where the changes in magnetic induction are greatest. Observation showed marked sparking at the reflecting surface, which fell rapidly to zero as B was approached, increased again to a maximum at C, then diminished to a second minimum at D, and finally increased as the circle was moved beyond D nearer to the vibrator, the disturbing influence of the neighbourhood of the vibrator being felt as before. These two experiments gave independently the length of the waves sent out by the vibrator, and in accordance with theory showed that the maxima for changes in magnetic induction lay between the points where the electric displacement currents were a maximum. The diagram illustrates this point, vertical distances between the dotted lines representing the intensity of the change in magnetic induction, and the same for the solid lines, giving the intensities of the displacement currents.

By these experiments the fact that we are here dealing with a wave motion may be regarded as established and the length of the wave determined. The time of vibration of the electric currents in the vibrator was calculated by Hertz from the form and dimensions of the apparatus as about 2·8 hundred-millionths of a second. If the wave length is divided by the period of vibration the velocity of the wave is obtained. Taking the figures given, we obtain thus 332,000,000 metres per second as the velocity of the wave; but the velocity of light is 300,000,000 metres per second, and the difference between the two may be readily due to an error in the calculated period of vibration of the apparatus, that being a quantity which cannot be accurately computed. It may be concluded, then, that so far as the velocity of the wave is determined by these experiments, they point to the same velocity as that of light.

It is well known that electro-magnetic disturbances are communicated from the sun to the earth, as shown in the magnetic

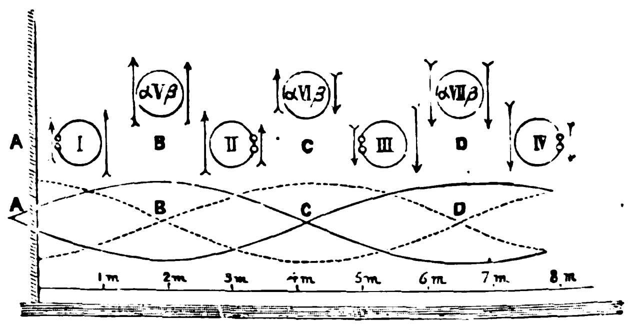



Fig. 5.

disturbances accompanying great sun spot activity. This indicates that some medium fills the region between the earth and sun which is capable of communicating these electro-magnetic disturbances, but the medium known as the luminiferous ether, or simply the ether, fills all space as far as light can travel, and it is more rational to suppose this to be the medium also by which electric disturbances are communicated rather than to imagine another medium, at least unless this supposition can be disproved. But the fact that electro-magnetic waves are propagated with the same velocity as light waves is almost proof positive of the correctness of the view, since the velocity of a wave depends on the properties of the medium in which it exists, as has been already noted.

Electro-magnetic waves are, then, ether waves; but light waves are also ether waves. What, then, is the difference between a wave of light and an electro-magnetic wave such as is sent out from a Hertz vibrator? The difference is believed to be solely one of wave length, or of the period of the vibration, only those electro-magnetic waves affecting the eye as light whose wave length is between one-thirty-thousandth of an inch and one-seventy-thousandth.

*Conclusion.*

The modern theory of electricity is characterised by its view of the importance of the dielectric medium. In looking at a dynamo supplying energy to a motor the current is no longer regarded as a fluid simply forced around the circuit and having no relation to the surrounding space; but not only is the flow of current always accompanied by magnetic whirls and electric

Digitized by Google

stresses in the medium, but Prof. Poynting has shown that it is through the medium rather than through the wire that the energy is to be regarded as communicated. Thus at the dynamo energy is being given to the medium in setting up lines of magnetic force, and these spreading outwards in every direction gradually grow smaller, forming circles around the wire, and finally collapse into it, their energy being transformed into heat in the wire at the point where they disappear. This spreading out of energetic whirls in the medium, and their collapse into the wire where the energy is dissipated as heat, continues as long as the current flows. The wire, from this point of view, does not convey the energy, but simply directs the energy which the medium receives at the dynamo, so that it shall be spent at the desired point, being simply a sort of leading string for the energy in providing a place where it may be dissipated in the form of heat, or, as in the motor, in mechanical work. Electrical science may, therefore, almost be called the science of the ether, for when a magnet attracts a weight it is forced up by the stresses in the ether, and even when a street car moves by a motor it is these same strains and stresses in the ether originating at the dynamo which urge it along.

## SOME PRACTICAL METHODS FOR THE DETERMINATION OF INDUCTIVE RESISTANCES AND SELF-INDUCTION OF ALTERNATE-CURRENT INSTRUMENTS.*

BY CHAS. STEINMETZ.

Since the system of distributing electricity by alternating currents and transformers has found such manifold applications, terms formerly rarely used, such as self-induction, retardation, &c., have come into general use, and determinations of inductive resistances, and of coefficients of self-inductions of measuring instruments, will soon be carried on as everyday work.

Now, the instrument mostly used for the determination of self-induction and mutual induction is the ballistic galvanometer. But not only is this instrument generally too delicate for the unstable floor of an electric factory, but it has the disadvantage that its readings very often cannot directly be applied for the alternating currents of our machines.

The following more simple method for the determination of self-induction requires no other apparatus but an alternate-current voltmeter and ammeter—instruments available in any electric factory which is building alternate-current apparatus.

### A. Inductive Resistances.

To find the coefficient of self-induction of an inductive resistance (induction coil, transformer, &c.), I connect the inductive resistance to be determined in series with an alternating-current ammeter, and connect an alternate-current voltmeter in shunt to ammeter and inductive resistance.

Let R be the true electric resistance of the induction coil, and L its unknown coefficient of self-induction. Let $r$ and $l$ be the corresponding quantities relating to the ammeter.

Now, in sending an alternating current of known number of periods through this circuit, the current in the inductive resistance, read by the ammeter, may $= c$, and the difference of potential around inductive resistance and ammeter, read by the voltmeter in the shunt circuit, may $= p$.

Then the E.M.F., or potential, lost in overcoming the whole electric resistance of this branch circuit is—

$$e+E=(r+R)c. \quad \dots\dots \quad (1)$$

The whole E.M.F. of self-induction in this circuit is—

$$e^1+E^1=\frac{2\pi(l+L)}{T}c, \quad \dots\dots \quad (2)$$

where T is the time in seconds of one full period.

The impressed E.M.F., $p$, measured by the voltmeter, is the resultant of these two E.M.F.'s: $(e+E)$ and $(e^1+E^1)$. But $e+E$ has the same phase as the current $c$. $e^1+E^1$ lags behind $c$ by a difference of phase of exactly 90°.

Therefore, the resulting E.M.F. of $e+E$ and $e^1+E^1$ is found by the law of the parallelogram of E.M.F.'s as the hypothenuse of a rectangular triangle, of which the sides are $e+E$ and $e^1+E^1$.

* Abstract from an article in the *Electrical Engineer* of New York.

Therefore $$p=\sqrt{(e+E)^2+(e^1+E^1)^2}.$$

Or, substituting (1) and (2) we get the coefficient of self-induction of the inductive resistance—

$$L=\frac{T}{2\pi}\sqrt{\left(\frac{p}{c}\right)^2-(r+R)^2}-l. \quad \dots\dots \quad (3)$$

When we can assume the approximation $r=0$, we get—

$$L=\frac{T}{2\pi}\sqrt{\left(\frac{p}{c}\right)^2-R^2}-l. \quad \dots\dots \quad (4)$$

And when $R=0$, too,

$$L=\frac{Tp}{2\pi c}-l. \quad \dots\dots \quad (5)$$

And, if the self-induction $l$ of the ammeter can be neglected also—

$$L=\frac{Tp}{2\pi c}, \quad \dots\dots \quad (6)$$

which formula will be found sufficiently exact in very many cases.

Therefore, for approximate determination of the coefficient of self-induction, if $r$ and R are small, it is not necessary to know the electric resistance at all, and the current in the alternating circuit is almost entirely independent of the electric resistance, depending only on the impressed E.M.F. and the self-induction. For the determination of small electric resistances, I consider as the most reliable method, to send a continuous current through them and measure current strength and potential.

Let the continuous current in the circuit of ammeter and inductive resistance $=c_0$, the potential difference $=p_0$. Then we have—

$$p_0=(r+R)c_0; \quad \dots\dots \quad (7)$$

and by substituting this we get—

$$L=\frac{T}{2\pi}\sqrt{\left(\frac{p}{c}\right)^2-\left(\frac{p_0}{c_0}\right)^2}-l; \quad \dots\dots \quad (8)$$

or, if $r$ and $l$ can be neglected—

$$L=\frac{T}{2\pi}\sqrt{\left(\frac{p}{c}\right)^2-\left(\frac{p_0}{c_0}\right)^2}. \quad \dots\dots \quad (9)$$

This method has the feature of eliminating the resistance of the connecting wires, which, when the main resistance is small, cannot well be neglected.

As an instance I shall give the following test made by me some time ago on an inductive resistance. The resistance of the ammeter, an electro-dynamometer, with one turn as the movable circuit, was—

$$r=\cdot01 \text{ ohm};$$

its coefficient of self-induction—

$$l=\cdot000066 \text{ henry}.$$

The alternate current was produced by a small Westinghouse dynamo, giving 100 complete periods per second; therefore—

$$T=\cdot01 \text{ second}.$$

The continuous current was derived from a storage battery. The readings were:—

Continuous current—

$c_0=26{\cdot}40$ amperes; potential, $p_0=1{\cdot}742$ volt.

Alternate current—

$c=16{\cdot}62$ amperes; potential, $p=31{\cdot}01$ volts.

Therefore, the coefficient of self-induction, by formula (8)—

$$L=\cdot002902 \text{ henry},$$

and the electric resistance—

$$r+R=\frac{p_0}{c_0}=\cdot066 \text{ ohm};$$

and since $r=\cdot01$ ohm,

therefore, $R=\cdot056$ ohm.

Formula (4) gives $L=\cdot002904$ henry,

and (5) $L=\cdot002970$ henry.

In considering that the exactness of the test was limited by the inconstancy of the speed of the alternator, which, driven by an ordinary steam engine, fluctuated by more than 2 per cent., the approximate figure ·002904 henry, and even ·002970 henry, could be considered exact enough for most purposes.

Digitized by Google

### B. Measuring Instruments.

The static electrometer is considered the best instrument for measuring alternate current potentials. But, unfortunately, this delicate instrument is hardly adapted for practical use in the factory. The calorimetric instruments, as, for instance, the Cardew voltmeter, can also be highly recommended. But for direct measurement of the strength of alternating currents, hardly any other instrument can be relied upon but the electro-dynamometer, although its self-induction has to be considered sometimes. If we make the necessary corrections for self-induction, the electro-dynamometer can also very well be used as a voltmeter. The main condition for all electro-dynamic alternate-current instruments is, that their magnetic field always corresponds to the instantaneous strength of the current, so that for the same current the magnetism is the same, no matter whether the current is increasing or decreasing. This condition excludes all instruments containing iron, and also such instruments in which eddy-currents can be set up. Seeing the difficulty of securing practical alternate current instruments without self-induction, we have to find methods to determine the amount of this self-induction and the corrections necessitated by it. In measuring the strength of currents only, by the electro-dynamometer-ammeter, self-induction has no influence; but its determination becomes necessary where these readings are to be used for calculations of resistance, self-induction, power, and so on.

To determine the self-induction of an alternate-current instrument, a very reliable way is, after having tested the instrument by continuous currents, so that it can be used as an ammeter, giving the effective current flowing through it, to proceed as follows:—

1. Connect it, together with an additional non-inductive resistance, if necessary, in parallel with a current-indicator. For this any instrument can be used, which for the same effective current always gives the same reading, no matter whether this reading is right or wrong; therefore, most of the non-polarised continuous-current instruments can be used.

Let the electric resistance of the instrument proper $= r$.

Let the additional non-inductive resistance $= r_0$.

Let the alternating current flowing through the instrument, and read by it as an ammeter $= c_1$.

Let the reading of the current-indicator in the shunt-circuit $= v$.

2. Connect the instrument $r$ with its additional resistance $r_0$ in series with a non-inductive resistance R and in parallel with the same current indicator, and vary the alternating current so that the current indicator gives again the same reading $v$, thereby showing that the shunt-current, and therefore the potential-difference at the terminals of the branch-circuit containing the instrument, is again the same as in connection (1).

Then let the alternate current flowing through the instrument $= c_2$.

Now, in the first connection (1), the electromotive force consumed by overcoming the electric resistance, is—

$$e_1 = (r + r_0)\, c_1.$$

The E.M.F. due to self-induction—

$$e_1' = \frac{2\pi L}{T} c_1;$$

where L is the coefficient of self-induction of the instrument, and T the period. Therefore, the resulting or impressed E.M.F., according to the parallelogram law, is—

$$\sqrt{e_1^2 + {e_1'}^2} = c_1 \sqrt{(r + r_0)^2 + \frac{4\pi^2 X^2}{T^2}}.$$

In the same way, the resulting or impressed E.M.F., with the second connection (2) is found:—

$$\sqrt{e_2^2 + {e_2'}^2} = c_2 \sqrt{(r + r_0 + R)^2 + \frac{4\pi^2 X^2}{T^2}};$$

and these expressions are equal, since the shunt currents are the same, and we therefore get—

$$L = \frac{T}{2\pi} \sqrt{\frac{c_2^2 (r + r_0 + R)^2 - c_1^2 (r + r_0)^2}{c_1^2 - c_2^2}}; \quad . \quad . \quad (10)$$

and the shifting of phase, that is, the difference of phase $\omega$ between current and terminal pressure of the instrument is given by the equation—

$$\tan \omega = \sqrt{\frac{c_2^2 \left(1 + \frac{r_0 + R}{r}\right)^2 - c_1^2 \left(1 + \frac{r_0}{r}\right)^2}{c_1^2 - c_2^2}} \quad . \quad (11)$$

Now, in making several readings with continuous currents, we can eliminate the resistances $r_0$ and R. In connecting the instrument in a continuous-current circuit in series with $r_0$, with R, and with both $r_0$ + R and varying the current so that the current indicator in the shunt gives the same reading $v_0$; or, interpolating for this reading $v_0$, we may get the three currents—

$c_3$ through $r_0$ and the instrument $r$.

$c_4$ through $r_0$ + R and the instrument $r$.

$c_5$ through R and the instrument $r$.

Then we have—

$$c_3 (r + r_0) = c_4 (r + r_0 + R) = c_5 (r + R); \quad . \quad . \quad (12)$$

and we can deduce—

$$L = \frac{rT}{2\pi} \cdot \frac{c_5}{c_4 c_5 + c_3 c_4 - c_3 c_5} \sqrt{\frac{c_2^2 c_3^2 - c_1^2 c_4^2}{c_1^2 - c_2^2}}, \quad . \quad (13)$$

with a similar modification for tan $\omega$.

Now, when we can attribute to the additional resistance $r_0$ a particular value, for instance make it = 0, or = R, we shall save one of the continuous current readings and the formulæ become simpler. Thus, if $r_0 = 0$, we have $c_5 = c_4$.

$$L = \frac{rT}{2\pi c_4} \sqrt{\frac{c_2^2 c_3^2 - c_1^2 c_4^2}{c_1^2 - c_2^2}} \quad . \quad . \quad . \quad . \quad (14)$$

$$\tan \omega = \frac{1}{c_4} \sqrt{\frac{c_2^2 c_3^2 - c_1^2 c_4^2}{c_1^2 - c_2^2}} \quad . \quad . \quad . \quad . \quad (15)$$

While, if $r_0 = R$, we have $c_5 = c_3$, and the formulæ become similarly modified.

An example will show the application of this method. In a low-reading voltmeter of the electro-dynamometer type the resistance was—

$$r = 19{\cdot}68 \text{ ohms.}$$

$$r_0 = 0;$$

no additional resistance being used. It was found—

For alternating currents—

$c_1 = {\cdot}3478$ ampere; $c_2 = {\cdot}1697$ ampere.

For continuous currents—

$c_3 = {\cdot}3734$ ampere; $c_4 = {\cdot}1628$ ampere.

Therefore, by formulas (14) and (15):—

$$L = {\cdot}03543 \text{ henry,}$$

the coefficient of self-induction of this voltmeter; and the angle shifting of phase—

$$\text{Angle } \omega = 29{\cdot}5 \text{ degrees.}$$

$$R = \frac{r(c_3 - c_4)}{c_4} = 25{\cdot}45 \text{ ohms};$$

and $$\frac{1 - \cos \omega}{\cos \omega} = {\cdot}149 = 14{\cdot}9 \text{ per cent.}$$

Therefore for such alternating currents of 100 full periods per second the readings of this instrument have to be increased by 14·9 per cent. to get the correct voltage. The correction for any other number of periods can easily be calculated. This method is open to the objection of inaccuracy upon the assumption that the alternate currents are true sine-waves. But in looking farther into the matter, we shall often find this to be of advantage for practical purposes. Because, if we do not want to know the absolutely exact value of the coefficient of self-induction for scientific purposes, but want to use the instruments to measure alternating dynamo currents and the behaviour of inductive resistances toward them, then the figures obtained in this way hold good for the same kind of dynamo currents, and allow us to assume them again as true sine-waves in the calculations of electric machinery. Besides, in most of the altenators built to-day, the deviation of current from the sine-wave is rather small.

## TESTING THE CENTRALITY OF CABLE CORES.*

BY PAUL LE GOAZIOU.

The following little apparatus has been devised to test the centrality of the copper conductors of submarine and subterranean cables.

The draw-plate, as I call it, consists of four copper rods, 1, 2, 3, and 4 (Fig. 1), arranged on a wooden or ebonite disc B B', which is pierced with a hole at the centre. These rods are 10 to 15 centimetres long, and can slide backwards and forwards on the disc so that their ends can be made to press lightly against the insulation of the cable to be tested. In Fig. 2 we have a longitudinal section of the apparatus, from which it can be seen that a sort of funnel is screwed on to the back of the disc B B', in order to guide the cable

* From *La Lumière Électrique*.

Digitized by Google

through the telephonic draw-plate. The calibre of this funnel is, of course, different for different sizes of cables. Water is sometimes poured into this funnel to prevent heating, and if it is of great importance to reduce friction to minimum the whole apparatus is placed in a vertical position.

Two differential telephones, T T′ (Fig. 1), are connected as shown, that is to say, the front and back portions of rod 1 are connected to

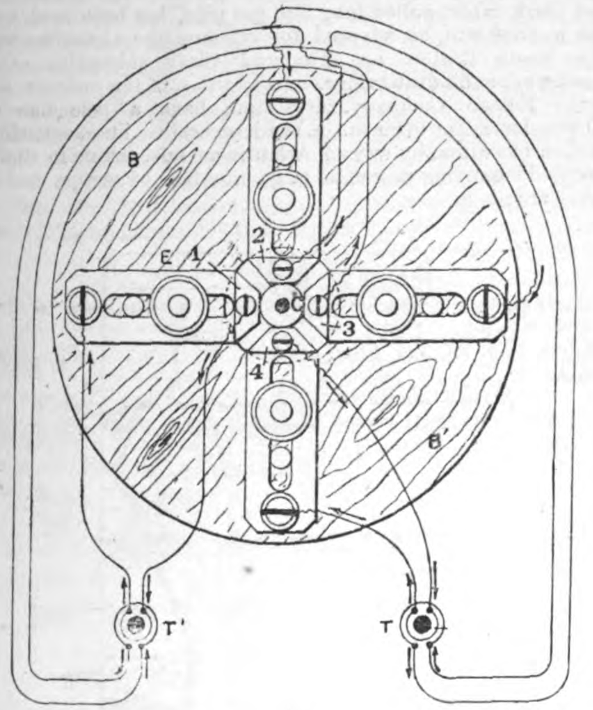



FIG. 1.—Cross-section of Apparatus (two-thirds actual size).

one part of the telephone T′, while the front and back portions of the opposite rod 3, are connected to the other coil of the same telephone, and so on. While the cable is being passed through the telephonic draw-plate, a weak intermittent current is sent through its conductor. This intermittent current traversing the conductor of the cable induces Foucault currents in the copper rods. If the centrality of the cable conductor is perfect, it is obvious that the telephones will remain silent, but if the centrality of the conductor

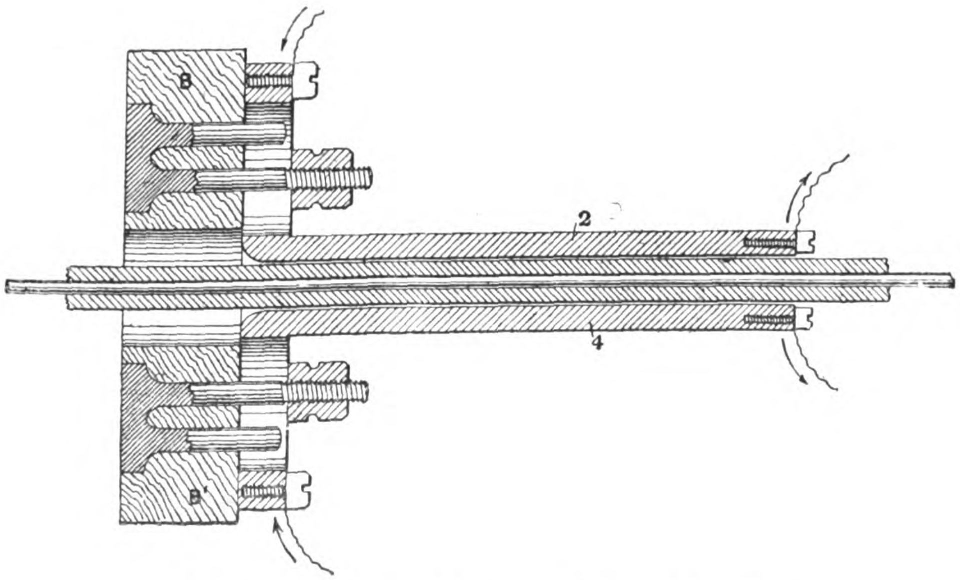



FIG. 2.—Longitudinal Section of Apparatus (two-thirds of actual size.

is imperfect, the rod nearest it has a stronger current generated in it than the opposite rod, consequently the particular telephone, the coils of which are connected differentially to these two rods, will be affected.

Fig. 3 shows clearly the different cases that may arise. If the conductor is well in the centre, as at *a*, nothing happens; if it is near rod 1, as at *b*, the coil connected to this rod is strongly affected acting on the telephone T. If the conductor is in the position shown at *c*, both the telephones T and T′ will speak. In this last case the position of the conductor can be determined by lightly turning the disc B B′ until the eccentric conductor has arrived at a position similar to that which it holds in *b*. In order to determine which rod the conductor is nearest to, it is only necessary to switch in a high resistance into the circuit of one of the differential coils. If the noise in the telephone is weakened, the cable-conductor obviously lies nearest the rod into whose circuit the high resistance has been switched, and *vice versâ*. The exact degree of eccentricity of the conductor can be determined by sliding back the rod nearest to the cable conductor. When the telephone is silent the two rods are obviously at the same distance from the inducing wire. The distance traversed by the rod is then read off on a millimetre scale, which is engraved on the disc, and half this distance gives the distance of the conductor from the centre of the cable. This postulates that the dielectric constants of air and gutta-percha are practically the same for currents of this order.

In carrying out this test in practice, the operator in charge has the telephonic receivers fixed to his ears in the ordinary manner, and whenever he hears a noise in either of the telephones he marks the cable as it passes through the draw-plate with a dab of paint, and the cable is subsequently re-examined more carefully at these marked points.

In order to avoid the necessity of constructing two differential telephones, two ordinary telephones may be used. In this case the connections are as follows:—The front ends of rods 1 and 3 (Fig. 1) are joined to the terminals of the telephone, and their other ends are joined together, rods 2 and 4 being similarly connected up. The same result is obtained by the circulation of opposite currents in the same coil as by the use of two distinct windings. This arrangement has, however, the inconvenience that if one wishes

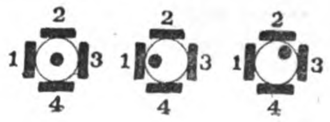



FIG. 3.

to determine exactly the degree of eccentricity of the cable conductor it is necessary to slide back one of the rods, which is a less rapid operation than merely switching in and out an additional resistance, as is done in the case of the differential telephones.

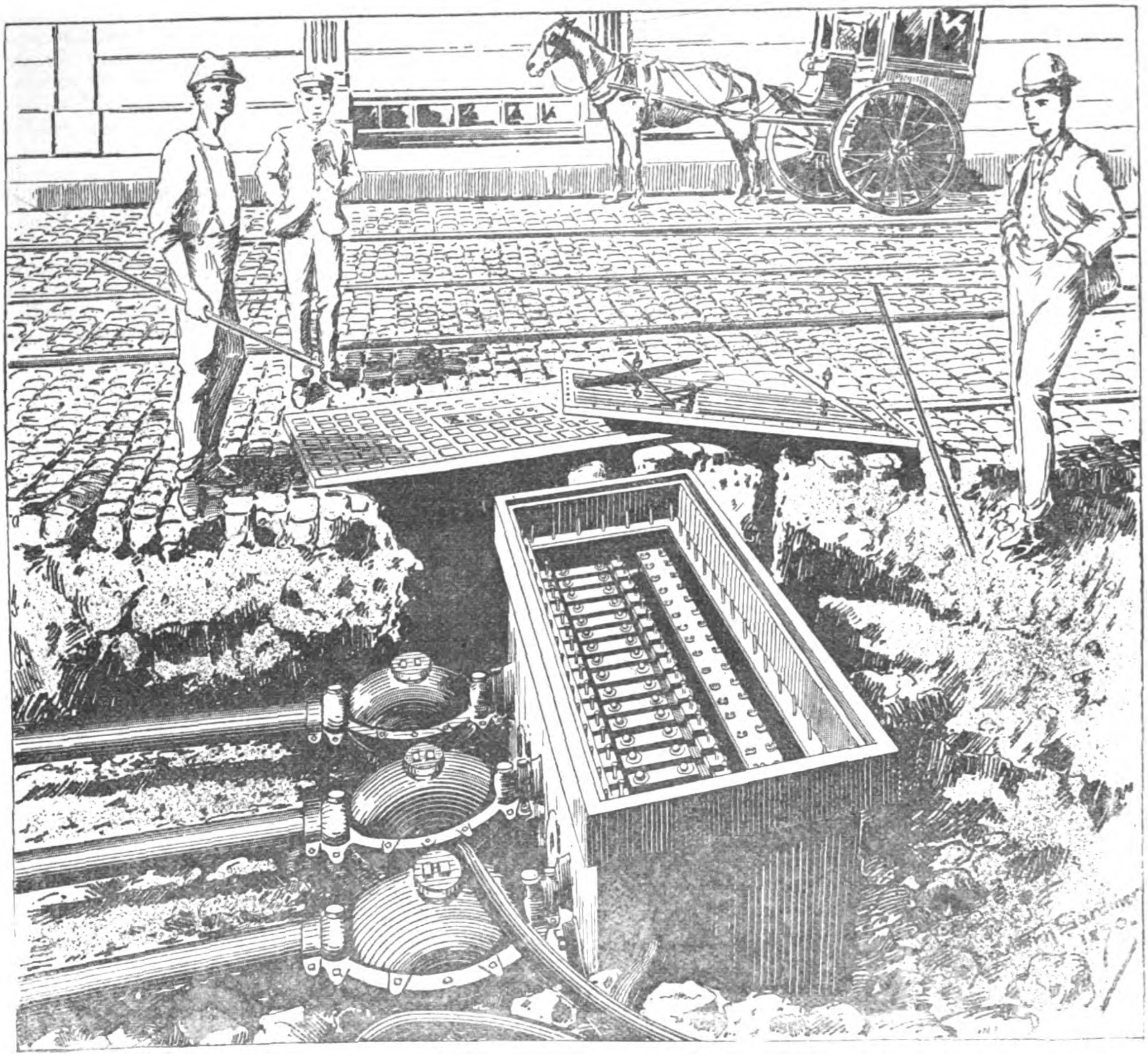
This little apparatus should prove of some use in testing the centrality of conductors of large cables. Up to the present the method employed somewhat resembles that of Alexander the Great when confronted with the Gordian knot; that is to say, the electrician charged with taking over the cable whenever he thinks the conductor is out of truth chops the cable in two; if his suspicions prove correct, the contractor pays for repairs; if the electrician is wrong, the purchaser pays.

Digitized by Google

## EDISON UNDERGROUND WORK IN BOSTON.*

BY A. C. SHAW.

The Edison system of underground feeders and mains is well enough known, but there are constantly improvements being made; and I show in the accompanying engraving a special feeder junction box, which has been designed and put into operation by the Edison Electric Illuminating Company, of Boston. The object of the junction box is to subdivide long feeders into sections of not over 1,000ft. in length, so that, should any trouble ever develop on such a feeder, it is not necessary to dig up the streets, and cut the feeder in two, three, four, or six parts to locate the trouble. As lighting extends, the feeders become longer, and in Boston there are some feeders as long as 6,000ft., and it becomes a serious matter to locate possible trouble. The junction box, as shown, is designed for six feeders, and is made of cast iron, the inside dimensions being 3ft. wide, 5ft. long, and 3½ft. deep. There is a projecting ledge in the found interesting. From the two stations, one in Head-place and the other on Hawkins-street, there are now running some 32,000 incandescent lights, about 1,400 horse-power in motor service, and about 50 Ward arc lights. The extreme distance covered by the underground system is about two miles. In all, there are some 40 miles of underground feeders and mains, the longest feeder being 6,000ft., several of 3,750ft., and the shortest being about 250ft. The largest feeder used is 750,000 circular mils (·587 sq. in.) solid copper. In crossing the bridges over the railway on Shawmut-avenue, specially prepared Clark cable, pulled into 3in. gas pipe, has been used, and a similar method will be adopted for crossing the Concord-street bridge to South Boston, an armoured Clark submarine cable being used under the drawbridge. In addition to the underground work, the Edison Company, of Boston, have a pole line of 100,000 circular mils (·0785 sq. in.) with several tie lines, extending from station to station, by way of Atlantic-avenue, taking in all the wharves, and supplying power to large numbers of motors used in these busy thoroughfares.



Edison Underground Mains in Boston.—Special Feeder Junction Box.

ordinary manner with screw studs for fastening down the inside cover, which is made water tight by means of a rubber gasket, and melted wax, in the usual way. As will be seen, there is provision for pressure wires, the small terminals on the right hand side being for that purpose, while copper strips shown on the left hand side serve to make connections for the feeder. By use of this box, when two or more feeders run through it, when a feeder is faulty it is not necessary to cut out the whole feeder while repairing; the faulty section only is cut out, and flexible insulated cable connections can be used from the upper nuts for short-circuiting the faulty part. The pressure wires are then connected from the junction box instead of the catch boxes at the end of the feeders, and the remainder of the two feeders are used like large mains, the potential being kept constant at the junction box instead of at the catch box. The Edison Company, of Boston, have now six in use, and provision is being made for putting them on all long feeders, different sizes of boxes being used according to the number of feeders in the locality. A few figures regarding the Edison work in Boston may be

* From the *Electrical Engineer* of New York.

## THE ELECTRO-MAGNET.*

BY PROFESSOR SILVANUS P. THOMPSON

*(Continued from page 50.)*

EFFECT OF SHAPE OF SECTION.

So far as the carrying capacity for magnetic lines is concerned, one shape of section of cores is as good as another; square or rectangular is as good as round if containing equal sectional area. But there are two other reasons, both of which tell in favour of round cores. First, the leakage of magnetic lines, from core to core, is, for equal mean distances apart, proportional to the surface of the core; and the round core has less surface than square or rectangular of equal section. All edges and corners, moreover, promote leakage. Secondly, the quantity of copper wire that is required for each

* A series of four Cantor Lectures delivered before the Society of Arts, January—February, 1890.

Digitized by Google

turn will be less for round cores than for cores any other shape, for of all geometrical figures of equal area the circle is the one of the least periphery.

### Effect of Distance between Poles.

Another matter that Du Moncel experimented upon, and Dub and Nicklès likewise, was the distance between the poles. Dub considered that it made no difference how far the poles were apart. Nicklès had a special arrangement made which permitted him to move the two upright cores or limbs, 9 centimetres high, to and fro on a solid bench or yoke of iron. His armature was 30 centimetres long. Using very weak currents he found the effect best when the shortest distance between the poles was 3 centimetres; with a stronger current 12 centimetres; and with his strongest current nearly 30 centimetres. I think leakage must have a deal to do with these results. Du Moncel tried various experiments to elucidate this matter, and so did Prof. Hughes, in an important but too little-known research which came out in the "Annales Télégraphiques" in the year 1862.

### Researches of Prof. Hughes.

His object was to find out the best form of electro-magnet, the best distance between the poles, and the best form of armature for the rapid work required in Hughes's printing telegraphs. One word about Hughes's magnets. This diagram (Fig. 51) shows the form of the well-known Hughes's electro-magnet. I feel almost ashamed to say those words "well known," because, although on the Continent everybody knows what you mean by a Hughes's electromagnet, in England scarcely anyone knows what you mean. Englishmen do not even know that Prof. Hughes has invented a special form of electro-magnet. Hughes's special form is this:—A permanent steel magnet, generally a compound one, having soft iron pole-pieces, and a couple of coils on the pole pieces only. As I have to speak of Hughes's special contrivance amongst the mechanisms that will occupy our attention only now refer to this magnet in one particular. If you wish a magnet to work rapidly, you will secure the most rapid action not when the coils are distributed all along, but when they are heaped up near, not necessarily entirely on the poles. Hughes made a number of researches to find out what the right length and thickness of these pole-pieces should be. It was found an advantage not to use too thin pole-pieces, otherwise the magnetism from the permanent magnet did not pass through the iron without considerable reluctance, being choked by insufficiency of section; also not to use too thick pieces, otherwise they presented too much surface for leakage across from one to the other. Eventually a particular length was settled upon, in proportion about six times the diameter, or rather longer. In the further researches that Hughes made he used a magnet of shorter form, not shown here, more like those employed in relays, and with an armature from 2 to 3 millimetres thick, 1 centimetre wide, and 5 centimetres long. The poles were turned over at the top towards one another. Hughes tried whether there was any advantage in making those poles approach one another, and whether there was any advantage in having as long an armature as 5 centimetres. He tried all different kinds, and plotted out the results of observations in curves, which could be compared and studied. His object was to ascertain the conditions which would give the strongest pull, not with a steady current but with such currents as were required for operating his printing telegraph instruments; currents which lasted but one to twenty-hundredths of a second.

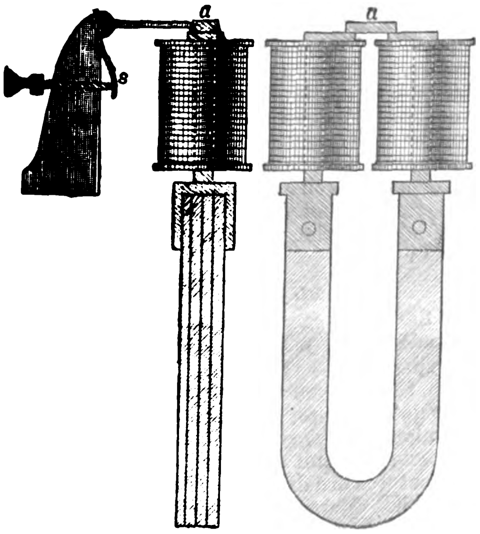


Fig. 51.—Hughes's Electro-magnet.

He found it was decidedly an advantage to shorten the length of the armature, so that it did not protrude far over the poles. In fact he got a sufficient magnetic circuit to secure all the attractive power that he needed, without allowing as much chance of leakage as there would have been had the armature extended a longer distance over the poles. He also tried various forms of armature having very various cross-sections.

### Position and Form of Armature.

In one of Du Moncel's Papers on electro-magnets* you will also find a discussion on armatures, and the best forms for working in different positions. Amongst other things in Du Moncel you will find this paradox; that whereas using a horse-shoe magnet with flat poles, and a flat piece of soft iron for armature, it sticks on far tighter when put on edgeways; on the other, if you are going to work at a distance, across air, the attraction is far greater when it is set flatways. I explained the advantage of narrowing the surfaces of contact by the law of traction, $B^2$ coming in. Why should we have for an action at a distance the greater advantage from placing the armature flatway to the poles? It is simply that you thereby reduce the reluctance offered by the air gap, to the flow of the magnetic lines. Du Moncel also tried the difference between round armatures and flat ones, and found that a cylindrical armature was only attracted about half as strongly as a prismatic armatures having the same surface when at the same distance. Let us examine this fact in the light of the magnetic circuit. The poles are flat. You have at a certain distance away a round armature; there is a certain distance between its nearest side and the polar surfaces. If you have at the same distance away a flat armature having the same surface, and, therefore, about the same tendency to leak, why do you get a greater pull in this case than in that? I think it is clear that if they are at the same distance away, giving the same range of motion, there is a greater magnetic reluctance in the case of the round armature, although there is the same periphery, because though the nearest part of the surface is at the prescribed distance, the rest of the under surface is farther away; so that the gain found in substituting an armature with a flat surface is a gain resulting from the diminution in the resistance offered by the air gap.

### Pole-pieces on Horse-shoe Magnets.

Another of Du Moncel's researches† relates to the effect of polar projections or shoes—movable pole-pieces, if you like—upon a horse-shoe electro-magnet. The core of this magnet was of round iron 4 centimetres in diameter, and the parallel limbs were 10 centimetres long and 6 centimetres apart. The shoes consisted of two flat pieces of iron slotted out at one end, so that they could be slid along over the poles and brought nearer together. The attraction exerted on a flat armature across air gaps 2 millimetres thick was measured by counterpoising. Exciting this electro-magnet with a certain battery, it was found that the attraction was greatest when the shoes were pushed to about 15 millimetres, or about ¼ of the inter-polar distance, apart. The numbers were as follows:—

| Distance between shoes, Millimetres. | Attraction, in grammes. |
|---|---|
| 2 | 900 |
| 10 | 1,012 |
| 15 | 1,025 |
| 25 | 965 |
| 40 | 890 |
| 60 | 550 |

With a stronger battery the magnet without shoes had an attraction of 885 grammes, but with the shoes 15 millimetres apart, 1,195 grammes. When one only pole was employed, the attraction, which was 88 grammes without a shoe, was *diminished* by adding a shoe to 39 grammes!

### Contrast between Electro-magnets and Permanent Magnets.

Now I want particularly to ask you to guard against the idea that all these results obtained from electro-magnets are equally applicable to permanent magnets of steel; they are not, for this simple reason. With an electro-magnet, when you put the armature near, and make the magnetic circuit better, you not only get more magnetic lines going through that armature, but you get more magnetic lines going through the whole of the iron. You get more magnetic lines round the bend when you put an armature on to the poles, because you have a magnetic circuit of less reluctance, with the same external magnetising power in the coils acting around it. Therefore, in that case, you will have a greater magnetic flux all the way round. The data obtained with the electro-magnet (Fig. 42), with the exploring coil, c, on the bend of the core, when the armature was in contact, and when it was removed, are most significant. When the armature was present it multiplied the total magnetic flow tenfold for weak currents, and nearly threefold for strong currents. But with a steel horse-shoe,

* *La Lumière Electrique*, Vol. II.
† *La Lumière Electrique*, Vol. IV., p. 129.

Digitized by Google

magnetised once for all, the magnetic lines that flow around the bend of the steel are a fixed quantity, and however much you diminish the reluctance of the magnetic circuit you do not create or evoke any more. When the armature is away the magnetic lines arch across, not at the ends of the horse-shoe only, but from its flanks; the whole of the magnetic lines leaking somehow across the space. When you have put the armature on, these lines, instead of arching out into space as freely as they did, pass for the most part along the steel limbs and through the iron armature. You may still have a considerable amount of leakage, but you have not made one line more go through the bent part. You have absolutely the same number going through the bend with the armature off as with the armature on. You do not add to the total number by reducing the magnetic reluctance, because you are not working under the influence of a constantly impressed magnetising force. By putting the armature on to a steel horse-shoe magnet you only *collect* the magnetic lines, you do not *multiply* them. This is not a matter of conjecture. A group of my students have been making experiments in the following way. They took this large steel horse-shoe magnet (Fig. 52), the length of which from end to end through the steel is 42½in. A light narrow frame was constructed so that it could be slipped on over the magnet, and on it were wound thirty turns of fine wire, to serve as an exploring coil. The ends of this coil were carried to a distant part of the laboratory, and connected to a sensitive ballistic galvanometer. The mode of experimenting is as follows:—The coil is slipped on over the magnet (or over its armature) to any desired position. The armature of the magnet is placed gently upon the poles, and time enough is allowed to elapse for the galvanometer needle to settle to zero. The armature is then suddenly detached. The first swing measures the change, due to removing the armature, in the number of magnetic lines that pass through the coil in the particular position.

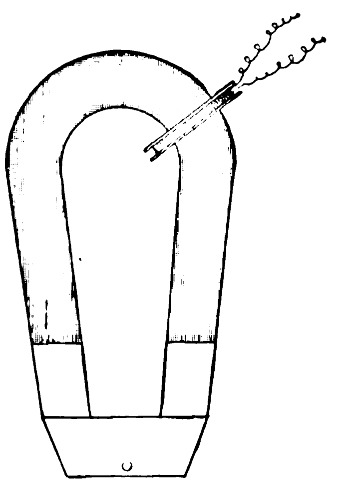


Fig. 52.—Experiment with Permanent Magnet.

I will roughly repeat the experiment before you: the spot of light on the screen is reflected from my galvanometer at the far end of the table. I place the exploring coil just over the pole, and slide on the armature; then close the galvanometer circuit. Now I detach the armature, and you observe the large swing. I shift the exploring coil, right up to the bend; replace the armature; wait until the spot of light is brought to rest at the zero of the scale. Now, on detaching the armature, the movement of the spot of light is quite imperceptible. In our careful laboratory experiments, the effect was noticed inch by inch all along the magnet. The effect when the exploring coil was over the bend was not as great as 1-3000th part of the effect when the coil was hard up to the pole. We are therefore justified in saying that the number of magnetic lines in a permanently magnetised steel horse-shoe magnet is not altered by the presence or absence of the armature.

You will have noticed that I always put on the armature gently. It does not do to slam on the armature; every time you do so, you knock some of the so-called permanent magnetism out of it. But you may pull off the armature as suddenly as you like. It does the magnet good rather than harm. There is a popular superstition that you ought never to pull off the keeper of a magnet suddenly. On investigation, it is found that the facts are just the other way. You may pull off the keeper as suddenly as you like; but you should never slam it on.

From these experimental results I pass to the special design of electro-magnets for special purposes.

### Electro-magnets for Maximum Traction.

These have already been dealt with in the preceding lecture; the characteristic feature of all the forms suitable for traction being the compact magnetic circuit.

Several times it has been proposed to increase the power of electro-magnets by constructing them with intermediate masses of iron between the central core and the outside, between the layers of windings. All these constructions are founded on fallacies. Such iron is far better placed either right inside the coils or right outside them, so that it may properly constitute a part of the magnetic circuit. The constructions known as Camacho's and Cance's, and one patented by Mr. S. A. Varley in 1877, belonging to this delusive order of ideas, are now entirely obsolete.

Another construction which is periodically brought forward as a novelty is the use of iron windings of wire or strip in place of copper winding. The lower electric conductivity of iron, as compared with copper, makes such a construction wasteful of exciting power. To apply equal magnetising power by means of an iron coil implies the expenditure of about six times as many watts as need be expended if the coil is of copper.

### Electro-magnets for Maximum Range of Attraction.

We have already laid down the principle which will enable us to design electro-magnets to act at a distance. We want our magnet to project, as it were, its force across the greatest length of air gap. Clearly, then, such a magnet must have a very large magnetising power, with many ampere-turns upon it, to be able to make the required number of magnetic lines pass across the air resistance. Also it is clear that the poles must not be too close together for its work, otherwise the magnetic lines at one pole will be likely to curl round and take short cuts to the other pole. There must be a wider width between the poles than is desirable in electro-magnets for traction.

### Electro-magnets of Minimum Weight.

In designing an apparatus to put on board a boat or a balloon, where weight is a consideration of primary importance, there is again a difference. There are three things that come into play—iron, copper, and electric current. The current weighs nothing, therefore if you are going to sacrifice everything else to weight, you may have comparatively little iron, but you must have enough copper to be able to carry the electric current; and under such circumstances you must not mind heating your wires nearly red hot to pass the biggest possible current. Provide as little copper as you conveniently can, sacrificing economy in that case to the attainment of your object; but, of course, you must use fire-proof material, such as asbestos, for insulating, instead of cotton or silk.

### A Useful Guiding Principle.

In all cases of design there is one leading principle which will be found of great assistance, namely, that a magnet always tends so to act as though it tried to diminish the length of its magnetic circuit. It tries to grow more compact. This is the reverse of that which holds good with an electric current. The electric circuit always tries to enlarge itself, so as to enclose as much space as possible, but the magnetic circuit always tries to make itself as compact as possible. Armatures are drawn in as near as can be, to close up the magnetic circuit. Many two-pole electro-magnets show a tendency to bend together when the current is turned on. One form in particular, which was devised by Ruhmkorff for the purpose of repeating Faraday's celebrated experiment on the magnetic rotation of polarised light, is liable to this defect. Indeed, this form of electro-magnet is often designed very badly, the yoke being too thin, both mechanically and magnetically, for the purpose which it has to fulfil.

Here is a small electric bell, constructed by Wagener of Wiesbaden, the construction of which illustrates this principle. The electro-magnet, a horse-shoe, lies horizontally; its poles are provided with protruding curved pins of brass. Through the armature are drilled two holes, so that it can be hung upon the two brass pins; and when so hung up it touches the ends of the iron cores just at one edge, being held from more perfect contact by a spring. There is no complete gap, therefore, in the magnetic circuit. When the current comes and applies a magnetising power, it finds the magnetic circuit already complete in the sense that there are no absolute gaps. But the circuit can be bettered by tilting the armature to bring it flat against the polar ends, that being indeed the mode of motion. This is a most reliable and sensitive pattern of bell.

*Electro-magnetic Pop-gun.*—Here is another curious illustration of the tendency to complete the magnetic circuit. Here is a tubular electro-magnet (Fig. 53), consisting of a small bobbin, the core of which is an iron tube about 2in. long. There is nothing very unusual about it; it will stick on, as you see, to pieces of iron when the current is turned on. It clearly is an ordinary electro-magnet in that respect. Now suppose I take a little round rod of iron about an inch long, and put it into the end of the tube, what will happen when I turn on my current? In this apparatus as it stands, the magnetic circuit consists of a short length of iron, and then all the rest is air. The magnetic circuit will try to complete itself, not by shortening the iron, but by *lengthening* it; by pushing the piece of iron out so as to afford more surface for leakage.

Digitized by Google

That is exactly what happens; for, as you see, when I turn on the current the little piece of iron shoots out and drops down. You see that little piece of iron shoot out with considerable force. It becomes a sort of magnetic pop-gun. This is an experiment which has been twice discovered. I found it first described by Count Du Moncel, in the pages of *La Lumière Electrique*, under the name of the "pistolet électro-magnétique;" and Mr. Shelford Bidwell invented it independently. I am indebted to him for the use of this apparatus. He gave an account of it to the Physical Society in 1885, but the reporter missed it, I suppose, as there is no record in the Society's proceedings.

### Electro-magnets for use with Alternating Currents.

When you are designing electro-magnets for use with alternating currents, it is necessary to make a change in one respect, namely, you must so laminate the iron that internal eddy-currents shall not occur; indeed, for all rapid acting electro-magnetic apparatus it is a good rule that the iron must not be solid. It is not usual with telegraphic instruments to laminate them by making up the core of bundles of iron plates or wires, but they are often made with tubular cores, that is to say, the cylindrical iron core is drilled with a hole down the middle, and the tube so formed is slit with a saw-cut to prevent the circulation of currents in the stance of the tube. Now when electro-magnets are to be employed with rapidly alternating currents, such as are used for electric lighting, the frequency of the alternations being usually about 100 periods per second, slitting the cores is insufficient to guard against eddy-currents; nothing short of completely laminating the cores is a satisfactory remedy. I have here, thanks to the Brush Electric Engineering Company, an electro-magnet of the special form that is used in the Brush arc lamp when required for the purpose of working in an alternating-current circuit. It has two bobbins that are screwed up against the top of an iron box at the head of the lamp. The

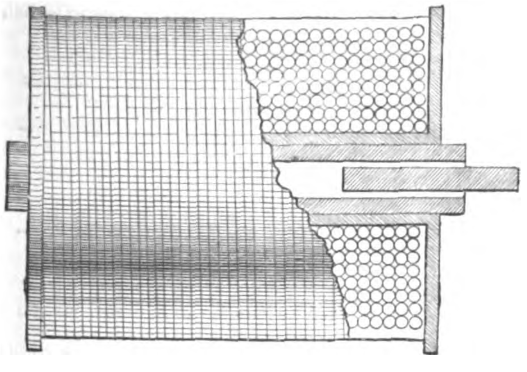


Fig. 53.—Electro-magnetic Pop-gun.

iron slab serves as a kind of yoke to carry the magnetism across the top. There are no fixed cores in the bobbins, which are entered by the ends of a pair of yoke plungers. Now in the ordinary Brush lamp for use with a steady current, the plungers are simply two round pieces of iron tapped into a common yoke; but for alternate-current working this construction must not be used, and instead a U-shaped double plunger is used, made up of laminated iron, rivetted together. Of course it is no novelty to use a laminated core; that device, first used by Joule, and then by Cowper, has been re-patented rather too often during the past fifty years to be considered as a recent invention.

The alternate rapid reversals of the magnetism in the magnetic field of an electro-magnet, when excited by alternating electric currents, sets up eddy-currents in every piece of undivided metal within range. All frames, bobbin tubes, bobbin ends, and the like must be most carefully slit, otherwise they will overheat. If a domestic flat-iron is placed on the top of the poles of a properly laminated electro-magnet, supplied with alternating currents, the flat-iron is speedily heated up by the eddy-currents that are generated internally within it. The eddy-currents set up by induction in neighbouring masses of metal, especially in good conducting metals, such as copper, give rise to many curious phenomena. For example, a copper disc or copper ring placed over the pole of a straight electro-magnet so excited is violently repelled. These remarkable phenomena have been recently investigated by Prof. Elihu Thomson, with whose beautiful and elaborate researches we have lately been made conversant in the pages of the technical journals. He rightly attributes many of the repulsion phenomena to the lag in phase of the alternating currents thus induced in the conducting metal. The electro-magnetic inertia, or self-inductive property of the electric circuit, causes the currents to rise and fall later in time than the electromotive forces by which they are occasioned. In all such cases the impedance which the circuit offers is made up of two things—resistance and inductance. Both these causes tend to diminish the amount of current that flows, and the inductance also tends to delay the flow.

### Electro-magnets for Quickest Action.

I have already mentioned Hughes's researches on the form of electro-magnet best adapted for rapid signalling. I have also incidentally mentioned the fact that where rapidly varying currents are employed, the strength of the electric current that a given battery can yield is determined not so much by the resistance of the electric circuit, as by its electric inertia. It is not a very easy task to explain precisely what happens to an electric circuit when the current is turned on suddenly. The current does not suddenly rise to its full value, being retarded by inertia. The ordinary law of Ohm in its simple form no longer applies; one needs to apply that other law which bears the name of the law of Helmholtz, the use of which is to give us an expression, not for the final value of the current, but for its value at any short time, $t$, after the current has been turned on. The strength of the current after a lapse of a short time, $t$, cannot be calculated by the simple process of taking the electromotive force and dividing it by the resistance, as you would calculate steady currents.

In symbols, Helmholtz's law is:—

$$i_t = \frac{E}{R}\left(1 - e^{-\frac{R}{L}t}\right).$$

In this formula $i_t$ means the strength of the current after the lapse of a short time $t$; E is the electromotive force; R the resistance of the whole circuit; L its coefficient of self-induction; and $e$ the number 2·7183, which is the base of the Napierian logarithms. Let us look at this formula; in its general form it resembles Ohm's law, but with a new factor, namely, the expression contained within the brackets. This factor is necessarily a fractional quantity, for it consists of unity less a certain negative exponential, which we will presently further consider. If the factor within brackets is a quantity less than unity, that signifies that $i_t$ will be less than E÷R. Now, the exponential of negative sign, and with negative fractional index, is rather a troublesome thing to deal with in a popular

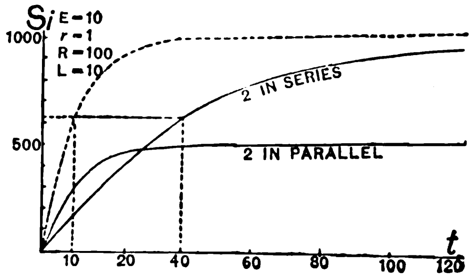



Fig. 54.—Curves of Rise of Currents.

lecture. Our best way is to calculate some values, and then plot it out as a curve. When once you have got into the form of a curve, you can begin to think about it, for the curve gives you a mental picture of the facts that the long formula expresses in the abstract. Accordingly we will take the following case. Let E=10 volts; R=1 ohm; and let us take a relatively large self-induction, so as to exaggerate the effect; say let L=10 quads. This gives us the following:—

| $t$ (sec.) | $e^{+\frac{R}{L}t}$ | $i_t$ |
|---|---|---|
| 0 | 1 | 0 |
| 1 | 1·105 | 0·950 |
| 2 | 1·221 | 1·810 |
| 5 | 1·649 | 3·936 |
| 10 | 2·718 | 6·343 |
| 20 | 7·389 | 8·646 |
| 30 | 20·08 | 9·501 |
| 60 | 403·4 | 9·975 |
| 120 | 162800·0 | 9·999 |

In this case the value of the steady current, as calculated by Ohm's law, is 10 amperes; but Helmholtz's law shows us that with the great self-induction, which we have assumed to be present, the current, even at the end of 30 seconds, has only risen up to within 95 per cent. of its final value; and only at the end of two minutes has practically attained full strength. These values are set out in the highest curve in Fig. 54, in which, however, the further supposition is made that the number of spirals S in the coils of the electro-magnet is 100, so that when the current attains its full value of 10 amperes, the full magnetising power will be S $i$=1000. It will be noticed that the curve rises from zero at first

Digitized by Google

steeply and nearly in a straight line, then bends over, and then becomes nearly straight again, as it gradually rises to its limiting value. The first part of the curve—that relating to the strength of the current after *very small* interval of time—is the period within which the strength of the current is governed by inertia (*i.e.*, the self-induction) rather than by resistance. In reality the current is not governed either by the self-induction or by the resistance alone, but by the ratio of the two. This ratio is sometimes called the "time-constant" of the circuit, for it represents *the time* which the current takes in that circuit to rise to a definite fraction of its final value. This definite fraction is the fraction $\frac{e-1}{e}$; or in decimals, 0·634. All curves of rise-of-current are alike in general shape—they differ only in scale; that is to say, they differ only in the height to which they will ultimately rise, and in the time they will take to attain this fraction of their final value.

*Example* (1).—Suppose E = 10; R = 400 ohms; L = 8. The final value of the current will be 0·025 ampere, or 25 milliamperes. Then the time-constant will be $8 \div 400 = \frac{1}{50}$th sec.

*Example* (2).—The P.O. standard "A" relay has R = 400 ohms; L = 3·25. It works with 0·5 milliampere current, and therefore will work with 5 Daniell cells through a line of 9,600 ohms. Under these circumstances, the time-constant of the instrument on short circuit is 0·0081 sec.

It will be noted that the time-constant of a circuit can be reduced either by diminishing the self-induction or by increasing the resistance. In Fig. 54 the position of the time-constant for the top curve is shown by the vertical dotted line at 10 seconds. The current will take 10 seconds to rise to 0·634 of its final value. This retardation of the rise of current is simply due to the presence of coils and electro-magnets in the circuit; the current as it grows being retarded because it has to create magnetic fields in these coils, and so sets up opposing electromotive forces that prevent it from growing all at once to its full strength. Many electricians, unacquainted with Helmholtz's law, have been in the habit of accounting for this by saying that there is a lag in the iron of the electromagnet cores. They tell you that an iron core cannot be magnetised suddenly; that it takes time to acquire its magnetism. They think it is one of the properties of iron. But we know that the only true time-lag in the magnetisation of iron—that which is properly termed "viscous hysteresis"—does not amount to any great percentage of the whole amount of magnetisation, takes comparatively a long time to show itself, and cannot therefore be the cause of the retardation which we are considering. There are also electricians who will tell you that when magnetisation is suddenly evoked in an iron bar, there are induction currents set up in the iron which oppose and delay its magnetisation. That they oppose the magnetisation is perfectly true; but if you carefully laminate the iron so as to eliminate eddy-currents, you will find, strangely enough, that the magnetism rises still more slowly to its final value. For by laminating the iron you have virtually increased the self-inductive action, and increased the time-constant of the circuit, so that the currents rise more slowly than before. The lag is not in the iron, but in the magnetising current, and the current being retarded, the magnetisation is, of course, retarded also.

### Connecting Coils for Quickest Action.

Now let us apply these most important, though rather intricate considerations to the practical problems of the quick working of the electro-magnet. Take the case of an electro-magnet forming some part of the receiving apparatus of a telegraph system, in which it is desired to secure very rapid working. Suppose the two coils that are wound upon the horse-shoe core are connected together in series. The coefficient of self-induction for these two is four times as great as that of either separately; coefficients of self-induction being proportional to the square of the number of turns of wire that surround a given core. Now if the two coils, instead of being put in series, are put in parallel, the coefficient of self-induction will be reduced to the same value as if there were only one coil, because half the line current (which is practically unaltered) will go through each coil. Hence the time constant of the circuit when the coils are in parallel will be a quarter of that which it is when the coils are in series; on the other hand, for a given line-current, the final magnetising power of the two coils in parallel is only half what it would be with the coil in series. The two lower curves in Fig. 54 illustrate this, from which it is at once plain that the magnetising power for very brief currents is greater when the two coils are put in parallel with one another than when they are joined in series.

Now this circumstance has been known for some time to telegraph engineers. It has been patented several times over. It has formed the theme of scientific papers, which have been read both in France and in England. The explanation generally given of the advantage of uniting the coils in parallel is, I think, fallacious; namely, that the "extra-currents" (*i.e.*, currents due to self-induction), set up in the two coils are induced in such directions as tend to help one another when the coils are in series, and to neutralise one another when they are in parallel. It is a fallacy, because in neither case do they neutralise one another. Whichever way the current flows to make the magnetism, it is opposed in the coils while the current is rising, and helped in the coils while the current is falling, by the so-called extra-currents. If the current is rising in both coils at the same moment, then, whether the coils are in series or in parallel, the effect of self-induction is to retard the rise of the current. The advantage of parallel grouping is simply that it reduces the time-constant.

### Battery Grouping for Quickest Action.

One may consider the question of grouping the battery cells from the same point of view. How does the need for rapid working, and the question of time-constant, affect the best mode of grouping the battery cells? The amateur's rule, which tells you to so arrange your battery that its internal resistance should be equal to the external resistance, gives you a result wholly wrong for rapid working. The supposed best arrangement will not give you (at the expense even of economy) the best result that might be got out of the given number of cells. Let us take an example and calculate it out, and place the results graphically before our eyes in the form of curves. Suppose the line and electro-magnet have together a resistance of 6 ohms, and that we have 24 small Daniell's cells, each of electromotive force, say, 1 volt, and of internal resistance, 4 ohms. Also let the coefficient of self-induction of the electro-magnet and circuit be 6 quadrants. When all the cells are in series the resistance of the battery will be 96 ohms, the total resistance of the circuit 102 ohms, and the full value of the current 0·235 ampere. When all the cells are in parallel the resistance of the battery will be 0·133 ohm, the total resistance 6·133 ohms, and the full value of the current 0·162 ampere. According to the amateur rule of grouping cells so that internal resistance equals external, we must

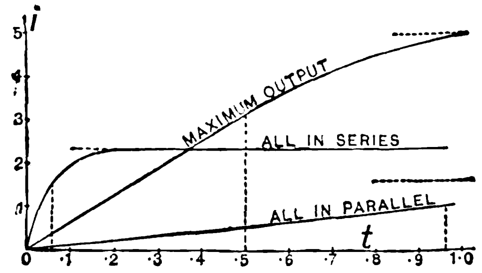



Fig. 55.—Curves of Rise of Current with Different Groupings of Battery

arrange the cells in four parallels, each having six cells in series, so that the internal resistance of the battery will be 6 ohms, total resistance of circuit 12 ohms, full value of current 0·5 ampere. Now the corresponding time-constants of the circuit in the three cases (calculated by dividing the coefficient of self-induction by the total resistance) will be respectively—in series, 0·06sec.; in parallel, 0·96sec.; grouped for maximum steady current, 0·5sec. From these data we may now draw the three curves, as in Fig. 55, wherein the abscissæ are the values of time in seconds, and the ordinates the current. The faint vertical dotted lines mark the time-constants in the three cases. It will be seen that when rapid working is required the magnetising current will rise, during short intervals of time, more rapidly if all the cells are put in series than it will do if the cells are grouped according to the amateur rule.

When they are all put in series, so that the battery has a much greater resistance than the rest of the circuit, the current rises much more rapidly, because of the smallness of the time-constant, although it never attains the same ultimate maximum as when grouped in the other way. That is to say, if there is self-induction as well as resistance in the circuit, the amateur rule does not tell you the best way of arranging the battery. There is another mode of regarding the matter which is helpful. Self-induction, while the current is growing, acts as if there were a sort of spurious addition to the resistance of the circuit; and while the current is dying away it acts of course in the other way, as if there were a subtraction from the resistance. Therefore you ought to arrange the battery so that the internal resistance is equal to the real resistance of the circuit, plus the spurious resistance during that time. But how much is the spurious resistance during that time? It is a resistance proportional to the time that has elapsed since the current was turned on. So then it comes to a question of the length of time for which you want to work it. What fraction of a second do you require your signal to be given in? What is the rate of the vibrator of your electric bell? Suppose you have settled that point, and that the short time during which the current is required to rise is

Digitized by Google

called $t$; then the apparent resistance at time $t$ after the current is turned on is given by the formula :—

$$R_t = R \times e^{\frac{R}{L}t} \div \left(e^{\frac{R}{L}} - 1\right).$$

TIME-CONSTANTS OF ELECTRO-MAGNETS.

I may here refer to some determinations made by M. Vaschy* respecting the coefficients of self-induction of the electro-magnets of a number of pieces of telegraphic apparatus. Of these I must only quote one result, which is very significant; it relates to the electro-magnet of a Morse receiver of the pattern habitually used on the French telegraph lines :—

| | L, in quadrants. |
|---|---|
| Bobbins, separately, without iron cores ......... | 0·233 and 0·265. |
| Bobbins, separately, with iron cores............... | 1·65 and 1·71. |
| Bobbins, with cores joined by yoke, coils in series........................................................ | 6·37. |
| Bobbins, with armature resting on poles......... | 10·68. |

It is interesting to note how the perfecting of the magnetic circuit increases the self-induction.

Thanks to the kindness of Mr. Preece, I have been furnished with some most valuable information about the coefficients of self-induction, and the resistance of the standard pattern of relays, and other instruments which are used in the British postal telegraph service, from which data one is able to say exactly what the time-constants of those instruments will be on a given circuit, and how long in their case the current will take to rise to any given fraction of its final value. Here let me refer to a very capital Paper by Mr. Preece in an old number of the *Journal* of the Society of Telegraph Engineers, a Paper "On Shunts," in which he treats this question, not as perfectly as it could now be treated with the fuller knowledge we have in 1890 about the coefficients of self-induction, but in a very useful and practical way. He showed most completely that the more perfect the magnetic circuit is—though, of course, you are getting more magnetism from your current—the more is that current retarded. Mr. Preece's mode of experiment was extremely simple; he observed the throw of the galvanometer when the circuit which contained the battery and the electro-magnet was opened by a key which at the same moment connected the electro-magnet wires to the galvanometer.

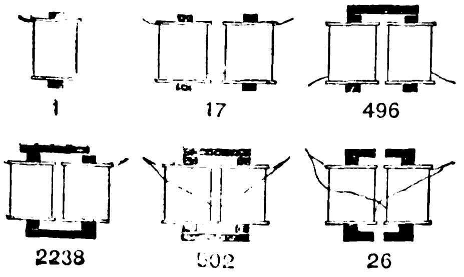



FIG. 56.—Electro-magnets of Relay, and their Effects.

The throw of the galvanometer was assumed to represent the extra current which flowed out. Fig. 56 represents a few of the results of Mr. Preece's Paper. Take from an ordinary relay a coil, with its iron core, half the electro-magnet, so to speak, without any yoke or armature. Connect it up as described, and observe the throw given to the galvanometer. The amount of throw obtained from the single coil was taken as unity, and all others were compared with it. If you join up two such coils as they are usually joined, in series, but without any iron yoke across the cores, the throw was 17. Putting the iron yoke across the cores, to constitute a horse-shoe form, 496 was the throw; that is to say, the tendency of this electro-magnet to retard the current was 496 times as great as that of the simple coil. But when an armature was put over the top the effect ran up to 2,238. By the mere device of putting the coils in parallel, instead of in series, the 2,238 came down to 502, a little less than the quarter value which would have been expected. Lastly, when the armature and yoke were both of them split in the middle, as is done in fact in all the standard patterns of the British Postal Telegraph relays, the throw of the galvanometer was brought down from 502 to 26. Relays so constructed will work excessively rapidly. Mr. Preece states that with the old pattern of relay having so much self-induction as to give a galvanometer throw of 1688, the speed of signalling was only from 50 to 60 words per minute; whereas, with the standard relays constructed on the new plan, the speed of signalling is from 400 to 450 words per minute. It is a very interesting and beautiful result to arrive at from the experimental study of these magnetic circuits.

* *Bulletin de la Société Internationale des Electriciens*, 1886.

SHORT CORES *versus* LONG CORES.

In considering the forms that are best for rapid action, it ought to be mentioned that the effects of hysteresis in retarding changes in the magnetisation of iron cores are much more noticeable in the case of nearly-closed magnetic circuits than in short pieces. Electro-magnets with iron armatures in contact across their poles will retain, after the current has been cut off, a very large part of their magnetism, even if the cores be of the softest of iron; but so soon as the armature is wrenched off the magnetism disappears. An air-gap in a magnetic circuit always tends to hasten demagnetising. A magnetic circuit composed of a long air-path and a short iron-path demagnetises itself much more rapidly than one composed of a short air-path and a long iron-path. In long pieces of iron the mutual action of the various parts tends to keep in them any magnetisation that they may possess; hence they are less readily demagnetised. In short pieces, where these mutual actions are feeble or almost absent, the magnetisation is less stable, and disappears almost instantly on the cessation of the magnetising forces. Short bits and small spheres of iron have no "magnetic memory." Hence the cause of the commonly received opinion amongst telegraph engineers that for rapid work electro-magnets must have short cores. As we have seen, the only reason for employing long cores is to afford the requisite length for winding the wire which is necessary for carrying the needful circulation of current to force the magnetism across the air-gaps. If, for the sake of rapidity of action, length has to be sacrificed, then the coils must be heaped up more thickly on the short cores. The electro-magnets in American patterns of telegraphic apparatus usually have shorter cores, and a relatively greater thickness of winding upon them, than those of European patterns.

(*To be continued.*)

## ELECTROLYSIS OF ALUMINIUM FLUORIDE.*

BY M. ADOLPHE MINET.

The author, by continuing his researches on the electrolysis of the fused fluoride of aluminium, has been able to determine the composition of the electrolytic bath, which, for a given temperature and current density, yields the best results. The physical properties of the mixture of salts, and the relation between the current density and the constants of electrolysis, have also been found.

*Composition of the Bath.*—The bath is formed of a mixture of sodium chloride, and the double fluoride of aluminium and sodium. It is expressed by the chemical formula $6\,NaCl + Al_2Fl_3, 3\,NaFl$. Its fusing point is 675°C., and the temperature of vaporisation 1035°C. Its electrical conductivity at the temperature t°C. is expressed by the formula

$$C_t = 3{\cdot}1\,[1 + 0{\cdot}0022\,(t - 870^{\circ})].$$

For a current of 1,200 amperes the weight of the bath should be 20 kilogrammes, the current density should be 1 ampere per square centimetre of active surface of the positive electrode, and the voltage of the electrodes should be 5·5 volts.

The composition of the bath is maintained constant by adding a mixture of aluminium hydrate, oxyfluoride of aluminium, and the double fluoride of aluminium and sodium, by the action of which the aluminium disengaged at the positive electrode is reabsorbed by the mixed electrolyte.

*Relation between the Current Density and the Electrolytic Constants.*

Let V be the voltage applied to the electrodes, $e$ the opposing electro-motive force in volts due to the polarisation of the electrolyte, R the resistance in ohms of the electrolyte, and C the current in amperes.

When the salts composing the bath are chemically pure, we may then distinguish three cases. In the first the current density is very small, and V and $e$ are practically identical. If the temperature is constant, V is found proportional to C until the current density reaches an upper limit. This limit, when the temperature $t$ is 870 deg., varies between 0·02 and 0·03 amperes per square centimetre. Beyond this limit, and until the current density exceeds 1 ampere per square centimetre, the formula $V = e + R\,C$ holds, and the author gives several numerical results obtained from experiment and calculation. A few are appended below :—

| $t$=852°C, $e$=2·15, R=0·01 | | | $t$=890°C, $e$=2·40, R=0·0044 | | | $t$=980°C, $e$=0·34, R=0·0033 | | |
|---|---|---|---|---|---|---|---|---|
| C | V Measured. | V Calculated. | C | V Measured. | V Calculated. | C | V Measured. | V Calculated. |
| 130 | 3·50 | 3·45 | 196 | 3·26 | 3·26 | 572 | 4·23 | 4·23 |
| 245 | 4·60 | 4·60 | 885 | 6·18 | 6·29 | 1030 | 5·78 | 5·74 |

* *Comptes Rendus*, October 27, 1890.

Digitized by Google

When the current density exceeds one ampere per square centimetre the value of V cannot be calculated as a function of C in any simple way. It rapidly attains a magnitude approximating to that required for an electric arc 30 or 40 volts.

When the electrolyte is mixed with extraneous salts, such as those of iron or silicon, it is still true that while the current density lies between certain limits the decomposition takes place according to Sprague's law. The following numbers were obtained from experiments on a bath, from which the salts of iron and silicon were successively removed.

| Iron present. $t=810°C.$ $e=0·75.$ R=0·0093. | | | Silicon present. $t=840°C.$ $e=1·37.$ R=0·0089. | | | Aluminium salts only. $t=870°C.$ $e=2·15$ R=0·0085. | | |
|---|---|---|---|---|---|---|---|---|
| C | V | | C | V | | C | V | |
| | Measured. | Calculated. | | Measured. | Calculated. | | Measured. | Calculated. |
| 75 | 1·45 | 1·45 | 65 | 1·95 | 1·95 | 100 | 3·00 | 3·75 |
| 225 | 2·85 | 2·85 | 217·5 | 3·35 | 3·31 | 187·5 | 3·75 | 3·25 |

## THE MOST FAVOURABLE POSITION FOR AN ELECTRIC LIGHT CENTRAL STATION.*

BY DR. A. FÖPPL.

As the question very frequently arises as to which is the best situation for a central station so far as the cost of mains is concerned, the following simple considerations, which do not require any complicated calculations, may be of use :—

If there are any number of points 1, 2, 3 . . . which may be regarded as centres for distribution, the mains to these points from the central station, O, must obviously, if practicable, lie in straight lines. Suppose $l_1$ $l_2$ $l_3$ . . . to be the lengths of these mains and $c_1$ $c_2$ $c_3$ . . . the respective currents, they will be called on to carry. The weight of copper required for the main $l_1$ will then be $k\ c_1\ l_1^2$, where $k$ is a coefficient depending on the tension, and, therefore, in our case a constant. The total weight of copper required for the mains is accordingly $k\ \Sigma\ c\ l^2$, the sum being taken over all the distributing centres of the system. But this expression is of the same form as that for the moment of inertia about 0 of masses proportional to $c_1$ $c_2$ $c_3$ placed at the distributing centres. But the moment of inertia is a minimum when the point about which it is taken is the centre of gravity of the system. We accordingly have the law :—The weight of copper required for the mains will be a minimum when the central station is placed at the centre of gravity of the system formed by placing masses proportional to the current consumed at each one of the distributing centres. Further, we know that the moment of inertia about any point distant $r$ from the centre of gravity of any system is equal to the moment of inertia about the centre of gravity $+ r^2\ \Sigma\ m$. From this we deduce the law that the weight of copper in the mains is the same when the central station is at any point on the circumference of a circle described with the centre of gravity, as determined above, for centre.

In order to apply the laws found to an example, the centre of gravity as defined is first found. Various values are then put for the moment of inertia about a point, and the distance of the point accordingly from the centre of gravity determined. These distances are taken as radii, and concentric circles are drawn with the centre of gravity for centre. It is then possible to see at a single glance the increase per cent. in weight of copper in the mains necessitated by removing the central station to any distance from the centre of gravity.

## BOOKS, &c., RECEIVED.

"Electric Bell Construction." By F. C. ALLSOPP. (London : E. and F. N. Spon.

"Practical Electrical Notes and Definitions." By W. PERREN MAYCOCK. (Second Edition : Revised and Enlarged.) (London : E. and F. N. Spon.)

"The Journal of the Franklin Institute." Vol. CXXX. No. 779. (Philadelphia Franklin Institute.)

"Fortification for English Engineers." By Major J. F. Lewis, R.E., Royal Engineers' Institute, Chatham.

"Pioneers of Electricity." By J. Munro. (London: The Religious Tract Society).

"Foundry, Forge, and Factory." By W. J. Gordon. (London : The Religious Tract Society.)

* From the *Elektrot Zeitschrift.*

## GERMAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

*November* 17, 1890.

The Darmstadt central station which was opened two years ago, with a capacity of 6,000 lamps, and which was built on the three-wire system, offers a splendid illustration of some of the advantages and disadvantages of the low-tension continuous-current system. The station supplies at present current for 7,000 lamps, when the accumulators are helping the machines. But there is still an increasing demand for light, and to avoid a still greater overloading, the engineers of the work are compelled to use a strange expedient. When anybody wants to have the light in a street where there are no cables, they ask them to pay five per cent. of the cost of the main cable to be laid. How they avoid new consumers in streets where there *are* mains I have not been able to find out. The central station is situated nearly in the centre of the town, and from there the feeders and mains spread through a circular area of 600 metres diameter. As all the ground around the building is occupied, it is rumoured that the municipalty is going to erect the second central station somewhere at the further end of the town, and that as there is also a demand for a new technical college, they propose to place the physical and electrical colleges in the central station buildings. This would certainly be to the benefit of the students; whether it would also prove a benefit to the station is a question.

There is a project on foot to build an electric tramway between Nürnberg and Fürth. These two Bavarian towns were the first in Germany to be united by a railway in December, 1835, and it may be of interest to state that the first locomotive built by Stephenson was in active service on it till 1887. If the electric line be made, Messrs. Schuckert, of Nürnberg, will probably have the contract.

The small town of Pforzheim is about to invite tenders for a 200 horse-power central station for the distribution of current to small electric motors. If the idea is proceeded with, this town will be the first in Germany to have a central station erected mainly to supply motive power.

## CORRESPONDENCE.

### THE TRANSMISSION OF ENERGY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR : With reference to your Editorial note, drawing attention to the contrast between the mechanical and the electrical manner of transmitting energy, *i.e.*, between the transmission of power by ordinary matter and by the ether, it is, perhaps, worth mentioning explicitly and briefly that the transmission of power by cog-wheels is extremely analogous to the electrical method. Consider a simple pair of cog-wheels in the same plane, say, one above driving or driven by another below. The axis of rotation lies, say, north and south, the direction of motion of the engaging cogs is east or west, the path of the transmitted energy is up or down. Energy moves perpendicularly to both the electric current and the magnetic axis. The motion of the rim of a cog-wheel is tangential; the transmission of energy by it is radial. The analogy bears some pressing. I doubt, however, whether many engineers have yet grasped the fact that energy is a definite thing, transmitted continuously from place to place like matter with no sort of discontinuity; so that its path, *viâ* belts, or shafting, or mill gearing, or dielectrics, is a thing which can be definitely studied and mapped out.—Yours, &c.,

OLIVER J. LODGE.

### LOSSES IN TRANSFORMERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR : In your issue of October 10th you have commented on some views which I have expressed elsewhere in regard to Mr. Swinburne's transformer. You have misunderstood some of my arguments, but the fault is entirely my own. As I value highly your opinion and that of your eminent co-workers, and am anxious that my views—correct or erroneous—should be so understood by your readers as I intended, I take the liberty to address you the following explanatory lines which you may deal with as you deem proper.

Digitized by Google

I imagine—for reasons which will subsequently be made clear—that a line through, say, the axis of a core, which constitutes in part the magnetic circuit of a transformer or other induction apparatus, be subdivided in units of length and the line integral taken along the line, then the total line integral is equal to the sum of all these unit integrals or "magnetomotive forces per unit length," if I am allowed to use this expression. These unit integrals are of necessity not equal since the magnetic force diminishes as we recede from the region adjacent to the coil or magnet energising the core. Usually, the magnetic force is taken as constant throughout the core, and in estimating the dissipation no account is taken of the fact that the same may be very different in the different parts of the core. As this statement might require an explanation I will illustrate it with an example. Suppose you take a transformer core consisting of a middle piece and the two sides embracing the coils, and you wind a coil on the middle piece leaving both the sides free as usual. If you pass an alternating current through the coil a certain amount of energy will be dissipated in the core, the dissipation will be equal in both the sides, and, of course, since the proper design requires that the section of each side piece should be equal to half the section of the middle core, the dissipation in both the sides together will be very nearly equally to that in the middle core. Mr. Swinburne has stated that in removing the sides the loss would be divided by three, and I was somewhat misled by his statement. Suppose now you wind on one of the side cores a coil and close the same upon itself. A very different distribution of the lines will now result. As the phase difference of the currents in both the coils will be more or less approximating to 180deg., the current in the closed coil must by taken negative, for the core upon which the coil is wound and positive for the other side core, hence the "magnetomotive forces" in both the circuits are very different. The closed secondary coil does not allow many lines to pass through the core it embraces. As a result, the loss in the other side core will be much greater. An analogous experiment may be performed with an electric circuit by setting up in one of two branches through which the current divides an opposing electromotive force of some kind. Like in an electric circuit, so in this example, one branch is inert and the other possesses self-induction so to speak. Of course the above example is exaggerated, and it is only given for better illustration. In practice, one of the side cores is replaced by air, and the case corresponds more to a core having a primary coil on one end and a secondary at the remote end. In this case, also, by closing the secondary coil a different line density in the various parts of the core will result, and the loss in the various parts will be different. Some phenomena observed on transformers, under overload, for instance, may be explained by taking into account the above effects.

Now, to come to the subject of this letter. I beg you will please to observe that Mr. Swinburne in his communication stated first, that in removing the embracing sides—that is, reducing the length to one-third to all appearance—the loss is divided by three (he evidently took the section of each of the sides to be equal to the section of the middle piece, probably without noticing that this assumption was important for his argument); and later he remarked that in his transformer the loss was below 1 per cent., that is, one-tenth of the loss in the closed circuit transformer. Following his reasoning I was under the impression that he had reduced the length of the core to one-tenth. My statement then, "in order that the loss might be reduced to one-tenth, it is necessary to reduce the weight of the core to one-tenth, and subject every unit length of the same to the same magnetomotive force," meant broadly to say, that if we take a core of a length L and operate it with a certain number of ampere turns, and then take a length $\frac{L}{10}$ of that core, and operate with the same ampere turns, the loss will generally not be one-tenth, though the weight *is* one-tenth, but may be greater or smaller. The same, in comparing two cores exactly alike and operated with the same ampere turns, we shall find that the loss will not be the same in both cases unless there is "per each unit of length the same magnetomotive force," or, in other words, unless the exciting coils are distributed alike. We can also easily see that a transformer core of a given length and section is most economically utilised when both the primary and secondary coils are distributed uniformly over whole core. But even in such a case, I have sufficient reason to believe that the various parts of a core (of a transformer of any kind or armature of a dynamo machine) are not utilised alike; that the line density is different in the different parts, that it is greater near the surface, or, rather, near the conductors conveying current, and that this condition is greatly affected by the periodicity, or, in dynamo machines, by the peripheral speed and number of poles. This condition may more or less modify the losses found on cores.

In his communication, Mr. Swinburne further stated that in his transformer the magnetomotive force and the exciting current were higher, but it did not appear as though he *sufficiently* appreciated the increased loss in consequence of the increased excitation. I meant to point this out by stating that "if a higher magnetomotive force is used, the loss will be proportionate to the square of the magnetomotive force."

At any instant the "magnetomotive force" corresponds to the instantaneous integral current value around the core, which value is computable from the primary and secondary turns and both the current ordinates at *that instant*. Since the magnetomotive force is 4 $\pi$ times that value, when, considering mere proportionality, that value alone need be considered, and my above quoted remark means that the loss is proportionate to the square of that value. In a closed circuit transformer in which the primary and secondary circuits are in very close inductive relation, and the increase of the inducing and induced currents is in a practically constant ratio, this value, and therefore the "magnetomotive force," remains constant for all loads, hence the loss is practically the same for all loads. It is more or less the value which we obtain from the primary current and turns when the secondary is open. If, under otherwise equal conditions of test, the electromotive force on the primary of a converter, or on a choking coil, is varied, the current is varied in proportion, and the above value is proportionate to the electromotive force. About two years ago, Dr. Louis Duncan pointed out that the loss in a core is nearly proportionate to the square of the electromotive force. In laboratory experience on motors and induction-cores, this proportionality has been found to exist, being more pronounced at high frequencies than at low, probably on account of the relatively greater loss in currents in the former case.

You have evidently misunderstood some of these statements. I did not say that in general the loss is independent of the length of the core as you seem to infer. I only stated that "magnetic resistance" has *little* to do with efficiency, and I gave the example of the two rings of different diameter as such a particular case in which "magnetic resistance" (and therefore length) is of comparatively small importance, and also to draw attention to the advantages of the "top-winding," which by many is not sufficiently appreciated, and which is the greater the longer the core and the higher the frequency.

Your reflections about the "relative magnitude of the waste due to eddy currents" and hysteresis induce me to say a few words about this subject to which I have devoted considerable thought.

I do not think that eddy currents, that is, currents circulating in paths of measurable length, are in a properly subdivided core as important an element of loss as it is generally assumed. In subdividing a core we soon reach a point where a further subdivision would be of no appreciable advantage, judging from the rapid diminution of the eddy-current effect as the thickness of the plates or wires is reduced, and, in fact, in practice it is better not to carry the subdivision too far for various obvious reasons, which, however, are not concerned in this argument. Now hysteresis loss, according to the accepted views, is a result of the periodic displacement of the molecular magnets. As far as this loss in a core is concerned, we can reduce it to anything desired. Imagine that in Ewing's experiments we apply to the pivoted magnets a magnetising force varying periodically many thousand times a second. Of course the magnets would not stir, but loss would nevertheless occur in a core composed of such magnets in consequence of currents set up in them. Since the magnets would not move (that is, not to any appreciable extent), there would then be no magne-

Digitized by Google

tisation, therefore no loss in hysteresis proper, but all the loss would practically be due to currents. We may now replace the magnets by small closed coils possessed of a directive tendency. When a current impulse is started in the coil which surrounds the small coils, currents will be set up in the latter. The tendency of the currents generated would be to place each small coil in such a position that no current is generated in it, that is, at right angles to the large energising coil, and certain positions of the small coils would result from this and the directive tendency and the interaction of the coils. When the currents subside the directive force would act, and bring the coils more or less in their former positions. When a current of opposite direction is generated in the small coil, a similar displacement would result, but in this case the displacement would be smaller or greater, according to the direction of the induced current, which may aid or oppose the directive force which the coils possess in virtue of their being magnets. If the coils would be devoid of inertia, and could move with perfect freedom, no current would be generated in them; but they possess weight and inertia (and directive tendency besides); time is therefore required to move them. As we increase the frequency the energy and duration of each current impulse is diminished, and soon a point is reached where the energy and time are not sufficient to move the coils into the positions which constitute magnetisation. Currents are then generated to their full value. At low frequencies the loss would be principally due to hysteresis proper; at excessively high frequencies the loss in hysteresis would be small, if any, and the loss in currents great.

We may conceive the core to consist of rings or similarly-shaped aggregations of atoms, which may be compared with so many closed coils, so that the described effects occur.

There are a good many reasons why I think that eddy currents in a well laminated core do not play an important part. They diminish rapidly as the lamination is carried further. Then, again, if we insert in a coil a bundle of thin wires, and pass an alternating current through the coil, the heating of the wires will be principally due to currents circulating, not through the mass from wire to wire, but in each individual wire, as the resistance to currents from wire to wire would be comparatively very great. Now each wire we may consider as consisting of a bundle of far thinner wires, each formed by a row of molecules with spaces between, and it seems probable that similar conditions must prevail.

On grounds of the view above given I have thought that the relative magnitude of the hysteresis and current loss may be determined by operating at an excessively high frequency, when there is little or no loss in hysteresis, and then from the value found, and from the time-rate of change at this and at a lower frequency, estimating the amount of the current loss with the lower frequency.—Yours, &c., NIKOLA TESLA.

## A NEW EMPIRICAL FORMULA FOR THE AIR-SPACE OF DYNAMOS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. Andersen's formula is so very startling that I think he will find that an error has crept into his calculations.

Without going into the subject any further, I would refer him to *Electrician*, Vol. XVIII., p. 39, in which is commenced a full report of a Paper on "Dynamo Electric Machinery," by Drs. J. and E. Hopkinson. This I take to be the standard publication on the subject. I see that Mr. Andersen does not take into account the question of leakage. Perhaps this is where the error can be found.—Yours truly,

H. RAVENSHAW.

## PROF. KIMBALL AND ELECTRICITY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The article which appeared on page 33 of your previous number, from the pen of Prof. Kimball, of Baltimore, has given me both surprise and pleasure. That you may know the cause of this, I quote the following from it:—

"It is an interesting fact that the old notion that electricity is a substance, one of the so-called class of imponderables held by the earlier investigators of electrical phenomena, after being generally supposed to be dead and buried, should be resurrected, and, in a dress to suit the times, should become a part of the orthodox scientific creed of to-day. . . . The modern theory differs from the older ones, however, in this important respect, that, whereas Franklin thought of each particle of the electric fluid as acting at a distance, repelling every other particle, the modern theory supposes no such repulsive force."

These passages of Dr. Kimball's embody the theory of electricity which I was enabled to publish in 1839, from the experiments and discoveries I then made about electricity. Why Dr. Kimball should have written that this theory is "a part of the orthodox scientific creed of the day" has somewhat puzzled me; it is possible his words may be true on the other side of the Atlantic, but they are, I am sorry to write, wide of the truth on this side of the Atlantic, for all the treatises on electricity which have hitherto been published in this country by our professors and teachers of electricity, within and outside of our colleges, have all been written so as to teach that Faraday's theory of two electric forces is true; whereas the theory Dr. Kimball now assists me in upholding, and the discoveries I made which enabled me to promulgate it in 1839 are a demonstration that Faraday's theory of two electric forces is utterly false. The two theories cannot co-exist, and yet Dr. Kimball has tried to make them do so, for he has written: "It appears, then, that the characteristic distinction between the older and modern theories of electricity is the recognition by the latter of the fundamental importance of the *dielectric* or insulating media. This great step forward was made by Faraday." I maintain that Faraday's theory of the *dielectric* must live or die with his theory of two electric forces. It is strange that Dr. Kimball did not see this. Faraday's theory of the *dielectric* is, that electricity passes through glass by means of that which he called *induction*, namely, that each atom of the glass is polarised by his imaginary two electric forces. Now, if Dr. Kimball really believes in the theory of only one electricity—a peculiar substance, as he describes it—then he should also believe that Faraday's two electric forces are defunct, and consequently that his theory of the *dielectric* is also defunct. One of the reasons why I was enabled to publish in 1839 my theory of one electricity having no repulsion for the particles of electricity, in opposition to Franklin's one theory of electricity, was the fact that I discovered that electricity passed through glass by *conduction*, and not by Faraday's imaginary thing called *induction*. The experiments which prove this I have shown to many electricians, and will be glad to show them at my laboratory to any electrician who arranges with me by letter as to a day and hour for seeing them.—Yours truly, JAMES JOHNSTONE.

8, Merchiston-park, Edinburgh, November 18, 1890.

## THE COLOGNE ELECTRIC LIGHT CABLES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of October 31st, your German Correspondent states that the cables which are being laid down in the streets of Cologne have been manufactured by "MM. Chaudoir, of Neuchâtel." We take the liberty to call your attention to the fact that there is no such firm in Neuchâtel, and that all the cables for the central station of Cologne are manufactured in our works.—Yours truly,

SOCIÉTÉ D'EXPLORATION DES CABLES ÉLECTRIQUES,
SYSTÈME BERTHOUD, BOREL ET CIE.

Cortaillod, November 7, 1890.

[Our German Correspondent informs us that "Chaudoir, of Neufchâtel," was an unfortunate slip of the pen for "Cortaillod, near Neufchâtel," where the cables in question are manufactured. ED. *E.*]

## THE ELECTROLYTIC PREPARATION OF BLEACHING AGENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The paragraph which deals with my process in your article of last week on "The Electrolytic Preparation of Bleaching Agents," translated from *La Lumière Electrique*, is merely

Digitized by Google

an extract of a patent which I did not consider worth protecting in England, owing to the improvements I have since introduced in my bleaching process, and in which I dispense altogether with carbon electrodes.

The example I quoted in my specification to give an idea of the production and cost of hypochlorite of sodium in comparison with bleaching powder is hypothetical, and, in practice, the cost of the electrolytic production of equivalent quantities of bleaching powder is much lower than I stated in my specification.

Through a misprint, the advantages of my process, compared with chemical bleaching, are lessened because the article I refer to says: "In order to obtain a quantity of bleaching liquor *equal to one ton of chloride of lime*, 4,000 *horse-power hours* are required. If 1½ kilog. of coal is consumed per horse-power hour, the coal consumption for 4,000 horse-power hours will be 6 tons, and taking coal at 20fr., the cost of production is still less than one-half the price of a ton of chloride of lime."

What I said in my specification is, that, assuming the yield of chlorine is only 1 gramme per ampere hour, 4,000 horse-power hours will produce a quantity of chlorine equivalent to *one ton and a-half* of the bleaching powder, and not one ton only. A difference of half a ton is not a negligible fraction of one ton and a-half. Given that a 1,000 amperes and 5 volts dynamo yield 1 kilo. of chlorine per hour, a 1,000 amperes and a 100-volt dynamo will yield, after 1 hour, 20 kilos., and after 24 hours 480 kilos. of chlorine, equal to 1,440 kilos. of bleaching powder, almost one ton and a half. To obtain 1 kilo. of chlorine, 5,000 watt hours are required. If we take the brake horse-power to be equal to 600 watts, it requires 8·33 horse-power, and the price of 1 kilo. of chlorine is therefore the cost of 8·33 horse power per hour. In a set of 20 tanks 166·66 horse-power are necessary to generate 20 kilos. of chlorine per hour, and for the constant generation of these 20 kilos. of chlorine per hour, during 24 hours, 3,998 horse-power hours are necessary, and will have transformed a given quantity of chloride of sodium solution into a hypochlorite of sodium solution, containing 480 kilos. of chlorine. Assuming that the consumption of coal is 2½lb. per horse-power per hour, it will represent, in round figures, six tons. Adding to the cost of this that of the salt lost and other items, the production of hypochlorite of sodium containing the same quantity of chlorine as a given quantity of bleaching powder will cost about 50 per cent. less than the powder. If the consumption of coal is only 2lb. per horse-power hour, and if the yield of chlorine per ampere hour is over 1 gramme, my electrolytic bleaching will be cheaper still.

With regard to the article on bleaching by ozone, written by Mr. A. Villon, in his own paper, *La Revue de Chimie Industrielle et Agricole*, of which you gave an extract, I may say that as soon as I read it in the several Paris papers in which it was reproduced, I made inquiries about the new system, asking where it was worked, and whether it was only a laboratory experiment, or if it was applied on a commercial scale? Nobody knew anything about it. I wrote to Mr. Villon himself, and then to MM. Broyer et Petit, who were described in the article as working an apparatus capable of producing 10 cubic metres of ozone per hour. I enclose their letter, dated September 1, 1890, by which you will see that they say they do not know the Villon process.—Yours truly,

62, Loughborough-park, S.W. E. ANDREOLI.

**Hotel Lighting in America.**—Perhaps no class of buildings in New York City is so admirably fitted with electric lighting plants as the hotels and theatres, says the *Electrical World*. At the Plaza Hotel, however, where four 650 light machines are installed, the thing seems to have been done rather too well. The floor of the dynamo room, says our contemporary, is of polished marble, white and grey in colour, and, although very handsome in appearance, it does not give the best satisfaction, owing to the fact that the insufficient ventilation of the room causes the temperature to reach a rather high point, and this keeps the marble floor hot at all times, producing somewhat unpleasant results.

## TRADE NOTES AND NOTICES.

TENDERS WANTED.—Tenders are required for lighting public hall, stores, &c., at Edmonton. Particulars may be obtained from Mr. Walker, People's Provider, Upper Edmonton.

SURVEYING INSTRUMENTS FOR SALE.—Our advertisement columns contain a notice of a sale of forty 5in. by 4in. theodolites and 9in. contouring levels, being a portion of surplus stock. Full particulars may be obtained from the officer in charge of stores, Ordnance Survey Office, Southampton.

ELECTRIC METER PATENTS.—In our advertisement columns will be found particulars of a notification by Messrs. Oulton and Edmondson for "leave to amend specification and letters patent No. 11,032 of 1889 for improvements in electric meters."

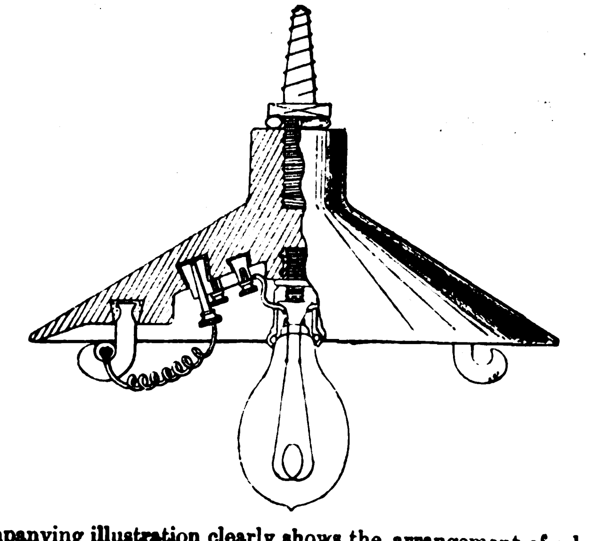
PORCELAIN FITTINGS.—In reference to our Trade Note upon the subject of threading with a fine thread the small holes in porcelain switches, &c., Messrs. Poole and White inform us that they have sold thousands of switches during the past six months which have been similarly treated. The porcelain fittings were made for Messrs. Poole and White by a well-known firm in the Midlands.

AMALGAMATION OF BUSINESSES.—We are informed that the business hitherto carried on by Sydney F. Walker and Co., at 92, Quayside, and by R. H. Barnett and Co., at Elswick-court, Newcastle-on-Tyne, will in future be carried on by Messrs. R. H. Barnett and A. S. Barnard, at 92, Quayside, Newcastle-on-Tyne, as "Barnett, Barnard and Co.," Electrical and General Engineers and contractors.

REMOVAL.—Messrs. William Coward and Co., agents for the Australian Gas Light Company, Sydney, have removed to 11, Queen Victoria-street, London, E.C.

——— The Elmore Companies are removing from 20, Bucklersbury, E.C., to 64, Cannon-street, London, E.C.

PORCELAIN INSULATOR FITTINGS FOR MINES.—In our last issue a description was given of these very ingenious fittings which are being supplied by the Electrical Engineering Corporation. The



accompanying illustration clearly shows the arrangement of a lamp beneath a massive porcelain shade, the whole of the contacts, cut-out, switch, &c., being under cover, and thus not only protected from dripping water but kept warm and dry by the lamp.

MESSRS. CECIL WRAY AND COMPANY.—This firm informs us that they are now carrying on the lighting station at Bradford set up by the Schmidt-Douglas Company, Limited.

FRENCH TELEGRAPHS.—The French Government have in contemplation the re-adjustment of the Paris telegraph and pneumatic tube service. It is proposed to make this service much more complete than it is at present.

## PATENT RECORD.

### APPLICATIONS FOR PATENTS.

October 30, 1890.

17,335. F. B. FAWCETT. Weston-super-Mare. Improvements in electric motors.

17,375. J. B. DENIS. London. An electric motor.

17,394. L. V. CHABRAND. London. Apparatus for effecting a permanent make or break of an electric circuit at any suitable number of points.

October 31, 1890.

17,444. M. MÜTHEL. London. An improved filling for galvanic batteries.

Digitized by Google

17,459. F. V. Maquaire, London. Improvements in and relating to electric arc lamps.

17,488. J. A. Radley. Norwich. Pivoted lamp-post for electric lighting.

November 1, 1890.

17,532. J. Collins. London. Improvements in electric motors.

17,558. J. W. Rathbone. London. Portable generator and electrometer for testing insulation resistance of electric wires.

17,560. J. A. Iliffe, and H. Barton. London. Improvements in and relating to locked switches for electric current circuits.

November 3, 1890.

17,580. J. M. M. Munro. Glasgow. Improvements in the decorative arrangement of electric lights.

17,589. C. Barnett. Godalming. Improved means for lighting street gas lamps by electric spark.

17,600. A. C. Lainchbury. Edmonton. An electrical switch for opening and closing of circuits, switching on currents, and so forth.

17,611. C. D. Abel. London. Improved electrical push button for signalling circuits (H. Messing, Germany).

17,631. P. Lauber. London. Improvements in or relating to electric accumulators.

17,635. P. Schoop. London. Improvements in electrodes and isolators or divisions for batteries.

November 4, 1890.

17,690. C. A. Randall. London. Method of and apparatus for obtaining electricity by hydraulic power.

17,711. H. Edmunds. London. Improvements in means for the distribution of electricity.

17,728. M. W. Dewey. London. Improvements in electric railways.

17,735. F. J. Cleaver and G. Fassold. London. Improvements in automatic regulators for dynamos and motors.

November 6, 1890.

17,829. J. E. Charnock. Manchester. Improvement in incandescent lamp holders or suspenders (C. Charnock, Russia).

17,851. H. Binko. London. Improvements in electric thermostats for ships' bunkers, refrigerating rooms, and other purposes.

17,852. H. Binko. London. Improvements in magneto generators for signalling or medical purposes.

17,861. J. Marx. London. Improvements in the manufacture of electrical conductors and electrodes, and for connecting them, and for analogous purposes.

17,863. M. P. Hardt. London. Improvements in portable electric lamps.

17,870. W. McGeoch. London. An improved make and break action adapted to the purpose of an electric switch.

November 7, 1890.

17,899. W. Lownds, E. Emanuel, and J. Wood (of the firm of A. Emanuel and Sons, Limited). London. An improved self-locking electric switch.

17,905. C. T. B. Brain. Helsby. An induction transformer coil, and methods of using the same for telephone call bells and other purposes.

17,912. J. T. Bottomley. Glasgow. An electricity meter.

17,929. B. Rejchman. London. Improvements in or connected with armatures for dynamo-electric machines.

17,937. F. V. Maquaire. London. Improvements in and relating to electric lamps or lighting apparatus.

17,941. Siemens Brothers and Co. (Limited). London. Improved means for charging accumulator batteries on electric circuits supplied by current generators (Siemens and Halske, Germany).

17,951. H. H. Lake. London. Improvements in electric switches (F. C. Jenkins, Germany).

17,954. H. L. Mangras. London. Improvements in electrical accumulators or storage batteries.

## SPECIFICATIONS PUBLISHED.

1890.

3,094. The Mining and General Electric Lamp Company Limited and Others. Electric lamps. (Price 8d.)

6,041. Dewey. Transformation of electrical energy. (Price 8d.)

10,595. Thomson. Measuring electrical energy. (Price 1s. 3d.)

12,228. Easton. Dynamo electric machines. (Price 6d.)

12,777. Gould and Schalk. Electric conductors. (Price 6d.)

12,979. Cox. Thermo-electric generators. (Price 8d.)

13,002. Lake (Thomson). Induction coils. (Price 8d.)

13,003. Pepper. Electrodes. (Price 6d.)

13,024. Rennerfelt. Electrolysis of melted haloid salts. (Price 4d.)

13,233. The Mining and General Electric Lamp Company, Ltd., & Moscrop. Portable electric lamps. (Price 6d.)

13,780. Elliott. Electric conduits. (Price 8d.)

13,905. Dewey. Electric welding. (Price 8d.)

13,906. Dewey. Electric welding. (Price 8d.)

14,603. Lake (The Hall Signal Company). Electric signalling. (Price 8d.)

14,604. Dewey. Heating metals, &c., by electricity. (Price 8d.)

# COMPANIES' MEETINGS & REPORTS.

## Eastern Extension, Australasia, and China Telegraph Company (Limited).

An extraordinary general meeting of this Company was held at the offices, Winchester House, Old Broad-street, on the 19th inst., for the purpose of confirming, as a special resolution, the following resolution, which was passed at the meeting of the Company on the 22nd ult. Sir John Pender, K.C.M.G., occupied the chair.

"*A. That the Board of Directors be, and are hereby authorised from time to time to create and issue Mortgage Debenture Stock of the Company to an amount not exceeding one-third of the share capital of the Company for the time being issued and paid-up, upon the terms that the aggregate amount of the said stock for the time being in issue, and the interest thereon, shall rank* pari passu *as a first charge on the undertaking and revenue of the Company, the Stock to be issued at such times, in such amounts, and on such terms and conditions as the Board shall from time to time determine, for the purpose of redeeming by exchange or otherwise the outstanding Debentures of the Company, or any other purpose to which capital of the Company may be lawfully applicable.*"

"*B. That the Board be and are hereby authorised to make such provision as they think fit for the registration and transfer of Mortgage Debenture Stock, and for the delivery of certificates thereof, and for the payment of the interest thereon, and generally as to the form and incidents of all documents relating to the said Stock, but so that no such provision be inconsistent with Paragraph A of this resolution.*"

PATENT

SILICIUM BRONZE AND SILICIUM COPPER WIRE.

The best for overhead Telephone and Telegraph Lines,

AND ALL ELECTRICAL PURPOSES.

Hard Drawn High Conductivity Copper Wire.

ROLLED AND DRAWN PHOSPHOR BRONZE.

PHOSPHOR BRONZE BEARINGS, BUSHES, AND OTHER PARTS OF ELECTRICAL MACHINERY.

*SOLE PROPRIETORS of the British, Indian and Colonial Patents,*

THE PHOSPHOR BRONZE COMPANY (Limited),

*87, Sumner Street, Southwark, London, S.E.*

WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

Digitized by Google

The SECRETARY (Mr. F. E. Hesse) having read the notice convening the meeting, as above,

The CHAIRMAN said: Gentlemen, you have heard the resolution read, and I think I had better say, in two words, that the object of this proposal is to enable us to replace the £320,000 of Six per Cent. Debentures by an issue of Four per Cent. Debenture Stock. That is the real object, and, as I stated at the general meeting on the 22nd inst., will effect a saving to the Company of over £6,000 a year. Without further remark, I beg to propose the confirmation of this resolution, which you have heard read.

The Marquis of TWEEDDALE seconded the motion.

The CHAIRMAN: I shall be glad to answer any questions that may be put to me.

Mr. J. LEWIS asked when the money for the new Mortgage Debenture stock would be required.

The CHAIRMAN: What we propose to do is to receive 5 per cent. on application, 5 per cent. on allotment, and 90 per cent. on the 15th of January. The 1st of February is the day on which we are obliged to have the money ready to redeem the Six per Cent. Bonds, so that we have carried over the bulk of this amount to January.

Mr. LEWIS: When will the first payment be made?

The CHAIRMAN: The probability is that we shall make the issue so as to get the two first payments of 5 per cent. in December, in order that we may have all the arrangements ready by the following month. He then put the resolution, which was carried unanimously. Continuing, he said: This is an unfortunate time, but I think we may congratulate ourselves that during all this crisis—and probably such a crisis has never previously occurred in London—our stocks have not varied ½ per cent. That is a very remarkable feature, showing very great confidence so far as our shareholders are concerned. Our shareholders are not great people, but, generally speaking, have small comfortable homes, and look for their dividends regularly, and know, in the case of these companies, that they will come when due. I think I may repeat what I have before told you. In travelling from my place in the country I met a gentleman and his wife, and the wife said to me, "We like your Companies, because your dividends are always so regular"—referring to the Eastern and the Eastern Extension Companies. Now, that is a very nice position to hold. The circular inviting subscriptions from the shareholders for the new Mortgage Debenture Stock will be sent out immediately. We made a promise to the shareholders to give them the option of taking this stock, though I may say that some of the old debenture-holders are putting in claims for a renewal of their holdings. We tell them that they have had 6 per cent. for a great many years. However, we shall deal with the matter as fairly as we can.

Mr. LEWIS proposed a vote of thanks to the Chairman, whom he congratulated on his hopeful tone.

Mr. WILLIAM WOOD seconded the motion, which was carried unanimously.

The CHAIRMAN: I am much obliged to you, gentlemen. It is Dickens who said that there was no credit in being jolly in good times, but that credit was due to him if he could be jolly in hard times.

The meeting then separated.

## Swan United Electric Light Company (Limited).

The following is the eighth annual report of the Directors, to be presented at the ordinary general meeting of the Company, to be held at the Cannon-street Hotel, London, on Tuesday, the 25th inst., at twelve noon. After paying all current charges, and making due allowance for depreciation, there is a credit balance of £44,477. 15s. 10d. The Directors recommend that out of this balance a dividend of ten per cent. for the year be declared; an interim dividend at the rate of six per cent. per annum, amounting to £11,104. 0s. 5d., has already been paid in respect to the first half of the year; the balance of the ten per cent. for the entire year to be distributed in accordance with Clause 77 of the Articles of Association, and to be payable on December 1st next. This will absorb £24,921. 17s. 7d., and leave £8,451. 17s. 10d. to be carried forward. The decision in the patent suit in Germany was given in favour of this Company in the Court of Appeal in Berlin during the summer. The Allgemeine Electricitäts Gesellschaft have appealed from that decision to the Supreme Court at Leipsic. It is expected that the case will be heard and finally decided before Christmas. The Compagnie Générale des Lampes Incandescentes in Paris have not yet been able to obtain a decision in the Courts on the validity of their French patents, but they think that the case will be reached and a decision given during next spring. Their business is increasing, but the competition which they have to sustain compels them to sell lamps at a lower price than heretofore. The Directors who retire by rotation are F. R. Leyland, Esq., and W. C. Quilter, Esq., M.P., who, being eligible, will offer themselves for re-election. Messrs. Welton, Jones and Co., the auditors, will also retire, and will offer themselves for re-election.

## CITY NOTES, &c.

**BANKRUPTS.**—Wednesday's *Gazette* announces that a receiving order has been issued in respect of John William Horace Gray, St. Augustine's-road, Camden Town, and Albert Gray (the said A. Gray trading on his own separate account as W. Gordon), Wellington-road and Staines-road, Twickenham, and Piccadilly, florist, trading in partnership as J. W. Gray and Son, Leadenhall-street, City, and Prince of Wales-road, Plaistow, engineers.

**BRAZILIAN SUBMARINE TELEGRAPH COMPANY.**—The receipts of this Company for the week ended November 14th amounted to £5,249.

**THE EASTERN AND SOUTH AFRICAN TELEGRAPH COMPANY.**—Notice is given of the drawing of 298 Five per Cent. Mortgage Debentures of £100 sterling each in the above Company. These will be paid at par on January 1st next by Messrs. Barclay, Bevan, and Co., of 54, Lombard-street, E.C. The numbers of the Debentures will be found in our advertisement column.

**ELECTRIC CONSTRUCTION CORPORATION.**—Subject to final audit, the Directors of this Corporation have decided to declare a dividend of 6 per cent. per annum upon the ordinary share capital of the Corporation for the past year.

**FOREIGN AND COLONIAL ELMORE PATENT COPPER DEPOSITING COMPANY.**—The Directors of this Company have issued a circular to the shareholders in which they state that, after subscribing for £50,000 debenture stock in the French Company, there remains a sufficient sum to pay a cash dividend of £5 per priority share, and the Directors now declare an interim dividend of £4 per share, payable on December 8th next.—The transfer books of this Company will be closed from December 1 to December 8 (inclusive), for the purpose of paying a Dividend.

**STOCK EXCHANGE.**—Application has been made to the Committee to allow the following security to be quoted in the Official List:—Eastern and South African Telegraph Company (Limited), £201,600 Four per Cent. Mortgage Debentures.

**RICHARD HORNSBY AND SONS (LIMITED).**—The Directors have declared the following dividends:—On Preference stock, at the rate of 6 per cent. per annum, for the half-year ending December 14th; on ordinary shares, 5s. 6d. per share, for the half-year ending September 30, 1890, making, with the interim dividend paid June 14th, 8s. 3d. for the year on the £7 paid.

**TAUNTON, DELMARD, LANE, AND CO. (LIMITED).**—A meeting of the shareholders of this Company was held on Wednesday, at Birmingham, at which resolutions to effect the voluntary winding-up of the Company were passed, Mr. A. H. Gibson being appointed liquidator, with a committee of inspection, consisting of three creditors and two shareholders' representatives.

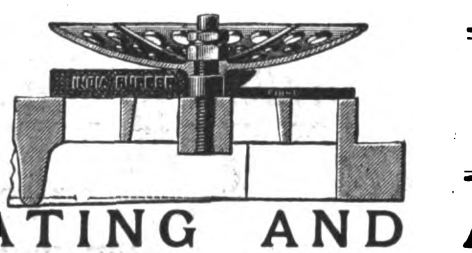
**WENHAM COMPANY (LIMITED).**—The Directors have declared a Dividend of 5 per cent., making 7½ per cent. for the year.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY.**—The traffic receipts of this Company for the week ending November 14, 1890, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited) were £4,087.

**WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).**—The estimated traffic receipts for the half-month ended Nov. 15th were £2,571, against £2,878 in the corresponding period of 1889.

NEW VALVE

No Rubber, Percha, or Leather.




One-half the price of Rubber or Metal.

FOR CIRCULATING AND AIR PUMPS.

Unaffected by any Lubricating Oils. Does not Expand in diameter. Feed Water may be worked at any temperature Suitable for any shaped guards. Only one quality manufactured.

"12, John-street, Sunderland, 20th Sept. 1888.

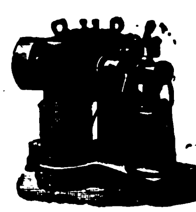
"DEAR SIRS,—In reply to your letter of the 25th inst., the Valves I got from you have done their work well, and ARE AN UNQUALIFIED SUCCESS. I will continue to get them from you as required.—Yours faithfully, JAMES WESTOLL."

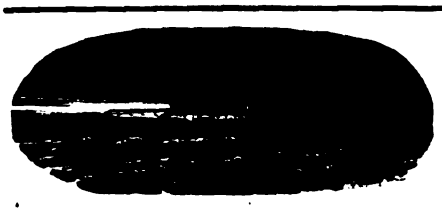
For further Testimony and Prices, apply to MOSSES & MITCHELL, 68-71, Chiswell Street, London.

Digitized by Google

## COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name. | Previous Week's Price, Nov. 12. | | Price Wednesday, Nov. 19. | | Rate per Cent. Yielded. £ s. d. | Dividend Due. | Business Done During Week Ending Nov. 19. Highest | Lowest. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **TELEGRAPHS.** | | | | | | | | |
| 1,331,390 | Stock | 15/0 | Anglo-American | 49 | 50 | 48 | 49 | 5 12 3 | Jan., Apr., July, Oct | 49½ | 48¾ |
| 2,809,310 | Stock | 30/0 | Do. Preferred | 85 | 86 | 84 | 85 | 6 9 5 | " " | 85½ | 84½ |
| 2,809,310 | Stock | .. | Do. Deferred | 13 | 13¼ | 12¾ | 13¼ | .. | " " | 13 7/16 | 13⅛ |
| 250,000 | £100 | 4% | African Direct, 4 per Cent. Debentures | 99 | 102 | 97 | 100 | 4 0 0 | January and July .. | .. | .. |
| 130,000 | 10 | 3/0 | Brazilian Submarine | 11¼ | 11¾ | 11 | 11½ | 6 10 5 | Mar., June, Oct., Dec. | 11⅝ | 11 1/16 |
| 84,500 | 100 | 5% | Do. 5 per Cent. Bonds | 101 | 103 | 101 | 103 | 4 17 1 | January and July .. | .. | .. |
| 75,000 | 100 | $1½ | Do. 5 per Cent. Bonds (2nd Series) | 104 | 108 | 104 | 108 | 4 12 7 | June and December | .. | .. |
| $7,216,000 | $100 | .. | Commercial Cables | 102 | 104 | 102 | 104 | 5 15 5 | April and October .. | 103½ | .. |
| £16,000 | £10 | 8/0 | Cuba Submarine | 11½ | 12 | 11½ | 12 | 7 1 8 | February and August | .. | .. |
| 6,000 | 10 | 10% | Do. Preference 10% | 17 | 18 | 17 | 18 | 5 11 1 | " " | .. | .. |
| 12,931 | 5 | 2/4½ | Direct Spanish (£4 paid) | 3¾ | 4¼ | 3¾ | 4¼ | 5 12 11 | April and October .. | .. | .. |
| 6,000 | 5 | 10% | Do. Preference 10% | 8½ | 9½ | 8½ | 9½ | 5 5 3 | " " | .. | .. |
| 60,710 | 20 | 3/6 | Direct United States | 10 | 10½ | 9½ | 10½ | 6 18 4 | Jan., Apr., July, Oct. | 10½ | .. |
| 400,000 | 10 | 2/6 | Eastern | 13⅜ | 13⅞ | 13⅜ | 13⅞ | 4 13 8 | " " | 13 11/16 | 13⅝ |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference | 14¾ | 15¼ | 14¾ | 15¼ | 3 18 8 | " " | .. | .. |
| 1,200,000 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock | 103 | 106 | 103 | 106 | 3 15 6 | May and November | 105½ | 103 |
| 200,000 | £100 | 5% | Do. 5 per Cent Debentures, 1899 | 106 | 109 | 106 | 109 | 4 11·9 | February & August | .. | .. |
| 250,000 | 10 | 2/6 | Eastern Extension | 13¾ | 14¼ | 13¾ | 14¼ | 4 19 1 | Jan., Apr., July, Oct. | 14¼ | 13¾ |
| 320,000 | 100 | 6% | Do. 6 per Cent. Debentures, 1891 | 100 | 102 | 100 | 102 | 5 17 8 | February & August | 101½ | .. |
| 91,800 | 100 | 5% | Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900 | 102 | 105 | 102 | 105 | 4 15 3 | January and July .. | .. | .. |
| 145,300 | 100 | 5% | Eastern & S. African 5 per Cent. Mor. Deb., 1900 | 101 | 104 | 101 | 104 | 4 16 2 | " " | .. | .. |
| 180,227 | 10 | 1/9 | Globe Telegraph and Trust | 8⅜ | 8⅞ | 8⅜ | 8⅞ | 5 9 10 | Jan., Apr., July, Oct. | 8¾ | 8⅝ |
| 180,042 | 10 | 6% | Do. 6 per Cent. Preference | 14⅜ | 14⅞ | 14⅜ | 14⅞ | 4 2 1 | " " | 14⅝ | .. |
| 150,000 | 10 | 5/0 | Great Northern | 15¾ | 16¼ | 15¾ | 16¼ | 4 12 4 | Jan., April, and July | 16 | .. |
| 15,000 | 100 | 5% | Do. 5 per Cent Debentures, 1881 | 101 | 104 | 101 | 104 | 4 16 2 | January and July .. | .. | .. |
| 230,000 | 100 | 5% | Do. 5 per Cent. Debentures, 1883 | 104 | 107 | 104 | 107 | 4 13 6 | March & September | .. | .. |
| 17,000 | 25 | 37/6 | Indo-European | 35 | 37 | 35 | 37 | 6 15 2 | May and November | .. | .. |
| 38,348 | 10 | 4/0 | London Platino-Brazilian ...xd | 6½ | 7½ | 6 | 7 | 5 14 4 | " " | .. | .. |
| 100,000 | 100 | 6% | Do. 6 per Cent. Debentures | 105 | 108 | 105 | 108 | 5 11 1 | March & September | .. | .. |
| 9,000 | 8 | 4/0 | Reuter's | 8½ | 8¾ | 8½ | 8¾ | 5 14 4 | April and October .. | .. | .. |
| 3,881 | £100 Cert. | 6% | Submarine Cables Trust ....x April Coupon, 1890 | 110 | 114 | 110 | 114 | 5 5 3 | " " | .. | .. |
| 15,609 | £10 | 6/6 | West African | 8½ | 9½ | 8½ | 9½ | 5 5 3 | January and July .. | .. | .. |
| 290,000 | 100 | 5% | Do. 5 per Cent. Debentures | 98 | 101 | 98 | 101 | 4 19 0 | March & September | .. | .. |
| 30,000 | 10 | 3/0 | West Coast of America | 4 | 5 | 4 | 5 | 10 0 0 | January and July .. | .. | .. |
| 150,000 | 100 | 8% | Do. Debentures 8% | 102 | 107 | 102 | 107 | 7 9 7 | June and December | .. | .. |
| 88,321 | 10 | Nil. | West India and Panama | 3¼ | 3¾ | 3 | 3½ | .. | .. | 3 1/16 | 3 |
| 34,563 | 10 | 6/0 | Do. 1st Preference 6% ...xd | 11½ | 12 | 11½ | 11¾ | 5 2 2 | May and November | 11⅝ | 11½ |
| 4,669 | 10 | 27/6 | Do. 6 p. c. 2nd Pref. | 14 | 15 | 11 | 12 | .. | " " | .. | .. |
| 64,174 | 15 | 6/0 | Western and Brazilian | 11 | 11½ | 10½ | 11 | 5 9 7 | " " | 11⅛ | 10⅝ |
| 27,873 | 7½ | 1/6 | Do. 5 per Cent. Cumulative Preferred | 6⅜ | 6⅞ | 6⅜ | 6⅞ | .. | — | 6¾ | .. |
| 27,873 | 7½ | 4/6 | Do. 5 per Cent. Deferred | 4½ | 5 | 4½ | 5 | .. | .. | 4¾ | .. |
| 200,000 | 100 | 6% | Do. 6 per Cent. Debs., Series "A" | 103 | 106 | 103 | 106 | 5 13 2 | February & August | .. | .. |
| 250,000 | 100 | 6% | Do. 6 per Cent. Mort. Debs., Series "B" | 103 | 106 | 103 | 106 | 5 13 2 | " " | 103 | .. |
| $1,836,000 | $1,000 | 7% | Western Union 7 per Cent. 1st Mortgage | 120 | 125 | 120 | 125 | 5 12 0 | May and November | .. | .. |
| £175,100 | £100 | 6% | Do. 6 per Cent. Sterling Bonds | 99 | 103 | 99 | 103 | 5 16 6 | March & September | .. | .. |
| | | | **TELEPHONES.** | | | | | | | | |
| 224,850 | 14/0 | 0/5¾ | Consolidated Telephone Const. & Maintenance. .. | [illegible] | [illegible] | 7/16 | [illegible] | .. | May and November | [illegible] | .. |
| 220,000 | £1 | .. | Oriental (11s. paid) | [illegible] | [illegible] | [illegible] | [illegible] | 4 8 3 | Yearly | .. | .. |
| 433,984 | 5 | 3/0 | National | 4½ | 4¾ | 4½ | 4¾ | 6 17 2 | June and December | 4½ | 4½ |
| 15,000 | 10 | 6/0 | Do. 6 per Cent. Cumulative 1st Pref. | 12 | 12½ | 12½ | 12¾ | .. | " " | .. | .. |
| 15,000 | 10 | 4/9¾ | Do. 6 per Cent. Cumulative 2nd Pref. | 9½ | 10½ | 9½ | 10½ | 5 14 3 | " " | .. | .. |
| 209,750 | 1 | .. | South of England, Ordinary | [illegible] | [illegible] | [illegible] | [illegible] | .. | .. | .. | .. |
| 20,000 | 5 | 2/0 | Do. 6 per Cent. Cumulative Pf. (£3 10s. pd) .. | 2½ | 3 | 2½ | 3 | .. | .. | .. | .. |
| 58,000 | 5 | 1/0 | United River Plate | 3 | 4 | 3 | 4 | .. | January and July .. | .. | .. |
| 146,128 | Stock | .. | Do. 5 per Cent. Debenture Stock | 90 | 94 | 90 | 95 | 5 5 3 | .. | .. | .. |
| 3,200 | 100 | .. | Do. 7 per Cent. Debentures | .. | | .. | | .. | — | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | | | |
| 200,000 | £5 | .. | London Electric Supply | 2⅜ | 2⅞ | 2½ | 2¾ | .. | — | .. | .. |
| 43,900 | 10 | .. | Metropolitan Electric Supply (£8 paid) | 5½ | 6 | 6½ | 6¾ | — | .. | 6½ | 5¾ |
| 42,853 | 5 | .. | Westminster Electric Supply (£3 paid) | 2½ | 3 | 2½ | 2¾ | .. | .. | .. | — |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | | | |
| 63,416 | 3 | .. | Brush Electrical Engineering | 1¼ | 1¾ | 1¼ | 1¾ | .. | .. | 1½ | — |
| 63,416 | 2 | 0/10 | Do. 6 per Cent. Preference | 1½ | 2 | 1½ | 2 | 6 0 0 | June and December | 1¾ | .. |
| 20,000 | 5 | .. | Crompton and Co., 7 per Cent. Pref. Shares | 5½ | 5¾ | 5½ | 5¾ | 6 1 9 | January and July .. | .. | .. |
| 17,130 | 5 | .. | Edison and Swan United | .. | | .. | | .. | .. | .. | .. |
| 45,000 | 10 | 6% | Electric Construction | 7¾ | 8½ | 8 | 8½ | 7 1 2 | .. | .. | .. |
| 70,000 | 2 | 10/0 | Elmore's Patent Copper Depositing | 4¼ | 4¾ | 3½ | 4 | .. | .. | 8½ | .. |
| 20,000 | 5 | .. | Fowler-Waring Cables (£4 paid) | 2½ | 3½ | 2½ | 3½ | .. | .. | 5¾ | 4 |
| 41,600 | 10 | 10/0 | India Rubber, Gutta Percha & Telegraph Works... | 18 | 19 | 18 | 19 | 5 5 3 | February & August | 18¾ | 18½ |
| 200,000 | 100 | 4½% | Do. 4½ per Cent. Debentures, 1896 | 100 | 102 | 100 | 102 | 4 8 3 | March & September | .. | .. |
| 78,949 | 5 | 6% | Swan United (£3. 10s. paid) | 5 | 5½ | 5 | ½ | 3 16 5 | May and November | 5½ | .. |
| 37,350 | 12 | 12/0 | Telegraph Construction and Maintenance | 43 | 45 | 43 | 45 | 5 6 8 | March and July | 44½ | .. |
| 150,000 | 100 | 5% | Do. 5 per Cent. Bonds, red. 1894 | 100 | 102 | 100 | 102 | 4 18 0 | January and July .. | .. | .. |



# BEFORE ORDERING!

## ELECTRICAL PLANT & ACCESSORIES

WRITE FOR THE FOLLOWING PAMPHLETS TO THE

(Statter's) ELECTRICAL ENGINEERING CORPORATION, Ld. (United)

PLANT WORKS: WEST DRAYTON, near LONDON.
FITTINGS WORKS: ALBERT WORKS, 36, ALBERT EMBANKMENT, S.E.
LONDON OFFICES: 3, PRINCES MANSIONS, VICTORIA STREET, WESTMINSTER.

"ELECTRICAL DISTRIBUTION."—Commercially considered, with Estimates.
"MACHINE DRIVING BY ELECTRICITY."—The Uses of Electro-Motors for Traction and Stationary Purposes.
"THE TELPHER SYSTEM OF CHEAP TRANSPORT," for Minerals, Goods and Passengers.
"ELECTRICAL SUPPLIES."—Prices and Particulars of the most approved Electrical Appliances

ELECTRICAL PLANT ON VIEW.


Digitized by Google

# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 654.—Vol. XXVI. FRIDAY, NOVEMBER 28, 1890. Price Fourpence.

## NOTES.

If a brilliant reception, followed next evening by an equally successful banquet, can compensate for the labour they entail, the President of the Institution of Electrical Engineers may congratulate himself on having signalised his year of office in an altogether satisfactory manner. The attendance at the former was unusually numerous, and the speeches at the latter were exceptionally encouraging, showing as they did the profound and intelligent interest taken in the welfare of the Institution, even by public men removed from the sphere of its professional influence. Much is evidently expected of it, and the present is regarded as a critical moment in the affairs of electrical science and industry.

A sample of the cable which has been made in accordance with the Board of Trade Regulations has been kindly sent us by Mr. Crompton, together with a sample of a "medium" pattern which is offered as a compromise, and which it is suggested should not be exceeded, and a sample of an ordinary cable which experience has shown to be thoroughly suitable for the purpose. We have prepared some illustrations, which will be found on another page, in order to give our readers some idea of the result of designing a cable with the paternal motive of "the protection of the public safety," and of prescribing the adoption of it without ever seeing a sample. The description of the insulation is as follows: "A thickness of not less than one-tenth part of an inch, and in cases where the extreme difference of potential in the circuit exceeds 2,000 volts, the thickness of insulation must not be less in inches, or parts of an inch, than the number obtained by dividing the number expressing the volts by 20,000. This insulation must be further efficiently protected on the outside against injury or removal by abrasion." This verbal description does not at first sight appear to be preposterous, and it was solemnly approved by a committee of the Council of the Institution of Electrical Engineers who saw neither a drawing nor a sample. If an illustration had been submitted, it is probable that, although there were only two engineers among them, some objection would have been raised: but the ridiculous character of the cable can only be judged by handling a sample.

Mr. Crompton strenuously opposed the rule, but he could hardly be expected to stand up against the Board of Trade and win the case off his own bat. The Electrical Trades Section of the London Chamber of Commerce addressed a letter to the Board of Trade without avail. Experiments were carried out at Chelmsford by Major Cardew with the cables proposed by Mr. Crompton, and to those who were present the results appeared striking enough to convince the scientific adviser to the Board that the proposed modifications were of a reasonable character, but they were grievously disappointed to find that the Board of Trade declined to yield, and that no relaxation would be permitted. The Council of the London Chamber of Commerce have now taken up the matter as being one of general trade importance, and we hope that their influence, together with the memorials of the four principal companies who are interested in the matter, will succeed in obtaining a compromise, both in the insulation of aerial cables and of the rule relating to bearers.

The two cases reported in our "Legal Intelligence" this week both turn on the absence of any written agreement between the supply company and the consumer. The one case, however, was won by the former, the other by the latter. It was no doubt very annoying to the well-known firm of drapers in Regent-street to have their light cut off without notice, even though it was being supplied on sufferance by a company who had no powers in that district; but, in pleading that "the gas injured the stock, and made the premises dirty," that "their goods became greatly damaged," and that to the absence of the electric light they attributed a "serious effect" on their business and goods, they give an admirable "unsolicited testimonial" to the benefits of the illuminant with whose purveyors they have quarrelled. They had neglected to agree to the form of contract which had been sent to them by the defendant company, and the result should be a warning to those who are relying on verbal arrangements for their supply.

The second case discloses two points of interest. First, the price per annum for a 10 candle-power lamp, the charge of £1 being said by the counsel for the plaintiff company to be "considerably under the market value of the current supplied;" second, the fact that after a meter has been fixed, the consumer declined to pay, presumably, because the charge was higher than before. We do not hear that the instrument was accused of that inherent prevarication which an experience of three-quarters of a century has attributed to the gas meter. A simple calculation shows that at 7¼d. per unit, a supply of about 1,000 lamp-hours of a 32 watt lamp may be purchased for £1. This is equiva-

Digitized by Google

lent to lighting from dusk until 9 p.m. all the year round, and since, we may presume, that the members of the Pall Mall Club do not retire to rest at this hour, the assertion of the counsel was well founded. In the lighting of a club, nearly the whole of the lamps are in use every night, and a contract for such a supply might be based with tolerable accuracy on a table of the hours of lighting, due allowance being made, from experience, for fogs. The lighting of dwelling-houses is of course of another character, and we have somewhat contradictory information on this point. The earning power of each lamp wired is very different in different localities, depending, as it does, not only on the proportion of the lamps wired to the maximum number in use at any time, and the mean number of lamp-hours per day, but also on the manners and customs of the consumers.

Among the numerous mathematical processes devised expressly for the investigation of physical phenomena, there is, perhaps, none the value of which to the physicist in general, and to the electrician in particular, is so misunderstood as that due to the genius of Laplace, and to which the name of Spherical Harmonic Analysis has been given by Sir William Thomson. To the physicist or electrician of moderate mathematical attainments, the very name Spherical Harmonic acts as a sort of scarecrow, recalling to his mind only a difficult chapter of Maxwell, or a still more difficult one in Thomson and Tait's great treatise. The treatment of the subject in the latter work is indeed quite beyond the comprehension of any but advanced mathematical students, and even to the majority of these it is difficult. Ferrer's excellent little treatise on the subject is unfortunately as yet almost unknown except to the professedly mathematical student, though it is by no means difficult, and would be easily apprehended by many who are needlessly frightened at the name.

For these reasons we would direct the attention of our mathematically-inclined readers to Professor Perry's recent communication on this subject to the Physical Society, of which an abstract appears in another column. Professor Perry has, in the first place, drawn up a table which we hope he will be able to extend considerably, of the numerical values of the Zonal Harmonics of the first few degrees. The Zonal Harmonic is the simplest and at the same time the most useful of the functions known as Spherical Harmonics, as it is the form applicable to all problems in which the conditions are symmetrical about an axis. It is a function merely of the angle made by the radius-vector of a point with this axis, and Professor Perry has calculated the values to four place of decimals for each angular degree from 0 to 90 degrees. The table even in its present restricted form will be of the greatest value to all who find occasion for making calculations with these functions, and we hope the author will see his way to having them introduced into some of the books of logarithmic and other mathematical tables in common use. The tabulation of these functions will enable them to be used in calculations as easily as the trigonometrical functions of angles; and if this is insufficient to make the name Spherical Harmonic no longer a kind of bogie to the practical electrician, we have the further interesting and most pertinent fact that Professor Perry has so completely succeeded in making the elements of Spherical Harmonic Analysis comprehensible to the classes of students at the Technical College, Finsbury, that they are not only interested in it, but perfectly able to make use of it in obtaining numerical solutions of numerous problems of importance to the electrical engineer.

The word of caution which will be found in our correspondence columns with regard to magnetic materials in laboratories is worthy of attention, and to the unsuspected cause of variations of temperature of pipes and stoves may be attributed the unaccountable behaviour of magnets which is often observed during delicate investigations. Permanent magnets are generally sufficient to control the terrestrial magnetism in the neighbourhood of a given point; but if it were desired to neutralise the greater part of a room, it would only be necessary to run a wire or cable two or three dozen times round the room in a plane perpendicular to the dip, and through it pass a current, giving a few hundred ampere turns.

**The British Guiana Cable.**—The cable between Trinidad and Demerara is at present interrupted.

**Correction.**—On page 75 of our last issue, after the word product, on the fifth line, the words "of a current" were accidentally omitted.

**The Electro-Harmonic Society.**—The next concert (Ladies' Night) of this Society will take place on Monday, December 8th, instead of, as is customary, on a Friday.

**International Telegraph Bureau.**—Dr. Rothen, hitherto Director of Swiss Telegraphs, has been appointed Director of the International Telegraph Bureau at Berne, in the place of the late M. Frei.

**Llanelly.**—It was unanimously decided at the last meeting of the Local Board that an application be made to the Board of Trade for an order authorising the Board to supply electricity for public or private purposes within the area of their district.

**Electrical Trades Union.**—All members are urgently requested to attend headquarters on Saturday, November 29th, at eight p.m., for the purpose of electing and instructing the delegates for the forthcoming convention to be held in Liverpool, on December 6th.

**University College, Dundee.**—In consequence of Prof. Ewing's election to the chair of engineering at this College, the Professorship of Mechanism and Applied Mechanics in Cambridge University will shortly be vacant. Further particulars will be found in our advertisement columns.

**The Patten Multiplex Telegraph.**—We hear that the multiplex telegraph devised by Lieutenant Patten, a description of which appeared in *The Electrician* of August 22, 1890, is working 16 circuits on a wire running between New York and Philadelphia, a distance of about 90 miles, at twenty-five words a minute.

**Reduction of Telephone Rentals.**—It is announced that the annual rate of subscription to the Bradford Exchange of the National Telephone Company will be reduced on and after New Year's Day from £15 to £10 for a connection within one mile of the Exchange. The trunk line tariff will also be revised at the same time.

**Frankfort Exhibition.**—Our German Correspondent informs us that the storms of Monday last greatly injured the machinery hall of the Frankfort Exhibition. The hall was of solid construction, and completed up to the cupola. Nobody was hurt. The contractor hopes to have repaired the damage done within four weeks.

Digitized by Google

**The Paris Electricity Meter Competition.**—The Conseil Municipal have nominated MM. Mascart, Potier, Hospitalier, Cochin, and Lyon-Alemand as members of the jury which is to examine the electricity meters sent in to compete for the municipal prize of £400 offered for the meter "giving complete satisfaction and equally applicable to alternate or continuous currents."

**National Telephone Electrical Society.** — The first meeting of the session of the Midland Branch of this society was held at Birmingham, on Friday evening last, when the president, Mr. Coleman, M.I.E.E., delivered an interesting address on "Telephony at the Present Time." There was a large attendance, members from Derby, Coventry, Kidderminster, Walsall, and Wolverhampton being present.

**Telephonic Appointment.**—Mr. A. R. Bennett, whose resignation from the National Telephone Company we had occasion to chronicle in August, has accepted a three-years' engagement with the Mutual Telephone Company as their general manager and chief engineer. We understand that Mr. Bennett, whose headquarters will be in London, has reserved the right to practise also as a consulting engineer and electrician.

**Glasgow Tramway Company.**—A petition was recently presented to the Court of Session, Edinburgh, by the Glasgow Tramway Company for sanction to an alteration of its Memorandum of Association, to the extent of allowing it to carry on omnibus traffic, carry mails, work the cars by electricity or steam, and to increase its capital by £150,000. Intimation to the magistrates of Glasgow was ordered, and answers in eight days.

**Glasgow and West of Scotland Technical College.**—The gold medal for electrical engineering presented annually by Sir John Pender, K.C.M.G., through Prof. Jamieson, to the Glasgow and West of Scotland Technical College, has been gained by Arthur H. Allen, who, besides taking the first place in all his College classes, took the first place with first class honours at the Science and Arts public examinations, and first class honours at the City and Guilds of London Institute technological examinations.

**New Telegraph Line between Berlin and Rome.**—Telegraphic communication between Germany and Italy is to be improved by the construction of a third line between the two capitals. The line will pass through Bavaria and the Tyrol, instead of through Switzerland, as the existing lines do. Its length will be 1,210 miles, and it will consist of 3mm. bronze wire. According to the *Elektrotechnische Zeitschrift*, this is the first line from Germany to any foreign country in which bronze wire has been employed.

**Glasgow.**—By the instruction of the Corporation Special Committee on Electric Lighting, Mr. Foulis, the Gas Manager-in-Chief, has just compiled a report on data which he has collected regarding about 40 electric lighting undertakings throughout the kingdom—both corporation and company concerns; and it is expected that the committee, at their next meeting, will take some further action, based on the report, and on the "expert" report which was obtained from Mr. R. E. Crompton some months since.

**Madrid.**—On Saturday night, during a performance at the Comedia Theatre, Madrid, before a full house, an alarm of fire was raised, and almost immediately the theatre was in complete darkness. It was, however, found that the fire was confined to part of the wings of the stage, and was of little importance, and the audience vacated the theatre quietly and without accident. The origin of the fire appears to have been the accidental short-circuiting of two imperfectly-covered wires, causing them to ignite some light canvas in the side scenes.

**Electric Light Mains in Paris.**—At a recent meeting of the Conseil Municipal four of the electric light companies petitioned for the prolongation of their concessions to 1930. The petitions were referred to a Committee. A member of the Conseil then asked that the companies should be requested to suspend their underground main laying operations until after the New Year, and was informed that the usual regulations suspending such work from December 15th to January 15th would be enforced. It was also intimated that measures had been taken to oblige the companies to carry out their operations in future in a more methodical manner.

**Australian Cable Rates.**—The Government of Victoria has decided to propose to the Legislature the adoption of the cable guarantee required by the telegraph companies to enable them to put into force the projected reduction of rates. The Government of Western Australia has likewise agreed to take similar action. It is also probable that New South Wales and South Australia will join in the guarantee. It is now the prevalent opinion here that the reduced rate will be brought into force from the commencement of next year, irrespective of the fact that the colonies of Queensland and New Zealand have declined to bear their share.

**Ice on Trolley Wires.**—With a view of preventing the adhesion of any considerable amount of sleet or ice to trolley wires, a Mr. Whittlesey, of Lynn, Mass., proposes to grease the conductor. The apparatus consists of a pan attached to the ends of the journal of the trolley itself. Inside the receptacle is a wheel. This grooved wheel is made of wood or hard rubber, and is covered with thick felt, so as to be adapted to carry up and smear upon the wire against which it presses the contents of the pan. When a semi-liquid substance is used for coating the conductor, an endless belt or chain may be passed over the wheel to assist in carrying up the grease.

**Electrical Testing Stations.**—At the last meeting of the London County Council, the Highways Committee recommended, and it was agreed, that the Parliamentary Committee be instructed to insert in the Council's General Powers Bill of next Session a clause giving the Council power to require any Electric Lighting Company to supply electrical energy to the Council's electrical testing stations, even if the station for which the supply is required be beyond the limits of the company's area of supply, and authorising such company, subject to the usual notices, to break up streets for the purpose of laying the mains necessary to afford such supply to the testing stations.

**Lagging for Steam-pipes.**—According to the *Revue Industrielle*, some of the waste products resulting from the manufacture of paper furnish excellent material for cheap and efficient lagging for steam-pipes. The waste products in question are chiefly those coming from the different cleaning and sorting machines, and which are of a fibrous nature. These, when dry, are to be mixed with potter's earth in the proportion of four to one, enough water being afterwards added to form a plastic compound. This is spread by hand over the surfaces to be protected in thin successive layers. When dry, the coating is said to adhere firmly, and is not easily broken. Its cost is practically no more than the cost of mixing and applying it.

**City and South London Railway.**—A number of trains, each consisting of an electric locomotive and three carriages, have been running regularly for some days on this railway in order to educate the staff in the working of the electrical plant, the hydraulic lifts, and other matters which are peculiar to the undertaking. It is expected that the final inspection of the Board of Trade will take place within a few days, and that the line will then be open to the public. On Monday, the 24th inst., Prince Hermann of Saxe-Weimar privately visited the railway. We understand that the announcement that the trains would commence running on this line on the 26th inst. was entirely unauthorised, and that no date has as yet been fixed.

**Agglomerate for Leclanche Cells.**—The *Bulletin International de l'Electricité* gives the following recipe for the manufacture of agglomerate for use in Leclanché cells:—

| | |
|---|---|
| Binoxide of manganese ... ... ... | 40 per cent. |
| Graphite ... ... ... ... ... ... | 44 ,, |
| Tar ... ... ... ... ... ... ... | 9 ,, |
| Sulphur ... ... ... ... ... ... | ·6 ,, |
| Water... ... ... ... ... ... ... | ·4 ,, |

This mixture must be reduced to fine powder, then compressed and heated to about 350° C. The heating drives out the water and most of the tar. Some of the sulphur combines with the volatile products of distillation, and the rest combines with non-volatile residue.

Digitized by Google

**Edinburgh Exhibition.**—At a recent meeting of the Finance Committee of the Dundee Town Council letters were read from the liquidator for the Edinburgh International Exhibition and the agents of the British Linen Company Bank, each claiming payment of the £200 which the Corporation agreed to subscribe towards the guarantee fund of the exhibition. The committee, in view of the whole circumstances, resolved to object to the Corporation being included in the list of contributors. It is understood that the foreign exhibitors are about to raise an action against the Exhibition Association to ordain the latter to deliver diplomas and medals awarded to them. They hold that medals in gold, silver, and bronze, as well as diplomas, were promised, but have not been given.

**City and Guilds of London Institute.**—The prizes gained by the students of the City and Guilds of London Institute were distributed by Lord Cross, at the Clothworkers' Hall, on Wednesday evening. The Lord Mayor presided, and among those present were Sir F. Bramwell, Sir S. Waterlow, Sir F. Abel, Sir P. Magnus, Prof. Unwin, and Prof. Thompson. Lord Cross having handed the prizes to the winners, said that the Clothworkers' Company had not been behindhand in furthering the question of technical education, for so long back as 1783 there was a conference called in that hall on the subject. Last year upwards of 12,000 students, mostly artizans, were taken into classes under the auspices of the City and Guilds of London Institute, and of these 6,000 presented themselves for examination and nearly 3,000 passed. He congratulated the Institution upon the exertions it had made.

**Safety Device for Overhead Wires.**—A simple but ingenious safety device has been brought out in America to immediately earth any overhead wire that may break, and thus render it harmless. It is principally intended to be used in connection with trolley wires, but it can, of course, be applied to any electrical wire. The device consists of a length of wire, one end of which is attached to the pole and thence to earth, and the other end to the trolley conductor. The wire is divided in the middle and enclosed in a weather-proof box, flat discs being fixed to the divided ends, which are kept apart by the tension of the wire. Should the trolley conductor snap, a strong spring inside the box causes the flat discs to come in contact and thus place the line to earth. Some such contrivance is apparently much needed in the States, where accidents due to persons coming into contact with the ends of live wires are frequently occurring.

**Royal Society.**—The anniversary meeting of the Royal Society will this year be held on Monday, December 1st. The medals are to be given as follows:—The Copley Medal to Prof. Simon Newcomb, for his contributions to gravitational astronomy; the Rumford Medal to Prof. Heinrich Hertz, for his work on electro-magnetic radiation; a Royal Medal to Prof. David Ferrier, for his researches on the localisation of cerebral functions; and a Royal Medal to Dr. John Hopkinson, for his researches in magnetism and electricity; the Davy Medal to Prof. Emil Fischer, for his discoveries in organic chemistry; and the first Darwin Medal to Mr. A. R. Wallace, for his independent origination of the theory of the origin of species by natural selection. The anniversary dinner will take place at the Hotel Métropole.—Among the Papers down for reading yesterday before the Royal Society was one by Messrs. G. J. Burch and V. H. Veley on "The Variations of Electromotive Force of Cells consisting of Certain Metals, Platinum, and Nitric Acid."

**A Charge Indicator for Accumulators.**—At a recent meeting of the Société Internationale des Électriciens, M. Gaston Roux described a form of direct-reading charge indicator devised by him for use with accumulators. The apparatus is based on the fact that within certain limits the density of the electrolyte varies according to the quantity of electricity stored in a storage cell in a chemical form. Experiments carried out by M. Roux show that the temperature correction is entirely negligible between 0°C. and 30°C. M. Roux employs a long cylinder reaching nearly to the bottom of the cell in order to take into account the want of homogeneity of the liquid. This cylinder is hung from the end of the short arm of a small lever, which should be horizontal when the cell is fully charged. On the same axis as the lever, and on the same side as the cylinder, there is arranged at an angle of 45deg. with the lever a small rod, along which a small weight can be screwed. On the long arm of the lever there is also an adjustable weight. At right angles to the lever there is a long pointer moving over an equally-divided scale. When the cell is discharged to its working zero, the pointer is brought to the scale zero by adjusting the weight on the long arm of the lever. When the cell is fully charged the pointer is brought to 100 by adjusting the weight on the rod fixed at 45deg. with the lever. The instrument being thus adjusted for a particular cell the percentage state of charge of that cell at any moment is seen from the position on the scale occupied by the pointer. An instrument such as this should prove of considerable use in an isolated installation, where a storage battery is left in the hands of an unskilled attendant.

**New Cable.**—The laying of the Great Northern Telegraph Company's new cable between Newcastle and Gothenburg, which was begun on the 16th inst., was successfully completed on Saturday last, and the cable was immediately opened for correspondence. This new cable has been manufactured by the Telegraph Construction and Maintenance Company, and is about 550 miles long, and will bring the number of telegraph cables landed by the Great Northern Company on our shores up to five. Of these the one between Scotland and Norway is landed at Peterhead, and worked from the Great Northern Station at Aberdeen, while the remaining four are landed at Newbiggin, and worked from the Company's station at Newcastle. The development undergone during the last 20 years by the traffic passing through Newcastle becomes apparent when comparing the number of telegrams exchanged with the Scandinavian countries in 1889 as against 1869. In 1889 there were sent to Denmark 156,000 telegrams, as against 28,000 in 1869; to Sweden 155,000, as against 24,000 in 1869; and to Norway 188,000, as against 33,000 in 1869. In spite of this great increase of work the Company has managed to reduce the time of transmission to about one-fourth of what it used to be. Messages from Copenhagen now reach the Quayside within one hour after they have been handed in at Copenhagen. The laying of the new North Sea Cable is the more commendable when it is borne in mind that at the late Telegraph Conference at Paris the Company agreed to reduce their rates to Denmark and Norway by ½d., and to Sweden and Russia by 1d. per word, although only four years ago, at the Berlin Conference, the rate to Russia was reduced from 9d. to 6½d., making a total reduction of about 50 per cent. within five years.

**Magnetic Rocks and Ships' Compasses.**—The following extract from a letter of Profs. Rücker and Thorpe, which appeared in *The Times* of Friday last, may be of interest:—

As it has been suggested that the loss of Her Majesty's ship Serpent may have been due to a deviation of the compass caused by magnetic rocks, we think your readers should be warned that such an explanation should only be accepted after rigorous proof. In the first place, it must be borne in mind that ordinary iron-stone is not magnetic. Metallic iron and the magnetic oxide are practically the only substances which could affect the compass to an appreciable extent. Large disturbances generally occur in the neighbourhood of basalts, gabros, and the like, throughout which magnetite is scattered in a more or less finely divided state. Such rocks are plentiful on the west coast of Scotland, and on the island of Canna there is a cliff named Compass Hill from the great effect which it produces on the magnet. . . . We have made a special study of the magnetic properties of this island, and can confirm the statement that its basaltic cliffs are powerfully magnetic. The needle of a compass placed near them may be deviated by two points. The effect, however, diminishes very rapidly with the distance, and is inappreciable on a ship's compass 200 yards from the base of the hill to which tradition ascribes, and in which we have ourselves detected, the most powerful magnetic properties. We have tested this on more than one occasion. In particular, in 1889, we approached the island from the north. The course was magnetic S. ½ E., a direction most favourable for the detection of the effect of Compass Hill. We passed it within 200 yards of the shore, but observed no effect on the compass. . . . . . Nowhere in the United Kingdom have we discovered a disturbance which extends for a mile, and also produces throughout that distance a constant deviation of the compass of as much as a couple of degrees. While, therefore, it is difficult to assign any limit to what might occur in an extraordinary and special case, and while we believe that there are some well-authenticated instances of magnetic rocks affecting seriously the compasses of ships in their immediate neighbourhood, the greatest caution ought to be exercised in accepting any such instance as proved. It is contrary to general experience that intense local magnetic disturbances should also be far-reaching.

Digitized by Google

## MAGNETISM IN IRON AND OTHER METALS.*—XXXVI.

BY PROF. J. A. EWING, F.R.S.

(*Continued from page 77.*)

§ 129. **Influence of Vibration on the Effects of Stress.**—These indications of hysteresis disappear almost entirely if we submit the piece under test to mechanical vibration either during or after the changes of load. As modified by vibration the curves for loading and unloading become nearly coincident. The whole amount of magnetic change is increased. A maximum point is still found, which lies, as regards load, between the two maximums that are observed when the processes are gone through without vibration. Tapping the wire at any stage in the process produces, in general, a large change in its magnetism; but if loading or unloading is then resumed, without further tapping, the presence of hysteresis is at once conspicuous. Fig. 111 illustrates the influence of vibration, by showing the curves got by repeated loading and unloading of an iron wire, suspended in a weak magnetic field, first without vibration, and also with smart vibration before each reading of the magnetometer was taken.

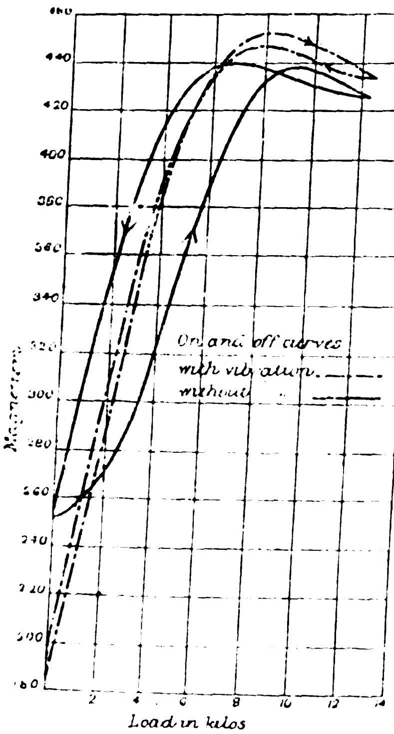



FIG. 111.—Influence of Vibration on Effects of Loading and Unloading

§ 130. **Effects of Loading Annealed Iron.**—On applying loads to an annealed iron wire, hanging in a magnetic field, we find at first the same extreme sensitiveness, the result of molecular instability. Repetition of the loading, if repeated often enough, brings about a cyclic state in which there is much less total change of magnetism than is found in the corresponding experiment with hardened metal. As to the character of the change, it depends on the magnitude of the load. With a sufficiently light load, loading produces increase and unloading produces decrease of magnetism; with a moderately heavy load these effects are reversed.†

§ 131. **Effects of Longitudinal Stress in Cobalt.**—Sir W. Thomson, testing a cobalt bar hung vertically in the earth's magnetic field, found that pulling decreased and relaxing the pull increased the induced magnetism. The effects of longitudinal pressure on the magnetisation of cobalt have been examined by Mr. C. Chree,* who found a reversal of effect, as the magnetisation was increased, resembling the Villari reversal in iron, but *opposite* to it in character. In iron, as we have already seen, after the first effects of stress are past, pressure will reduce magnetism in weak fields, but will increase it in strong fields. In cobalt the reverse happens; pressure increases magnetism in weak fields, but reduces magnetism in strong fields. This may be shown either by magnetising when the pressure is on, and again when it is off, or by applying and removing pressure while a constant magnetising force is in action. If the latter plan is followed, we have, of course, to exclude the initial effects, which, as Mr. Chree has pointed out, occur in cobalt as they occur in iron. The first application of pressure in weak fields causes a large increase of induced magnetism, just as, we may anticipate, the first application or removal of stress of any kind would do; but repetition of the process soon establishes a cyclic state.

The effects of longitudinal pressure in modifying the magnetisation curve of cobalt are illustrated in Fig. 112 (from an experiment by the writer and Mr. W. Low). The full lines are two curves of induced magnetism for a rod of cast cobalt, tested within a yoke without stress, and also with a comprehensive stress amounting to 16·2 kilogrammes per square millimetre. The broken lines are the corresponding curves of residual magnetism. The induced curves cross, illustrating the reversal described by Mr. Chree. The residual curves do not cross within the limits of field used here; but other experiments, made with the same rod but with heavier loads, show a crossing in them also. Curves of the permeability in terms of **B**, drawn from the data of the same experiment, have already been given in Fig. 42, § 76.

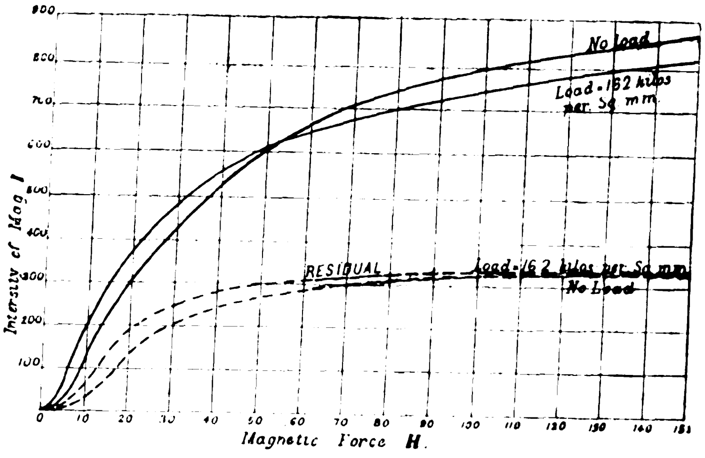



FIG. 112.—Induced and Residual Magnetisation of Cobalt with and without Compressive Stress.

§ 132. **Relation between the Effects of Stress on Magnetism, and the Effects of Magnetism in Changing the Dimensions of Magnetic Metals.**—In his book on "Applications of Mathematics to Physics and Chemistry" (p. 47, *et seq.*), Prof. J. J. Thomson has discussed this subject, and has pointed out that it is possible, from theoretical considerations, to predict the general character of the effects of stress from a knowledge of the changes of dimension caused by magnetisation. Mr. Shelford Bidwell, in a Paper which will be referred to later in more detail†, has shown that an iron rod lengthens when it is magnetised, provided the magnetising force does not exceed a certain limit, but shortens if the force does exceed that limit. Prof. Thomson shows that this reversal of effect is to be anticipated from the Villari reversal which is observed in the effects of longitudinal stress. Again, a nickel rod shortens when magnetised, and continues to shorten under high magnetic forces; this agrees with the fact that in nickel there is no Villari reversal, and that longitudinal pull diminishes the magnetism, whether that is weak or strong. Again, with cobalt Bidwell has found from

* All rights are reserved.

† For examples of the curves got by loading and unloading annealed iron see *Phil. Trans.*, 1885, plates 62 and 64. Many of the effects of stress, both in annealed and in hardened metal, will be found exhibited there, by means of curves, more completely than it is possible to exhibit them here. A few examples of the effects of *compressive* stress on the curves of I and H for iron will be found in a paper in the *Phil. Mag.* for September, 1888. The presence of compressive stress lowers the curve, as might be anticipated from the raising of it by tensile stress, shown in Figs. 103 and 105.

* *Phil. Trans.*, 1890, A, p. 329; *Proc. Roy. Soc.*, December 1889.
† *Phil. Trans.*, 1888, A, p. 205.

Digitized by Google

effects opposite to those found in iron, namely, that weak magnetisation shortens a cobalt rod and strong magnetisation lengthens it. Applying his equations to this result, Prof. Thomson anticipates what the character of the effects of stress in cobalt should be. Mr. Chree's experiments have verified his conclusions, by showing that the effects of stress in cobalt are the reverse of the effects of stress in iron, tension diminishing weak magnetism but augmenting strong magnetism.*

§ 133. **Residual Effects of Stress applied before Magnetising.**—Perhaps the most interesting of all the effects of stress are those that occur in unmagnetised iron. To apply and remove load before beginning to magnetise a piece of iron has been found to affect the magnetic susceptibility, even when the load is well within the elastic limit, and when the piece is perfectly free from magnetisation during application and removal of the load. We have, in fact, evidence that even in unmagnetised iron the process of loading and unloading causes changes of molecular configuration which are not reversible. These changes exhibit hysteresis with regard to the loads which cause them. They affect more than one physical quality of the metal; in particular, they produce an effect upon the magnetic susceptibility which becomes obvious when the piece is magnetised. These residual effects of past loads may be wiped out by subjecting the piece to the operation of demagnetising by reversals. They may also be wholly, or almost wholly, removed by tapping the piece smartly and so causing vibration.

Hence, in experiments designed to show the difference in susceptibility of iron or steel when subjected to different amounts of load, the piece should be passed through the operation of demagnetising by reversals after the load has been put on. This procedure was, in fact, followed in the experiments that have been described above.

The residual effects of these, occurring in the absence of any actual magnetisation, are of very great interest in their bearing on any theory of the molecular constitution of magnetic metals. One or two experiments may be cited to show their general character.†

Let an iron wire be subjected to pulling stress, and let the load be removed before beginning to magnetise. Then, provided the load which has been applied lies within the elastic limit, or is less than some load by which the wire has been previously stretched, we observe no mechanical change of any ordinary kind as the result of applying and removing the load. And if, before beginning to take a curve of magnetisation, we put the wire through the process of demagnetising by reversals, we shall find nothing in the curve to show whether there has or has not been any application of load before that. But suppose, after the process of demagnetising has been gone through, we apply and remove some load before beginning to magnetise. Though there has been no immediately obvious mechanical change, the wire has undergone a change of structure which shows itself in the form assumed by the curve of magnetisation. We find the magnetic susceptibility, especially under low forces, much greater in this than in the former case. The whole difference in procedure may be no more than this, that in one case the load is removed before the process of demagnetising is performed; in the other case, the process of demagnetising is performed before the load is removed. So slight a difference in procedure might, perhaps, be expected to have no influence on the form of the curve; in fact, however, it has a large influence. The curve of magnetisation depends not merely on the load actually present: it is affected, especially in its early portion, by any changes of load which have taken place since the preceding demagnetisation. For instance, it has been observed that if a curve be taken with (say) a pull of 3 kilos. on an iron wire, and if, after complete demagnetisation, the load be raised to 4 kilos. and 1 kilo. be removed, and a second curve be then taken, the second curve will differ very sensibly from the first, in spite of the fact that the wire may have previously held many times that amount of load, and was, therefore, in a mechanically stable state.

* See the introduction to Mr. Chree's Paper, *Phil. Trans.* 1890, A, p. 329.
† *Phil. Trans.*, 1885, Part II., pp. 612-619.

*(To be continued.)*

## DRUM ARMATURE WINDING.

BY F. M. WEYMOUTH.

*(Continued from page 73.)*

In Figs. 10 and 11 we find the method adopted by Edison of placing insulated metal discs *a a* at each end of the core, and of the same number at each end as there are segments in the commutator, and of the same outside diameter as the core. A few of the parallel bars only are shown. The two bars of a coil would thus at the pulley end be connected to the approximately opposite edges

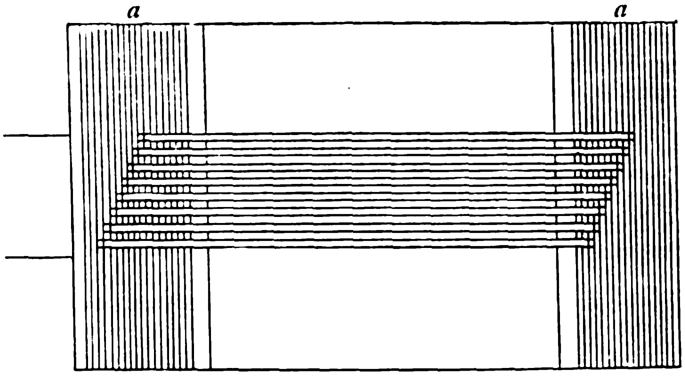



Fig. 10.

of the same insulated disc, while at the commutator end they would be jointed to separate discs. Fig. 11 shows one of these discs. A hole through the middle serves for the passage of the spindle and ventilation, and a tongue *b* shown across it, cut through at one end, is bent outwards parallel with the spindle for connection with a commutator segment. The four smaller holes *c c* are for the passage of insulated screws running parallel with the spindle by which the whole set of discs at one end are bolted to the end plate of the core.

This arrangement has the advantage of being compact, and has all the joints on the outside and accessible. Hence any burnt or damaged bars can easily be renewed singly without disturbing the remainder. By making the discs rather stout in proportion to the current they have to carry, their

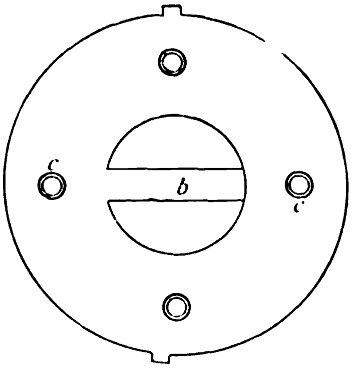



Fig. 11.

resistance can be kept low, and the tendency to heat obviated, rendering their ventilation not so necessary. The discs, however, are liable to the disadvantage of having a maximum difference of potential between any two that are adjacent; and will thus require more care as to their insulation from each other. A drawback, however, to using round discs is that these have to be stamped or cut out from sheet metal, involving waste of metal, beside extra cost in labour and use of machinery. It is a point as to whether or not this cost is counterbalanced by subsequent facility of construction. It will be noted that the bars are straight, and have no bends; but in both designs, however, as shown in Figs. 9 and 10, it will be observed that these are solid, and are liable to heat with Foucault currents.

The next example we may take is Messrs. Crompton and Swinburne's evolute end winding. This, as illustrated in

Digitized by Google

Figs. 12 to 17, will be seen to differ entirely from the foregoing. Fig. 12 represents an end view of the armature, Fig. 13 a longitudinal section, and Fig. 14 an outside elevation, all diagrammatic, and with a very open winding for the sake of clearness. It will be noted that alternate parallel bars run the full length of the armature, and are united to the commutator

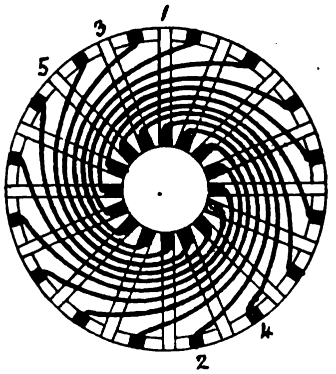



Fig. 12.—Crompton-Swinburne Winding. End view of Armature.

lugs at one end. The remaining bars are short, at least as to their straight portions, and we will for convenience call them so. A "long" bar and a "short" one opposite thus form the two sides of a coil. In Fig. 13 it will be seen that the short bars are cranked inwards towards the shaft, as shown at *a a*. At *b b* are sections through the evolute connections formed of

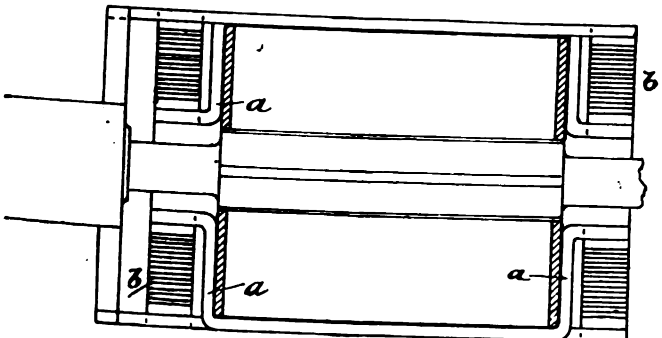



Fig. 13.—Crompton-Swinburne Winding. Longitudinal Section.

thin pliable copper strips, indicated more clearly in the end view, Fig. 12. Each of these, jointed at its interior end to the crank of a short bar is carried round in an evolute path till it reaches the desired long bar on the approximately opposite side, and there is jointed to it. Thus, referring to Fig. 12, the short bar 1 is connected by an evolute strip jointed to its cranked

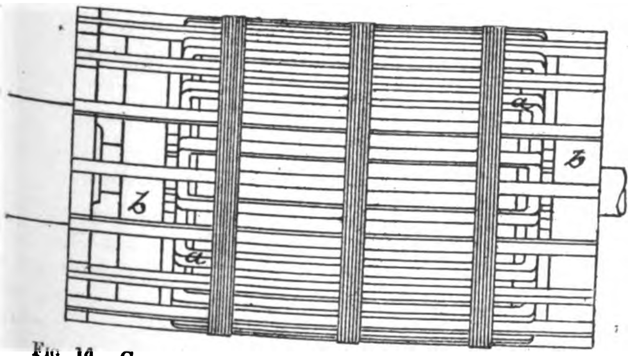



Fig. 14.—Crompton-Swinburne Winding. Outside Elevation.

end to long bar 2 opposite; this, at the other end of the armature, is similarly connected to bar 3, and 3 again to 4, and 4 to 5, and so on all round. It will be noted how the evolute connectors lie neatly within each other, though in practice they fit closely, separated only by mica or other insulation.

In the arrangement, however, as here shown, the cranked conductors, if burnt, cannot be removed without dismounting the whole winding, or a great part of it. Hence the modification shown (Fig. 15), where the crank is separately jointed to the turned-up end of the "short" bar, as indicated at *f*. By unsoldering these joints *f*, and also the joints *g* between the "long" bars and the evolute connectors, any single parallel bar can be removed. Further, by withdrawing the spindle (which can be done if the coil is carried on a spider, or otherwise self-contained apart from the spindle), the loose crank piece can be drawn in radially, its joint with the interior end of its connector unmade, when both can be removed singly. Thus any one, or a few sections, can be replaced without dismounting the remainder. The total number of joints is, however, increased. It will be noted that these bars are here

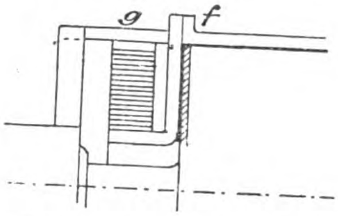



Fig. 15.—Crompton-Swinburne Winding.

all solid, and when single can only be used for small currents. For large currents double bars are used, as already described in connection with Figs. 4 to 7. In Fig. 16 is shown a modification to gain more room for the evolute connectors, the long bars being slightly cranked outwards. Thus far we have dealt

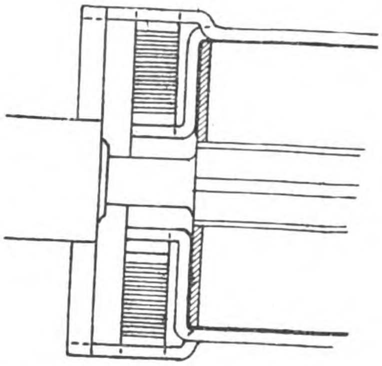


Fig. 16.—Crompton-Swinburne Winding.

with but a single turn per section. In Fig. 17 is shown the arrangement for two turns per section. It will be seen that there are two parallel series of evolutes; also, the cranks are alternately long and short to suit. In this case the connectors may be narrower and thicker than in the former arrangement; thus in the total mass there will be more copper and less

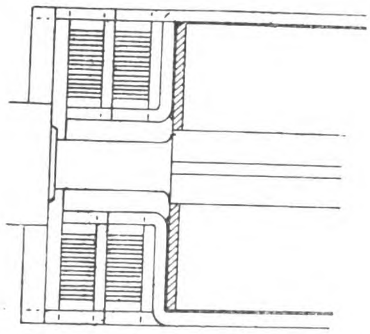


Fig. 17.—Crompton-Swinburne Winding.

insulation than when the curved plates are thin; and so space is economised. The spindle within the core is either of triangular or square section, with slightly rounded angles. The core is carried tight on the angles, its interior bore being grooved to fit these, and ventilation is thus allowed for along the flats. Sometimes a spider is used to carry the core, instead of its being built on the shaft direct.

*(To be continued.)*

Digitized by Google

## NOTES ON THE CHEMISTRY OF SECONDARY CELLS.*

By Professor W. E. Ayrton, Vice-President; C. G. Lamb, B.Sc., and E. W. Smith, Associates.

I.

In our paper on "The Working Efficiency of Secondary Cells," read at the meeting of this Institution in Edinburgh in July, it was stated that, "In spite of accumulators with actual accumulator plates in action. We are therefore now, with the assistance of Mr. Robertson, making a complete investigation of the chemical state of the plugs of both the positive and negative plates at all stages of the charge and discharge of an 1888 E.P.S. type of accumulator in good condition." The present paper contains an account of the results thus obtained.

The cell selected to remove the plugs from had the same size as the cells employed in the investigations described in the previous communication, and was one of the batch of 50

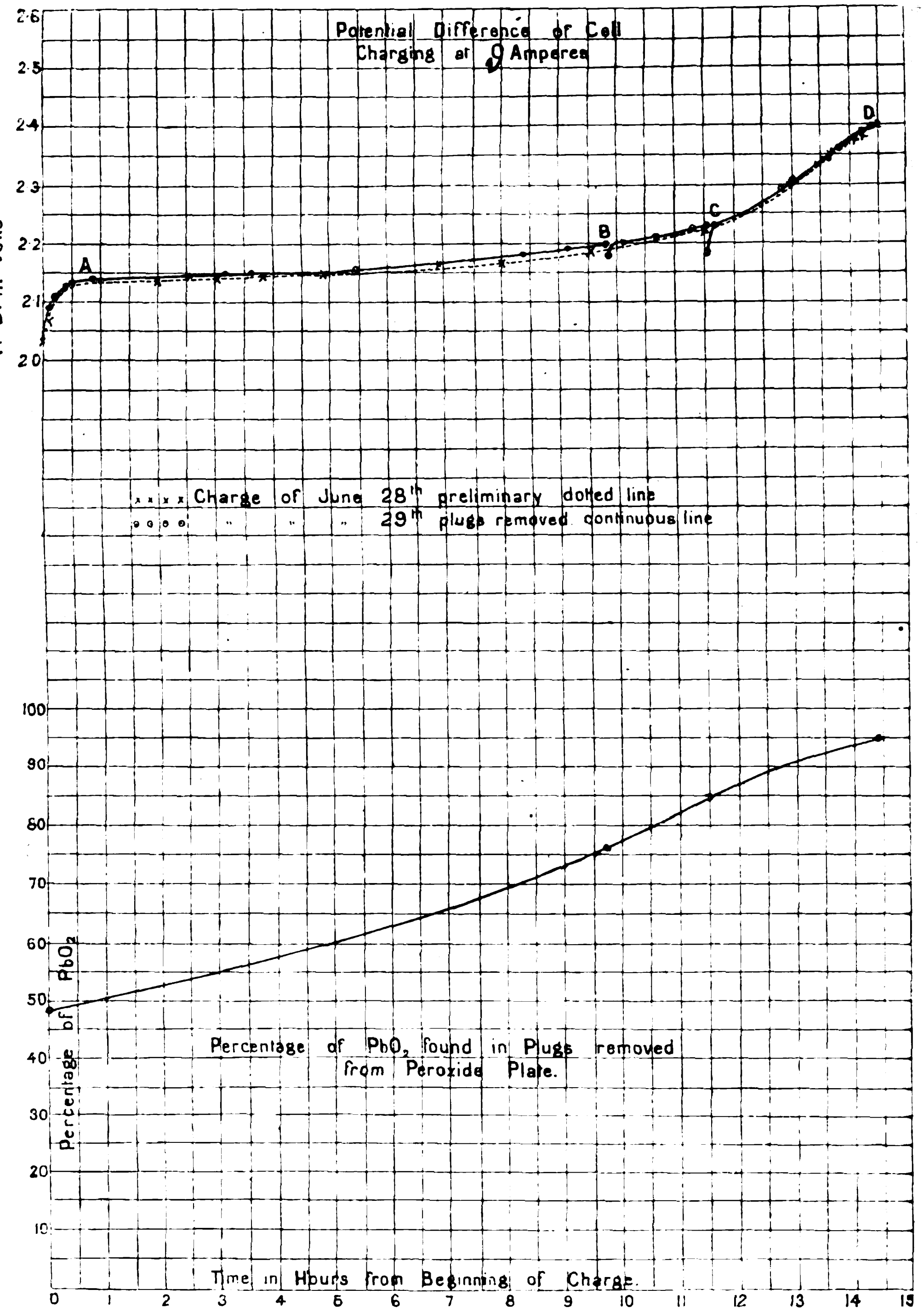



Fig. 1.

pasted plates having been in use now for nine years, the chemical action that takes place during the different stages of the charge and discharge has only been conjectured, and, odd as it seems, no decisive experiment appears to have been made to settle this much-debated question. Various analyses have been made by different chemists of salts of lead acted on in certain ways with sulphuric acid, but apparently not of purchased for the Central Institution about the middle of 1888. Since it first came into our possession it had never been overcharged, never been left discharged, nor permitted to send more than the maximum current allowed by the makers for cells of this size—viz., 10 amperes—and consequently, at the beginning of the present investigation in June of this year, this cell was in excellent condition.

First, the cell was several times charged with a current of 9 amperes, and discharged with a current of 10, without stopping

* Paper read before the Institution of Electrical Engineers on Thursday, November 13, 1890.

Digitized by Google

day or night, so as to bring it into what we have called its steady "working" state. The dotted curves, Figs. 1 and 2, show the large charge and discharge obtained on June 28th. During the next charge, indicated by the continuous curve, Fig. 1, plugs were removed from both the positive and the negative plates at the points marked A, B, C, and D, when the terminal potential difference of the cell was 2·134, 2·2, 2·234, and 2·4 volts respectively. In order to remove the plugs from the positive plates, these plates were bodily removed out of the liquid, but, to prevent oxidation, the negative plates were left on the curve; that is to say, the potential difference observed immediately after replacing the positive plates in the liquid and closing the circuit is plotted directly under the potential difference that was observed just before the circuit was broken, prior to the removal of the positive plates from the liquid.

We were afraid that the bodily withdrawal of the positive plates out of the liquid, combined with the removal of the plugs on the several occasions, would produce so great a change in the conditions of the cell as to render the potential difference curve quite discontinuous. It was, therefore, as interesting as

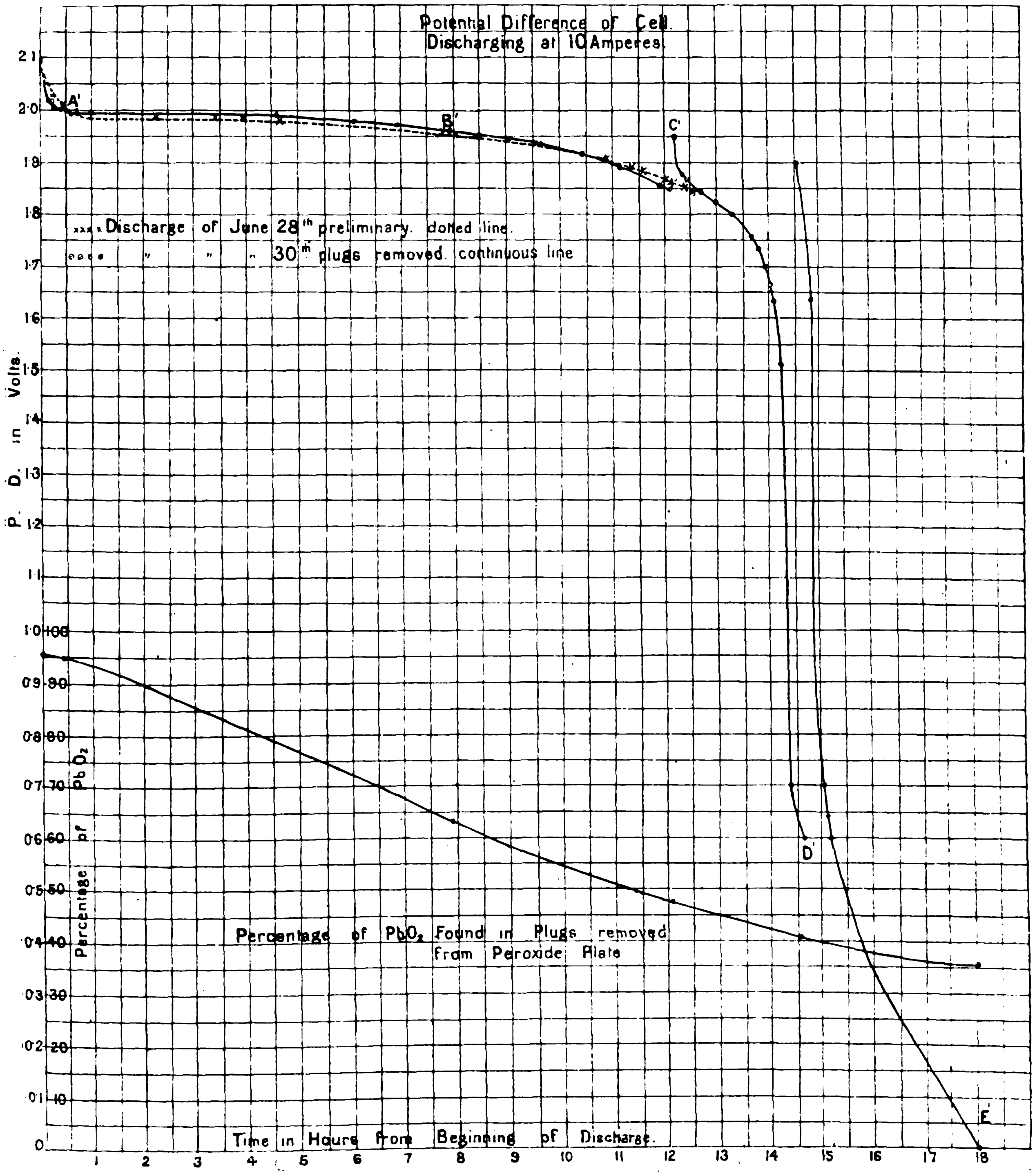



Fig 2.

in the liquid, and the plugs removed in a way that will be described later on. The time occupied in removing the plugs from the two sets of plates occupied about 15 to 20 minutes on each occasion. Immediately after the removal of the plugs the positive plates were put back in position in the cell, the resistance in the circuit rapidly adjusted, if necessary, to make the charging current exactly 9 amperes and the time variation of the potential difference at the terminals of the cell noted. The interval that elapsed while the current was broken is not shown it was unexpected to find that the terminal potential difference, on restarting the normal charging current of 9 amperes, rapidly acquired the value it had before the withdrawal of the plates; so that, with the exception of the rapid rise of the potential difference on restarting the charging current, the potential difference curve obtained on June 29th was almost the same as the potential difference curve obtained on charging on the previous day.

After the cell had been charged until the terminal potential difference reached 2·4 volts, it was immediately discharged with

a perfectly constant current of 10 amperes, and, as it was anticipated that the removal of the plugs would spoil the cell, it was allowed to discharge far below the normal limit. In previous discharges (the last one of which is shown by the dotted line, Fig. 2), the discharge was stopped when the terminal potential difference fell to 1·85 volts. But in the discharge on June 30th, when the plugs were removed the discharge current was kept at 10 amperes, by using auxiliary cells, until the E.M.F. of the test cell fell to nought, and even reversed. Plugs were removed from both the positive and the negative plates when the terminal potential difference was 2, 1·95, 1·85, 0·6, and nought volts, as indicated by the points A′, B′, C′, D′, and E′. The recovery of the E.M.F. on breaking the circuit was very marked, especially near the end of the discharge.

II.—Method of Obtaining Samples of the Plugs.

On the first removal of plugs corresponding with the point A (Fig. 1), a curved pointed glass rod was used, as shown in Fig. 3, with the idea of prising out the plugs; but by this method only the surface of the positive plugs could be removed, as they were much too hard to be loosened in this way. Indeed, one of the most striking things noticed in this investigation was the firm way in which the plugs were held in the plates of an E.P.S. cell that had been carefully used for two years. Before the next attempt was made to remove plugs corresponding with the

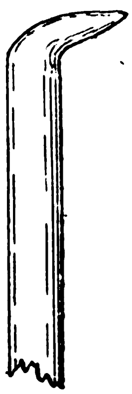


Fig. 3.

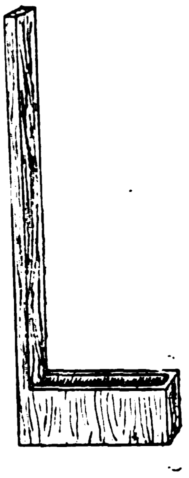


Fig. 4.

point B (Fig. 1), a straight piece of glass rod was pointed, and mounted in a wooden handle. This glass chisel was used to pierce and loosen the positive plugs, which were then driven bodily out of the grid by means of a hard wooden punch cut square to fit the holes in the grid, and which was tapped with a small mallet. The plugs on being driven out of the grid were caught in a long wooden scoop (shaped so that it could be just slipped in between the plates), and then washed by Mr. Robertson into wide-mouthed bottles containing 300 or 400 cubic centimetres of distilled water. As soon as the water cleared it was decanted off and fresh added.

As several glass chisels were broken, and the wooden punches worn down in the removal of the plugs, the method had the disadvantage of mixing with the specimens to be analysed splinters of glass and wood, which were found difficult to remove afterwards. On the other hand, the method had the advantage of enabling specimens of the positive plugs to be removed in a comparatively short time on each occasion from the top, the middle, and the bottom of the plates.

As the negative plates were never removed from the acid, the only way to remove the plugs was by working them loose under the liquid by means of long curved glass rods pointed at the end, and by catching the plugs in a narrow wooden scoop with a long handle, as shown in Fig. 4. It was possible to use this method throughout for the removal of the negative plugs, as they were softer and more easily removable than the positive ones. The scoop held sufficient liquid to enable the negative plugs to be dropped into wide-necked bottles containing water without the plugs being even momentarily exposed to the air. The water in these bottles Mr. Robertson had washed free from dissolved oxygen by previously bubbling hydrogen through it for a considerable time. After the negative plugs had been put into the bottles the water was gradually decanted off from time to time, and fresh added until the liquid in the bottle was quite free from acid.

Both in the case of the positives and the negatives the top samples were removed from the corner of the plates nearest the lug, and the bottom samples from the corner diametrically opposite, so as to obtain evidence, if possible, of any difference of current-density which might exist at different parts of the plates in charging and discharging.

The plugs from the top, the middle, and the bottom of each set of plates were at each of the removals of plugs put into six separate bottles, and, to avoid the possibility of error in their subsequent identification, there was noted on the label of each the character of the plates and the position on them from which the plugs were removed, the time, the potential difference, and the specific gravity of the liquid in the cell.

III.—Appearance of Plates at Removals of Plugs.

The following notes were made by Mr. Robertson and ourselves at the successive removals of the plugs:—

*Charging.*

| Positive Plates. | Negative Plates. |
|---|---|
| *Point A on Curve 1. Terminal Potential Difference,* 2·134 *volts. Specific Gravity of Liquid,* 1·178. | |
| The upper part of the plates had a greyish-brown colour, and presented the appearance of being coated with a very thin film of white sulphate. The lower part of the plates was of a reddish-brown colour. The plugs at the top were hard, while those at the bottom were quite soft. | The plugs at the top were the softest. |
| *Point B on Curve 1. Terminal Potential Difference,* 2·2 *volts. Specific Gravity of Liquid,* 1·198. | |
| The plates had entirely lost their whitish appearance, and showed a uniform reddish-brown colour, darker than the previous colour of the bottom of the plates. | The plugs both at the top and at the bottom harder than before, those at the top having hardened more than those at the bottom. |
| *Point C on Curve 1. Terminal Potential Difference,* 2·234 *volts. Specific Gravity of Liquid,* 1·201. | |
| The previous charges increased in amount. | The previous charges increased in amount. |
| *Point D on Curve 1. Terminal Potential Difference,* 2·4 *volts. Specific Gravity of Liquid* 1·206. | |
| The plates had the rich deep brown colour of lead peroxide, except where they were covered with the ebonite separators: there the colour was lighter. The plugs at the top were slightly the softest, while those at the bottom were much the same as at the beginning. | The plugs had a brilliant metallic lustre, and looked quite silvery when first removed from the plates. The plugs at the top were now the hardest. |

*Discharging.*

| Positive Plates. | Negative Plates. |
|---|---|
| *Point A′ on Curve 2. Terminal Potential Difference,* 1·998 *volts. Specific Gravity of Liquid,* 1·205. | |
| The plugs at the top were harder than those at the bottom. | The plugs had the brilliant metallic lustre observed at the end of the charging. |
| *Point C′ on Curve 2. Terminal Potential Difference,* 1·850 *volts. Specific Gravity of Liquid,* 1·180. | |
| The plugs had become much harder. | The plates had become decidedly white, and the plugs were white right through. |
| *Point D′ on Curve 2. Terminal Potential Difference,* 0·6 *volt. Specific Gravity of Liquid,* 1·175. | |
| The plugs had become extremely hard, especially at the bottom. | The plugs were somewhat softer. |
| *Point E′ on Curve 2. Terminal Potential Difference,* 0 *volt. Specific Gravity of Liquid,* 1·172. | |
| The plugs had become so hard that they splintered, and bits flew about on trying to remove them. | |

Digitized by Google

The bubbling of gas from the negative plates ceased when the terminal potential difference on discharging fell to 1·85 volts (point C′ on curve 2), and it began again when the terminal potential difference fell to somewhere near zero.

The following figures (5 and 6) give an idea of the way in which we found the hardness of the top and bottom plugs of the positive and the negative plates respectively to vary during a normal charge. The figures are not drawn to scale, as we had no standard of hardness beyond our sensations, hence the figures only profess to be qualitative sketches from which mental pictures can be obtained. Distance measured upways from O A indicates roughly the degree of hardness; distance measured downwards the degree of softness.

It will be seen that during the charging the variation in the hardness of the plugs is far greater at the top than at the bottom of the plates, and consistently with this fact Mr. Robertson's analyses show that, on the whole, the rate of chemical action at the top of the plates is greater than at the bottom. The difference in the hardness, however, is far more marked than the difference in the chemical action. For example, while the plugs

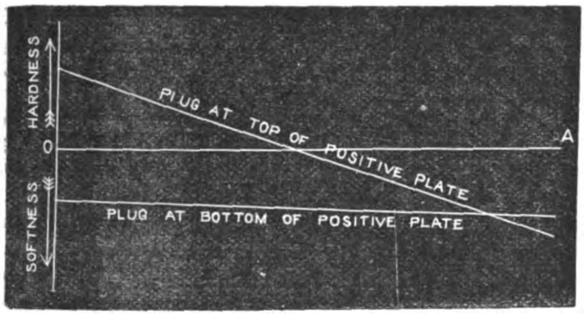



Fig. 5.

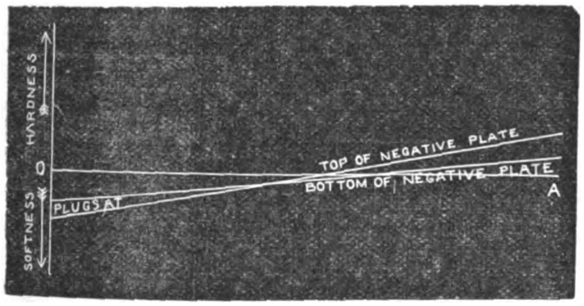



Fig. 6.

at the top of the positive plates are, during the earlier part of the charging, much harder than those at the bottom, no such striking difference is observable in the percentage of lead peroxide contained by these plugs. The cause of this we are examining experimentally at the present time.

*(To be continued.)*

## ON THE USE OF THE LANTERN IN CLASS-ROOM WORK.*

BY PROFS. BARR AND W. STROUD.

Prof. Barr described a lantern with inclined mirrors for projection of horizontal slides on which experiments could be performed on a small scale; and he described the practice of sketching on oiled ground glass.

At the Yorkshire College, Leeds, photographic lantern slides are used very extensively in teaching many different subjects. An assistant is employed in making slides, and 50 slides are frequently made per week. A very complete apparatus was exhibited for making slides from book and other illustrations. A frame or open box was arranged with a flat top. The book being opened, the page, on which is the illustration required, hangs down, while the other is laid face downwards on the top of the frame; the page thus lies quite flat. The camera is mounted on a slide on a long board, provided with a scale. The numbers on the scale, while arbitrarily denoting the distance of the camera from the picture to be copied, refer to the longest actual dimension of the illustration in inches. The body of the camera is also provided with a scale graduated similarly, and so arranged that when the pointers are adjusted to the same numbers the object is accurately focussed, without the use of a ground glass screen, and the image is exactly the right size for a lantern slide. The camera was mounted in a very ingenious manner on two pair of hinged boards, arranged at right angles and disposed similarly to the first pair of folds of a camera bellows on two adjacent sides. The parallel motion is excellently adapted for the purpose. One of the hinges is provided with a spiral spring, which approximately balances the camera at any height.

Such an apparatus has been in use for some time at the Yorkshire College, Leeds, and has led to a great development in the application of the lantern in class-room work; so much so, that not only in the science classes and the technical classes but even in the classes of classics, geography, and others the lantern is utilised.

* Abstract of Paper read before the British Association in Section A, Leeds, September, 1890.

DISCUSSION.

Dr. OLIVER LODGE said that he was much struck with the beauty of the arrangement which had been described. His practice was never to darken the room when using a lantern for projection. He used a very translucent screen of oiled silk one yard square. Being small, the disc was strongly illuminated. Light falling on the screen from in front does no harm; the audience may be in a good light; any stray light from behind is bad. He thought that experiments with the reflecting arrangement were not advisable.

Prof. BARRETT thought that more attention should be paid to the light. He had tried specially-made glow lamps with close-coiled filaments. These required 10 to 20 amperes, but emitted a great deal of heat. He much preferred a modification of a Werdermann lamp giving a very small arc. It had two slender carbons almost touching. It required three or four amperes. With this lamp he could use a microscope slide mounted with Canada balsam, and it would not be injured by ten minutes' exposure without an alum cell.

Prof. BARR, in reply, said that he preferred an opaque screen about five feet square for an audience of about 100 persons. He thought a small transparent screen was not suitable for an audience of such a size, and besides, with such a screen the lantern could not be conveniently worked by the lecturer himself, which he considered a very important point. Arrangements were being made with a large maker of cameras for the manufacture of the complete apparatus, which he hoped would be obtainable from any dealer.

## MEETINGS OF SCIENTIFIC SOCIETIES, &c.

**FRIDAY, November 28th.**

PHYSICAL SOCIETY.

*5 p.m.* Papers to be read: "Notes on Secondary Batteries," by Dr. GLADSTONE and W. HIBBERT; "An Illustration of Ewing's Theory of Induced Magnetism," by Prof. S. P. THOMPSON, D.Sc.

**MONDAY, December 1st.**

ROYAL INSTITUTION.

*5 p.m.* General Monthly Meeting.

SOCIETY OF ENGINEERS.

*7.30 p.m.* Ordinary Meeting. Paper to be read: "On Ship Caissons for Dock Basins and Dry Docks," by J. J. F. ANDREWS.

SOCIETY OF ARTS.

*8 p.m.* Cantor Lecture I. 2. "Gaseous Illuminants," by Prof. VIVIAN B. LEWES.

ROYAL MICROSCOPICAL SOCIETY.

*8 p.m.* Conversazione.

**TUESDAY, December 2nd.**

INSTITUTION OF CIVIL ENGINEERS.

*8 p.m.* Ordinary Meeting. Paper to be further discussed: "The Vibratory Movements of Locomotives," by Prof. JOHN MILNE, F.R.S., and JOHN McDONALD. Papers to be read, time permitting: 1. "The Sukkur Bridge at Benares," by F. E. ROBERTSON, M.I.C.E.; 2. "The New Chittravati Bridge, Madras Railway," by E. W. STONEY, M.I.C.E.

ROYAL VICTORIA HALL.

*8.30 p.m.* Lecture: "Rocks seen through a Microscope," by E. WETHERED.

**WEDNESDAY, December 3rd.**

SOCIETY OF ARTS.

*8 p.m.* Ordinary Meeting. Paper to be read: "The Chicago Exhibition, 1893," by JAMES DREDGE.

**THURSDAY, December 4th.**

CHEMICAL SOCIETY.

*8 p.m.* Ballot. Paper to be read: "On the Volumetric Estimation of Tellurium," by G. D. BRANNER.

Digitized by Google

# The Electrician.

**Published every Friday, Price Fourpence; Post Free, Fourpence Halfpenny.**
**Editorial, Publishing, and Printing Offices:**
**SALISBURY COURT, FLEET ST., LONDON, E.C.**
*Telephone No.* 2714. *Telegrams:* "ELECTRICIAN NEWSPAPER, LONDON."

*All Letters relating to Subscriptions, Advertisements and other business matters should be addressed to the Publisher,* "THE ELECTRICIAN," *Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to* "THE ELECTRICIAN" *Printing and Publishing Company, Limited, and be crossed* "*Coutts and Co.*" *All other letters to be addressed to the Editor.*

*All letters intended for insertion in* "THE ELECTRICIAN," *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

"THE ELECTRICIAN" *is published every Friday morning, in time for the morning mails. Subscribers should receive their copies by the first post on Friday morning.*

"THE ELECTRICIAN" *is on sale at the railway bookstalls throughout the Kingdom on Friday morning, and can be obtained of all Booksellers and Newsvendors; or direct from the Publishing Offices as above.*

*New Volumes of* "THE ELECTRICIAN" *commence in May and November.*

## SUBSCRIPTION RATES.

The rates for Subscriptions to "THE ELECTRICIAN" are as follows :—

| | 3 months. s. d. | 6 months. s. d. | 12 months. s. d. |
|---|---|---|---|
| For the United Kingdom | 5 0 | 10 0 | 19 6 |
| For Foreign Parts and Colonies :— | | | |
| Within Postal Union | 6 6 | 12 6 | 24 0 |
| Aden Borneo, Ceylon, China, India, Japan, Java, Labuan, Mozambique, New Caledonia, Persia, Philippine Islands, Siam, Transvaal, and Zanzibar | 7 6 | 14 6 | 28 0 |



## TO ADVERTISERS.

"THE ELECTRICIAN" *offers exceptional advantages to Advertisers.* **It has by far the largest circulation of any English Electrical paper, and circulates all over the World.**

*Particulars relating to Advertisements will be promptly forwarded on application to the Offices as above.*

TRADE ADVERTISEMENTS *intended for the current issue must reach the Offices not later than First Post on Thursday morning. Renewals of expiring advertisement orders and alterations to standing advertisements should be in the Publisher's hands by Wednesday at latest. No alteration can be made in Wrapper advertisements after Wednesday evening.*

SMALL PREPAID ADVERTISEMENTS *(for Rates see page xvii.) are accepted up to 4 p.m. on Thursday.*

## TECHNICAL PRINTING.

"THE ELECTRICIAN" PRINTING AND PUBLISHING COMPANY (LIMITED) *inform Electricians, Electric Light Engineers, &c., that they make a specialty of Technical Printing, and have a large Staff thoroughly acquainted with Electro-Technology. They can, therefore, promise Accuracy and Despatch in the Printing of Electro-Technical Literature, &c.*

## "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. (Royal 8vo.)

*Early in each year is issued* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. *The* DIRECTORY *was established in 1883, and the 1890 Edition consisted of about 850 pages of printed matter. The names and addresses of all persons engaged in the Electrical Industries at home and abroad may be relied upon as accurate. Useful Tables and Electrical Formulæ, and information specially compiled for this work are given, together with popularly-written Biographical Notices of the leading Electricians, Electrical Engineers, &c., accompanied in many cases by Portraits.*

*Orders for the 1890 issue should be forwarded* AT ONCE *to the Publishing Offices, Salisbury-court, Fleet-street, London, E.C.*

*The 1891 Edition is now preparing, and New Names, &c., can now be received.*

## ELECTRICAL BOOKS AND PUBLICATIONS.

***All Books, Newspapers, and other publications, dealing with Electrical and kindred subjects, can be ordered direct of* "THE ELECTRICIAN" *Printing and Publishing Company, who are proprietors of the well-known* "ELECTRICIAN" *Series of Standard Electrical Works, and are agents for all the leading publishing houses at home and abroad.***


## CONTENTS OF THE CURRENT NUMBER.


NOTES ... 95
Magnetism in Iron and other Metals.—XXXVI. By Prof. J. A. Ewing, F.R.S. Illustrated. Continued ... 99
Drum Armature Winding. By F. M. Weymouth. Illustrated Continued ... 100
Notes on the Chemistry of Secondary Cells. By Prof. W. E. Ayrton and Messrs. C. G. Lamb, B.Sc., and E. W. Smith. Illustrated ... 102
On the Use of the Lantern in Class-room Work. By Profs. Barr and W. Stroud ... 105
Meetings of Scientific Societies. 105
THE INTERCHANGE OF CENTRAL STATION STATISTICS ... 106
The Central Stations of the Metropolitan Electric Supply Company. By Dr. J. A. Fleming. Illustrated. Concluded ... 107
The Electro-Magnet. By Prof. Silvanus P. Thompson, D.Sc., B.A., M.I.E.E. Illus. Continued ... 109
Physical Society—
On Certain Relations existing amongst the Refractive Indices ot the Chemical Elements ... 112
On Tables of Spherical Harmonics, with Examples of their Practical Use ... 112
The Board of Trade Overhead Wire Regulations ... 112
Overhead Electric Light Conductors. Illustrated ... 113
The Reynier Elastic Accumulator ... 113
Dinner of the Institution of Electrical Engineers ... 114
American Notes ... 117
Scandinavian Notes ... 117
CORRESPONDENCE—
An Ideal Physical Laboratory for a College—Oliver J. Lodge ... 117
Physics v. Metaphysics—I. F. 118
Bourseul's Speculations on Telephone — T. D. Lockwood ... 11
Oil Insulation—A. A. Campbell Swinton ... 118
Legal Intelligence ... 118
Trade Notes and Notices ... 119
PATENT RECORD ... 119
COMPANIES' MEETINGS, &c.—
Montevidean and Brazilian Telegraph Company Ltd.) 120
Swan United Electric Light Company (Limited) ... 122
Reuter's Telegraph Company (Limited) ... 124
Electric Construction Corporation (Limited) ... 124
Blackpool Electric Tramway Company (Limited) ... 125
New Companies Registered ... 125
City Notes, &c. ... 125


## THE INTERCHANGE OF CENTRAL STATION STATISTICS.

If at this early stage of its existence the electric supply industry can so far sink the jealousy which too often accompanies healthy competition, and can act upon the scheme for exchange of statistical information which has been proposed by the Committee of the Electrical Trades Section of the London Chamber of Commerce, the economic administration will probably advance as rapidly as has the purely scientific construction. The two desiderata at the present time are a reliable continuous supply of electrical energy at a uniform prssure to the satisfaction of the consumer, and an equally reliable, continuous, but perhaps gradually increasing dividend for the gratification of the shareholder. The question of price need not concern us here. So long as the light is good, and the power, where motors are used, effectual, if sufficient demand be found to enable a fair return to be paid on the capital, it is of minor importance whether the relative prices of electricity and gas be widely different or approximately equal. There is no doubt whatever about the highly satisfactory supply of several of the London companies, and the question which remains to be settled is the profit which can be made by them. The excellence of the supply might have—though it certainly has not—been brought about by machinery, stations, and mains designed by a committee of the Royal Society. Fortunately there is plenty of sound engineering, and but little laboratory work to be found in our central stations. We have seen a small station in the provinces where an extremely ingenious manager had to make the best of a very antiquated lot of machinery, and was obliged to work the circuits upon an utterly obsolete system. The engine-room

Digitized by Google

was full of most remarkable devices of a home-made description, but of such complication that their clever inventor never dared to leave the place for a single night. Happily, our more important supply companies had the good fortune to come into existence at a time when electrical engineering had arrived at some maturity, and most of their work has been done deliberately, and in a sound manner. What would have happened if the electric lighting boom of 1882-3 had not been checked is fearful to contemplate. Many a supply station in America has been found to have been arranged upon lines which could not possibly pay, and new buildings and machinery have had to be erected. We, too, have had our failures. Colchester and Barnet have unfortunately not only been failures, but they have taught us no useful lesson. These, however, were primarily failures in the quality of the supply. Difficulties of that kind have been surmounted, and the next thing to look for is the dividend.

Until lately, the jealousy of competition has been excusable, and not to be wondered at. The alternating current system and the battery system have each found enthusiastic advocates, and these, citing what they meant to do rather than what had been done, found no temptation to prove the advantages of their systems by pointing to their balance-sheets, for, when the controversy was at its height, they had none to show. They are now offered a splendid opportunity of proving from experience the efficiency of their generating plant and that of their method of distribution. The engineers of each system are fully convinced that theirs is the best, and would not hesitate on such grounds to let others know what they are doing, For several years the sectional area of field magnets and of armature cores was the trade secret of each drawing office, but to-day no one cares to conceal such details, and the method of designing the essential parts of ordinary continuous current machines is common knowledge. Alternating machines are only now emerging from a similar stage, and transformers and their designs are still shrouded in that secrecy which to the inventor is an instinct, and to the manufacturer an obvious precaution. Outside the station we still find specialities in the form of patented systems of mains, but these are not for the most part likely to be of great importance, since up to the present it appears that a variety of unpatented methods give satisfactory results; at all events, there is no secrecy whatever. We have endeavoured to go over the grounds for any reluctance that may be expressed with regard to the structural or engineering part of the scheme for exchange of information, and in the present state of the industry, we cannot see why any supply company should hesitate to fill up and to return Table I. of the Chamber of Commerce circular given in our last issue. The exchange of such information will be of far greater use to the trade generally than a number of forms filled up by themselves would be to the individual engineers.

Coming now to the second table, which relates to costs, opposition may be raised by secretaries or managers who have to deal with the finance rather than with the machinery. But they should bear in mind that the information sought differs altogether from an inquiry into the books of a manufacturer. They are obliged by Act of Parliament to submit their accounts to the Board of Trade, and the actual cost of generating and of supply will have to be clearly stated. The total prime cost being thus disclosed, there should be no reluctance in allowing an analysis to be interchanged. Hitherto an additional reason for declining to publish prime costs of supply has been created by the fact that the local authorities are eager to acquire the electric supply business if they think that it is profitable. It is the careless and incapable vestryman especially who muddles away the money, and who welcomes anything which would "relieve the rates," when through his lack of administrative knowledge they have become a burden. But he will anxiously compare the total cost as stated in the Board of Trade form of accounts with the revenue earned by the company. Cost of fuel, and of superintendence per unit generated, will have no interest for him. The men who will value these returns the most are not only the secretary or manager, but the engineer also. The manager wants the cost reduced somehow, that a good dividend may be earned; and if he finds that a certain item of expenditure in his table of costs exceeds the average he will naturally attempt to reduce it. But to do this effectually he will have to appeal to the engineer. It will be for the engineer to investigate the reason, to remove the cause by improved arrangements, and thus to benefit his company in a way which would be impossible if his attention were not thus drawn to the matter.

An exchange of information as to cost of production has been undertaken by the Iron and Steel Institute, and has been readily responded to by ironmasters who were not obliged to disclose their profits: the information given by them, as Mr. Crompton has already pointed out, does not contain anything that would prematurely indicate the dividends, and the interchange has been of immense benefit to the iron and steel trade. There are several other matters which might with great advantage form the subject of interchange of information. Such are the proportions and degree of magnetisation of transformers to which we have already alluded, and the relative number of glow lamps sold at various voltages and candle-power. Unfortunately, it is considered by those who could give the information, that since they have little to gain by such publication, the undoubted advantage to the trade is not a sufficient inducement. The proposition before us presents no difficulty of this kind. The total cost must be published in the Board of Trade returns. The analysis would undoubtedly be of considerable value even to a manager who finds that he is doing as well or better than his neighbours, and the information which he gives after all only states the results, and does not in any way disclose the means by which he attains them.

## THE CENTRAL STATIONS OF THE METROPOLITAN ELECTRIC SUPPLY COMPANY.

BY DR. J. A. FLEMING, M.A.

*(Concluded from page 72.)*

We have next to notice the switch-board arrangements at Manchester-square. There are three switch-boards—one for the exciters, one for the dynamos, and one for the circuits. These boards are mounted on a partition which stands away from the wall of the dynamo room, and permits access to the connections behind the board. The working connections are mounted on enamelled slate bases, affixed to the wood frame of the switch-board. The dynamo switch-board is divided into ten panels corresponding to the ten dynamos. On each of these panels there is a main ammeter and ammeter short-circuiting plug, which reads the main primary current flowing out of each dynamo. There is also a Cardew voltmeter which reads the primary volts on one coil of the armature of each dynamo, and hence gives the total primary volts. Under each ammeter is a rheostat for introducing resistance into the field circuits of the dynamos, and thus regulating the electromotive force. At the bottom of each panel is a magnetic cut-out, the working arrangements of which

Digitized by Google

are shown in Fig. 15. The exciting current passes round the coils of the electro-magnets of this electro-magnetic cut-out. When the exciting current exceeds a certain safe value the attraction of an armature by this electro-magnet releases a double pole switch which is kept locked by a clutch and the switch springs back and opens the circuit of the fields. The exciter board

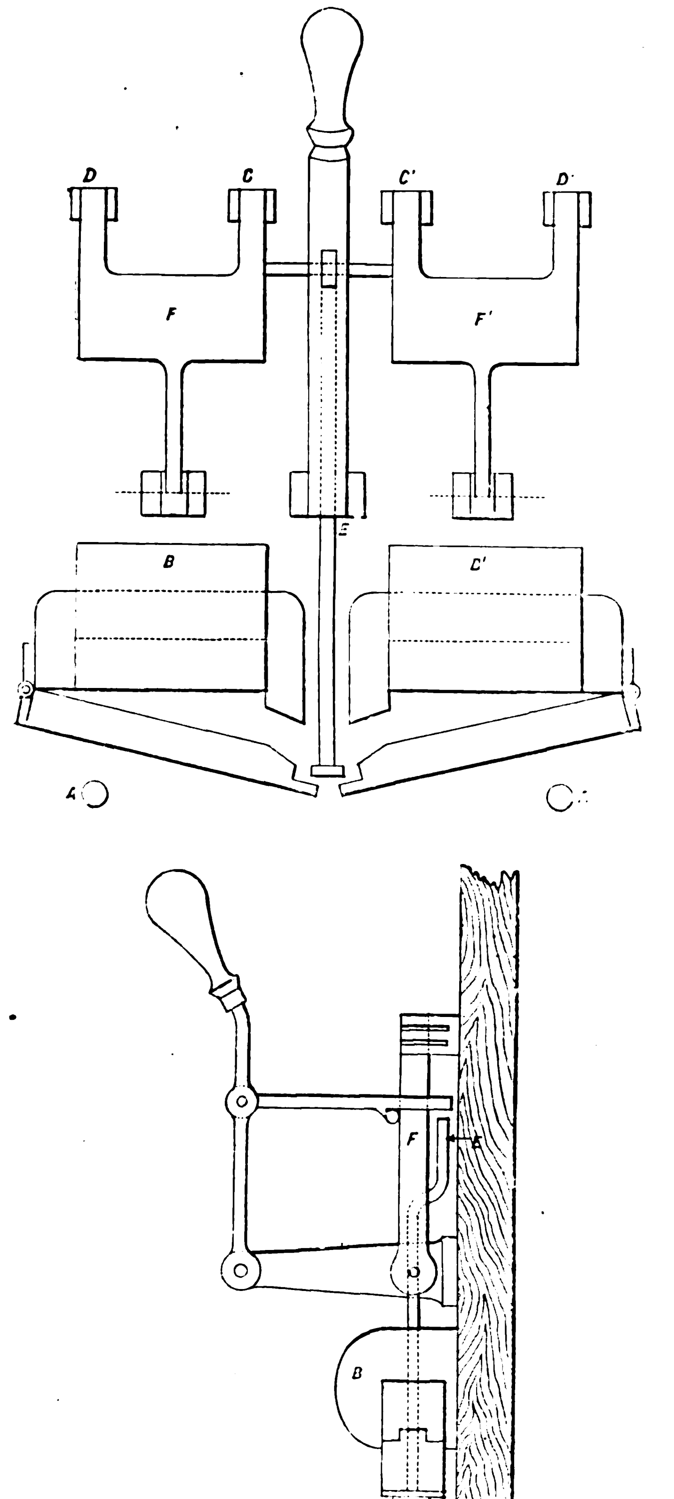



Fig. 15.—Magnetic Cut-Out.

A, A, Exciter Terminals. B, $B^1$, Magnetic Coils in Exciter Circuits. C, $C^1$, Contacts on Exciter Circuits. D, $D^1$, Contacts on Field Circuits of Dynamos. E, Releasing Rod raised by Magnets. F, $F^1$, Double Pole Switches, forced open by Springs when released.

resembles a telephone switch-board. The object of the arrrangements is to group the exciters and dynamos. There are four exciters, one of which is sufficient for five dynamos. Hence at full load two exciters have to be operated. On the exciter board there are a series of vertical and horizontal bars which can be connected by plugs. The vertical bars are connected to the dynamo-field circuits, and the horizontal bars to the exciter poles. Hence by plugging together these strips any exciter can be put into the fields of any dynamo or dynamos arranged in parallel, and the exciters can be arranged so as to work in parallel on one

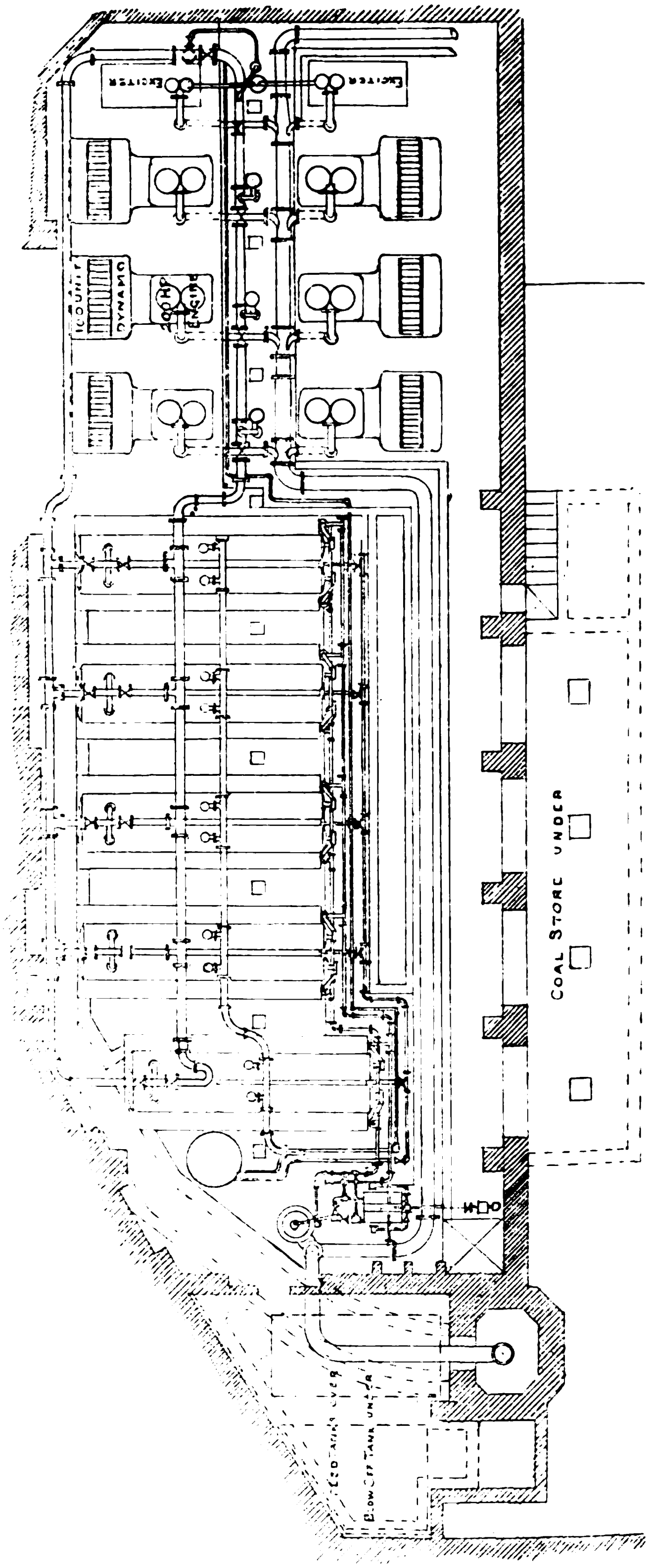



Fig. 16.—Rathbone-place Station. Plan.

group of dynamos or separately on separate groups. There are the usual rheostats for introducing resistance into the fields of the exciters. The main circuit switch-board closely resembles that of Sardinia-street which has been fully described. There are twenty-two circuits which proceed out from this board, and by means of plugs any dynamo can be put on to any circuit or group of circuits, and by means of a throw-over switch that circuit can be instantly changed on to a spare dynamo. There is one

Digitized by Google

difference, however, in the circuit switch-boards at Sardinia-street and Manchester-square, that the plugs in the circuit board in this last-mentioned station are made to screw into place for greater security instead of being simply plugged in as taper plugs. The twenty-two panels in this circuit board are all exactly similar. From this circuit board highly insulated cables pass out into a subway, where they are laid and fixed on wooden shelves. From this subway they pass into the iron pipes laid in the streets, and which have already been described in connection with the Sardinia-street station, and the arrangement of mains is otherwise the same. The difficulties which have presented themselves at Manchester-square in dealing with the limited space at disposal have been overcome with great ingenuity, and it has required the exercise of much judgment to place 2,000 horse-power in a space so limited, having regard to all the conditions of freedom from noise, vibration, and smoke. We understand that the arrangement of steam drums over the boilers, alluded to in a former part of this article (see *Electrician*, Vol. XXVI., p. 69), was designed and worked out by Mr. Rosenthal, of the Babcock and Wilcox Water Tube Boiler Company.

### Rathbone-place Station.

This station (*see* Fig. 16) is, generally speaking, designed on the lines of Manchester-square. There are six Elwell-Parker 100 unit alternators, combined with Willans engines of the same size and make as those at Manchester-square. There are two combined Willans engines and Elwell-Parker dynamos as exciters, either one of which will do the whole work of the station. There are five Babcock boilers, each capable of evaporating 6,000lb. of water per hour, and the necessary pumps, heaters, &c. Rathbone-place was formerly a small private station which was taken over by the Metropolitan Electric Supply Company in 1888 (see *Electrician*, Vol. XXIV., p. 237). The interesting point to notice about it is that whereas formerly the maximum possible output of the station was current for some 2,000 lights, by an economical utilisation of the space, and by the selection of the present plant, a possible maximum output of current for 15,000 8-candle-power lamps has been obtained. The station occupies the bottom floor of a factory, and great care has been exercised in the building construction, and by the introduction of a fire-proof roof, to render the station as free as possible from danger of interruption.

These stations of the Metropolitan Electric Supply Company are connected together by trunk mains, and in the summer, when the demand is small, it will be possible to shut down altogether one or more of these stations, and greatly to economise working expenses. At present the whole of these stations are working on the system of distributed transformers; when, however, a business has been built up, and the consumption in the areas of supply become sufficiently great, it is possible that a system of transformer sub-centres will be initiated, and be found to be advantageous.

## THE ELECTRO-MAGNET.*

BY PROFESSOR SILVANUS P. THOMPSON.

*(Continued from page 87.)*

### Electro-Magnetic Mechanism.

The task before me to-night comprises the following matters:—First, to speak of that particular variety of the electro-magnet in which the iron core, instead of being attached to the coils, is movable, and is attracted into them. Secondly, to speak of the modes of equalising the pull of electro-magnets of various sorts over their range of action. Thirdly, to describe sundry mechanisms which depend on electro-magnets. Lastly, to discuss the modes of prevention or diminution of the sparking which is so almost invariably found to accompany the break of circuit when one is using an electro-magnet.

### The Coil-and-Plunger.

First, then, let me deal with the apparatus wherein an iron core is attracted into a tubular coil or solenoid, an apparatus which, for the sake of brevity, I take the liberty of naming as the *coil-and-plunger*. Now, from quite early times, from 1822 at any rate, it was known that a coil would attract a piece of iron into it, and that this action resembled somewhat the action of a piston going into a cylinder—resembled it, I mean to say, in possessing an extended range of action. The use of such a device as the coil-and-plunger was even patented in this country in 1846, under the name of "a new electro-magnet." Electro-magnetic engines, or motors, were made on this plan by Page, and afterwards by others, and it became generally known as a distinct device. But even now, if you inquire into the literature of the text-books to know what are the peculiar properties of the coil-and-plunger arrangement, you will find that the books give you next to no information. They are content to deal with the thing in very general terms by saying: Here is a sort of sucking magnet; the core is attracted in. Some books go so far as to tell you that the pull is greatest when the core is about half-way in, a statement which is true in one particular case, but false in a great many others. Another book tells you that the pull is greatest at a point one centimetre below the centre of the coil for plungers of all different lengths—which is quite untrue. Another book tells you that a wide coil pulls less powerfully than a narrow one, a statement which is true for some cases and not for others. The books also give you

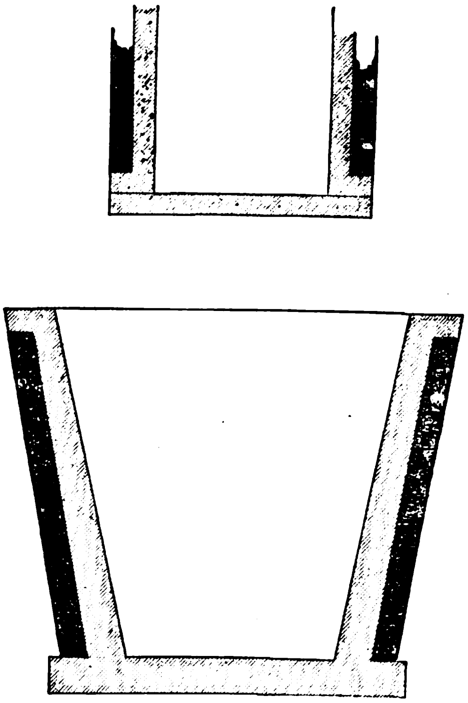


Fig. 57.—Hjörth's Electro-magnetic Mechanism.

some approximate rules, which, however, are very little to the point. The reason why this ought to receive much more careful consideration is because in this mechanism of coil-and-plunger we have a real means not only of equalising, but also of vastly extending the range of the pull of the electro-magnet. Let us take a very simple example for the sake of contrasting the range of action of the ordinary electro-magnet with the range of action of the coil-and plunger.

Here are some numbers which are given in a paper with which I have long been familiar, a Paper read by the late Mr. Robert Hunt in 1856 before the Institution of Civil Engineers, and discussed, with that eminent engineer, Robert Stephenson, in the chair. Mr. Hunt described the various types of motors, and spoke of this question of the range of action. He recounted some experiments of his own in which the following was the range of action. There was a horse-shoe electro-magnet which at distance zero—that is, when its armature was in contact—pulled with a pull of 220lb; when the distance was made only $\frac{1}{1000}$th of an inch (4 mils), the pull fell to 90; and when the distance was increased to 20 mils (1-50th of an inch), the pull fell to only 36lb. The difference from 220 to 36 was within a range of 1-50th of an inch. He contrasts this with the results given by another mechanism, not quite the simple coil-and-plunger, but a variety of electro-magnet brought out about the year 1845 by a Dane living in Liverpool named Hjörth, wherein a sort of hollow truncated cone of iron (Fig. 57), with coils wound upon it—a hollow electro-magnet, in fact—was caused

* A series of four Cantor Lectures delivered before the Society of Arts, January—February, 1890.

Digitized by Google

to act on another electro-magnet, one being caused to plunge into the other. Now we have no information what the pull was at distance zero with this curious arrangement of Hjörth's, but at a distance of 1in. the pull (with a very much larger apparatus than Hunt's) was 160lb., the pull at 3in. was 88lb., at 5in. 72lb. Here, then, we have a range of action going not over 1·50th of an inch, but over 5in., and falling not from 220 to 36, but from 160 to 72, obviously a much more equable kind of range. At the Institution of Civil Engineers on that occasion, a number of the most celebrated men, Joule, Cowper, Sir William Thomson, Mr. Justice Grove, and Prof. Tyndall, discussed these matters—discussed them up and down—from the point of view of

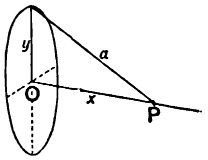


FIG. 58.—Action of Single Coil on Point-pole on Axis.

range of action, and from the point of view of the fact that there was no means of working them at that time except by the consumption of zinc in a primary battery; and they all came to the conclusion that electric motors would never pay. Robert Stephenson summed up the debate at the end in the following words:—"In closing the discussion," he remarked, "there could be no doubt from what had been said that the application of voltaic electricity, in whatever shape it might be developed, was entirely out of the question commercially speaking. Without, however, considering the subject in that point of view, the mechanical applications seemed to involve almost insuperable difficulties. The power exhibited by electro-magnetism, though very great, extended through so small a

lately whether sound varies as the square of the distance—or rather, whether the intensity of it does—and the people who dispute on both sides of the case do not seem to know what the law of inverse squares means. I have also seen the statement made last week in the columns of *The Times*, by one who is supposed to be an eminent authority on eyesight, that the intensity of the colour of a scarlet geranium varies inversely with the square of the distance from which you see it. More utter nonsense was never written. The fact is, the law of inverse squares, which is perfectly true mathematical law, is true not only for electricity but for light, for sound, and for everything else, provided it is applied to the one case to which a law of inverse squares is applicable. That law is a law expressing the way in which action at a distance falls off when the thing from which the action is proceeding is so small compared with the distance in question that it may be regarded as *a point*. The law of inverse squares is the law universal of action proceeding from a point. The music of an orchestra at 10ft. distance is not four times as loud as at 20ft. distance; for the size of an orchestra cannot be regarded as a mere point in comparison with these distances. If you can conceive of an object giving out a sound, and the object being so small, in relation to the distance at which you are away from it, that it is a point, the law of inverse squares is all right for that, not for the intensity of your hearing, but for the intensity of that to which your sensation is directed. In no case, however, are sensations absolutely proportional to their causes. When the magnetic action proceeds from something so small that it may be regarded as a point compared with the distance, then the law of inverse squares is necessarily and mathematically true.

You may remember that I produced an apparatus (Fig. 27, see *The Electrician*, Vol. XXV. p. 683), which I said was the only apparatus hitherto devised which did directly prove experimentally the law of inverse squares for the case of a magnetic pole. There was in it a pole, virtually a point at a considerable distance from a small magnetic needle, which was also virtually a point.

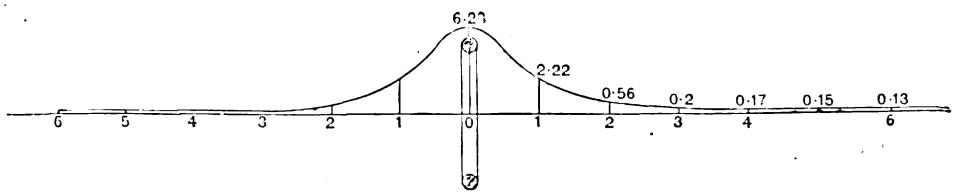


FIG. 59.—Action along Axis of Single Coil.

space as to be practically useless. *A powerful magnet might be compared, for the sake of illustration, to a steam-engine with an enormous piston, but with an exceedingly short stroke; such an arrangement was well known to be very undesirable.*"

Well, from the discussion in 1856—when this question of the length of range was so distinctly set forth—down to the present, there have been a large number of attempts to ascertain exactly how to design a long range electro-magnet, and those who have succeeded have, as a general rule, not been the theorists; rather they have been men compelled by force of circumstances to arrive at their result by some kind of—shall we call it—"designing eye," by having a sort of intuitive perception of what was wanted, and going about it in some rough and ready way of their

The law of inverse squares is true; but it is not what one works with when one deals with electro-magnets having ends of a visible size, acting on armatures themselves of visible sizes, and quite close to them. If you take a case which never occurs in practice, an armature of hard steel, permanently magnetised, so far away from an electro-magnet (or, rather, from one pole only) that the distance between the one pole and the armature on which you are acting is so very great compared with each of them, that each of them may be regarded by comparison as a point, then the law of inverse squares may be rightly applied, but not unless.

Now we want to arrive at a true law. We want to know exactly what the law of action of the coil-and-plunger is. It is not a very difficult thing to work out, provided you get hold of the right ideas.

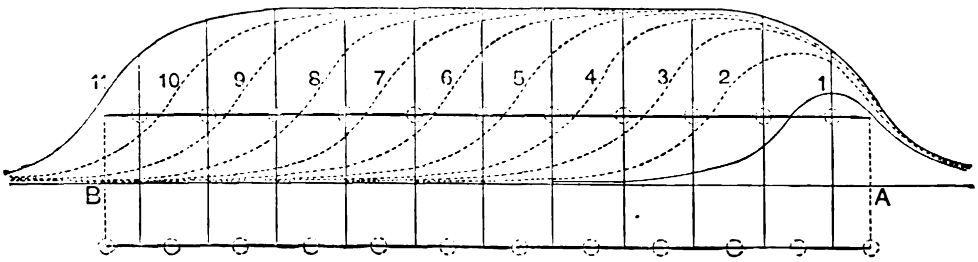


FIG. 60.—Action of Tubular Coil.

own. Indeed, I am afraid had they tried to get much light from calculations based on orthodox notions respecting the surface distribution of magnetism, and all that kind of thing, they would not have been much helped. There is our old friend, the law of inverse squares, which would of course turn up the first thing, and they would be told that it would be impossible to have a magnet that pulled equally through any range, because the pull was certain to vary inversely according to the square of the distance. I notice that, in a report of my second lecture in one of the London journals, I am announced to have said that the law of inverse squares did not apply to electric forces. I beg to remark that I have said no such thing. It is well to be precise as to what one does say. There has been a lively discussion going on quite

We must begin with a simple case, that of a short coil consisting of but one turn, acting on a single point-pole. From this we may proceed to consider the effect on a point-pole of a long tube of coil. Then we may go on to a more complex case of the tube coil acting on a very long iron core; and last of all from the very long iron core we may pass to the case of a short core.

You all know how a long tube of coil such as this will act on an iron core. Let us make an experiment with it. I turn on the current so that it circulates around the coil along the tube, and when I hold in front of the aperture of the tube this rod of soft iron, it is sucked into the coil. When I pull it out a little way it runs back, as with a spring. The current happens to be a strong one—about 25 amperes; there are about 700 turns of wire on the

Digitized by Google

coil. The rod is about 1in. in diameter and 20in. long. So great is the pull that I cannot pull it entirely out. The pull was very small when the rod was outside, but as soon as it gets in it is pulled actively, runs in, and settles down with the ends equally protruding. The tubular coil I have been using is about 14in. long; but now let us consider a shorter coil. Here is one here only half-an-inch from one end to the other, but I have one somewhere still shorter, so short that the length, parallel to the axis, is very small compared with the diameter of the aperture within. The wire on it consists of but one single turn. Taking such a coil, treating it as only one single ring, with the current going once round, in what way does it act on a magnet that is placed on the axis? First of all, take the case of a very long, permanently magnetised steel magnet, so long, indeed, that any action on the more distant pole is so feeble that it may be disregarded altogether, and only one pole, say the north pole, is near the coil. In what way will that single turn of coil act on that single pole? This is the rule, that the pull does not vary inversely as the square of the distance, nor as any power at all of the distance measured straight along the axis, but inversely as the cube of the slant distance. Let the point O in Fig. 58 represent the centre of the ring, its radius being $y$. The line O P is the axis of the ring, and the distance from O to P we will call $x$. The slant distance from P to the ring we will call $a$. Then the pull on the axis towards the centre of this coil varies inversely as the cube of $a$. That law can be plotted out in a curve for the sake of observing the variations of pull at various points along the axis. Allow me to draw your attention to Fig. 59, which represents a section or edge, view of the coil. At various distances right and left of the coil are plotted out vertically the corresponding force, the calculations being made for a current of 10 amperes, circulating once round a ring of 1 centimetre radius. The force with which such a current acts on a magnetic pole of unit strength placed at the central point is 6·28 dynes. If the pole is moved away down the axis, the pull is diminished; at a distance away equal in length to the radius it has fallen to 2·22 dynes. At a distance equal to twice the radius, or 1 diameter, it is only 0·56 dynes, less than one-tenth of what it was at the centre. At 2 diameters it has fallen to 0·17 dyne, or less than 3 per cent.; and the force at 3 diameters is only about 2 per cent. of that at the centre.

If, then, we could take a *very* long magnet, we may utterly neglect the action on the distant pole. If I had a long steel magnet with the south pole 5ft. or 6ft. away, and the north pole at a point 3 diameters (*i.e.*, 6 centimetres in this case) distant from the mouth of the coil, then the pull of the current in one spiral on the north pole 3 diameters away would be practically negligible; it would be less than 2 per cent. of what the pull would be of that single coil when the pole was pushed right up into it. But now, in the case of the tubular coil, consisting of at least a whole layer of turns of wire, the action of all of the turns has to be considered. If the nearest of the turns of wire is at a distance equal to three diameters, all the other turns of wire will be at greater distances, and, therefore, if we may neglect such small quantities as 2 per cent. of the whole amount, we may neglect their action also, for it will be still smaller in amount. Now, for the purpose of arriving at the action of a whole tube of coil, I will adopt a method of plotting devised by Mr. Sayers. Suppose we had a whole tube coiled with copper wire from end to end, its action would be practically the same as though the copper wire were gathered together in small numbers at distant intervals. If, for example, I count the number of turns in a centimetre length of the actual tubular coil which I used in my first experiment, I find there are four. Now if, instead of having four wires distributed over the centimetre, I had one stout wire in the middle of that space to carry four times the current, the general effect would be the same. This diagram (Fig. 60) is calculated out on the supposition that the effect will not be greatly different if the wires were aggregated in that way, and it is easier to calculate. If, beginning at the end of the tube marked A, we take the wires over the first centimetre of length and aggregate them, we can draw a curve, marked 1, for the effect of that lot of wires. For the next lot we could draw a similar curve, but instead of drawing it on the horizontal line we will add the several heights of the second curve on to those of the first, and that gives the curve marked 2; for the third part, add the ordinates of another similar curve, and so gradually build up a final curve for the total action of this tubular coil on a unit pole at different points along the axis. This resultant curve begins about 2½ diameters away from the end, rises gently, and then suddenly, and then turns over and becomes nearly flat with a long level back. It does not rise any more after a point about 2½ diameters along from A; the curve at that point becomes practically flat, or does not vary more than about 1 per cent., however long the tube may be. For example, in a tubular coil 1in. in diameter and 20in. long, there will be a uniform magnetic field for about 15in. along the middle of the coil. In a tubular coil 3 centimetres in diameter and 40 centimetres long, there will be a uniform magnetic field for about 32 centimetres along the middle of the coil. The meaning of this is that the value of the magnetic forces down the axis of that coil begins outside the mouth of the tube, increases, rises to a certain maximum amount a little within the mouth of the tube, and after that is perfectly constant nearly all the way along the tube, and then falls off symmetrically as you get to the other end. The ordinates drawn to the curve represent the forces at corresponding points along the axis of the tube, and may be taken to represent not simply the magnetising force, but the pull on a magnetic pole at the end of an indefinitely long, thin steel magnet of fixed strength.

*(To be continued.)*

## REVIEWS.

**Electric Bell Construction.** F. C. Allsop. E. and F. N. Spon: London, 1890.

This book will give an amateur a fair idea of the construction of electric bells, indicators, and magnetos; but it contains no information about wholesale manufacture, nor does it touch upon wiring, which is dealt with in another book by the same author. "Is electricity within the grasp of the ironmonger? I say most distinctly it is," writes a correspondent to *Ironmongery*; but we cannot with equal confidence assert that Ohm's law is within the grasp of our author. He gives a diagram of a Leclanché cell coupled up with a push and a bell. On the previous page he has given the volts of this as 1½ roughly. He then supposes the resistance of the circuit to be 1½ ohms, and arrives at the conclusion that "the current in the circuit will be exactly one ampere." "In Fig. 4, however, we have added another cell, which has doubled the E.M.F., so that, the resistance being the same, the current is also doubled, being two amperes instead of one." It is a very common mistake among beginners to neglect the resistance of a battery, especially when no information as to the resistances of various batteries is given in the text-books; but we hoped for better things from the author of four books on electrical matters.

**Electromotors.** How made and How Used. By S. R. Bottone. Whittaker and Co.: London, 1890.

This is essentially an amateur's book. But there are amateurs and amateurs. Some turn geometric patterns on ivory boxes, some play at manufacturing, and others, alas! follow the suggestions that we find in this little book, and mount toy armatures on knitting-needle shafts with a copious use of Prout's glue. The author, after describing these electrical whirligigs, proceeds to give instructions for making small motors, and a persevering amateur might succeed in turning out something that would go, if he follows the directions; but many details, such as the rounding of the corners of an armature over which wire has to be wound, are omitted, while the directions for winding are needlessly prolix. A good deal of space is taken up with descriptions of Immisch and other really serviceable motors, while the last fourth of the book is devoted to alternate current motors which can hardly be of use to an amateur at present. The method of calculating the winding of armatures and of fields is very remarkable. The unfortunate amateur might as well be told to guess at the half, and to multiply by the cube root of 8. Allusion is made to the statement that "it will be seen on reference to a 'properties of copper wire table' that the 'safe current' for No. 18 wire is only three amperes, while that of No. 16 is six amperes." Surely the author must know that arc light dynamos have been made for years with No. 18 wire for nine amperes, and No. 17 has often been used for 15 amperes. A two-page table is given of primary batteries, their chemicals and volts, and a praiseworthy attempt is made to give their internal resistances.

## BOOKS, &c., RECEIVED.

"Electro-Motors: How made and how used." By S. R. Bottone. (London: Whittaker and Co.)

"Anleitung zum Bau Elektrischer Haustelegraphen Telephon und Blitzableiter Anlagen." (Berlin: Hof-Verlagsbuchhandlung Gebr. Radetzki.)

Digitized by Google

## THE PHYSICAL SOCIETY.

The following communication was made at the meeting of the Physical Society on November 14th by the Rev. T. PELHAM DALE, M.A.,

### "On certain relations existing amongst the refractive indices of the Chemical Elements."

The first part of this Paper corroborated the results announced in a communication made in May, 1889, on the same subject, and said that as far as experimental data are forthcoming, the refraction $(\mu - 1)$, divided by the vapour density $(d)$ is equalled to a constant multiplied by some integer. Several metals whose refractions have since been determined conform to this law. On examining the relation between molecular weight (M) and refraction, similar conclusions are arrived at, for to a fair degree of approximation the ratio $M/\mu - 1$ is a constant or simple multiple of this constant. Another relation is between the molecular distances $(h)$ (see *Proc. Phys. Soc.*, Vol. IX., p. 167) and the atomic weight $(a)$ of the elements, $h$ being nearly proportional to $\sqrt{a}$. In the case of selenium, sulphur, and phosphorous the agreement is close, but for bromine, chlorine, and carbon not so good. A relation appears to exist between the upper limit of refraction and the line spectra of elements. For example, the upper limit of refraction for selenium occurs at wave length 5295 7, whilst its spectrum exhibits a remarkable series of strong lines about this wave length. A similar relation apparently holds with sulphur, phosphorous, and bromine. Gold also shows a series of strong lines about C, in the vicinity of which the metal has the greatest reflective power.

DISCUSSION.

Dr. GLADSTONE said that the question whether $(\mu - 1)/d$ is constant or not, is being investigated by many. The French physicists had found the quantity nearly constant, but Lorenz's expression, $(p^2 - 1)/(p^2 + 2)$, is slightly better when applied to compounds in the liquid and gaseous states. Metals were difficult to deal with, especially as, according to the recent Paper of Du Bois and Reubens, their refractions do not follow the law of sines.

Mr. DALE here suggested that they might be related to hyperbolic sines.

Dr. GLADSTONE, continuing, said that by taking solutions of metals, it was found that their specific refractive energies were nearly inversely as the square roots of their combining weights, but at present the known cases were not sufficient to establish a law.

Prof. RÜCKER said that of the two expressions, $(\mu - 1)/d$ and $\frac{(\mu^2 - 1)}{(\mu^2 + 2)}$ the latter seemed preferable, for it could be converted into electrical quantities by writing $\kappa$ for $\mu^2$. The expression then becomes $(\kappa - 1)/(\kappa + 2)$, and if this can be shown to be constant by electrical work, this would be an argument in its favour.

Mr. DALE, in reply, pointed out that from the nature of the two formulæ, any inaccuracy or variation in $\mu$ would affect theirs more than Lorenz's. He also thought that $(\mu - 1)/d$ was a limit towards which the numbers tend.

Prof. J. PERRY, F.R.S., then read a Paper

### "On Tables of Spherical Harmonics, with Examples of their Practical Use."

The author, for the benefit of members of the Society not familiar with the subject, defined a spherical harmonic as a homogeneous function of $x$, $y$, $z$, satisfying the equation $\frac{d^2 V}{d x^2} + \frac{d^2 V}{d y^2} + \frac{d^2 V}{d z^2} = 0$, stated some of the fundamental properties of these functions, and pointed out their importance in the solution of various problems in heat, electricity, and general dynamics. It will be observed that the defining equation is the well-known one, satisfied when V is the potential of an attracting mass of matter, at all points unoccupied by matter. If V is the potential of an electrostatic distribution, it is satisfied at all points of no electrification. Lastly, if V is a magnetic potential, the equation is satisfied at all points within a homogeneous substance in a magnetic field, and at all points of empty space. The general spherical harmonic of any degree, being a function of the three co-ordinates $x$, $y$, $z$, is called a solid harmonic. By transforming to polar co-ordinates $r$, $\phi$, $\theta$, it can be shown that from a solid harmonic of degree $i$, a function of $\phi$ and $\theta$ only which also satisfies the equation, can be derived by dividing by $p^{2i+1}$, and this is called a surface harmonic. Spherical harmonics which are independent of $\phi$ are known as zonal harmonics, and are of special importance, as being applicable to the solutions of all problems in which there is symmetry about an avis. The surface harmonics of this class are functions of $\theta$ only, and the solid harmonics derived from them are, of course, functions of $r$ and $\theta$, or of $x^2 + y^2$ and $z$.

It was the surface zonal harmonics or functions of a single angle only which Prof. Perry had tabulated, the tables giving the values to four places of decimals of the functions of degrees 0 to 8 for every degree of arc from 0° to 90°.

As an example of the use of these tables, the case of a spherical surface covered with attracting matter whose density varied as the square of its distance from a diametral plane, was taken. It was required to find the potential both outside and inside the sphere, and to determine the equipotential surfaces and lines of force. The potentials inside (A) and outside (B) were shown to be given by

$$\frac{A}{\pi} = 8 + \frac{16}{5} r^2 P_2, \text{ and } \frac{B}{\pi} = \frac{8}{r} + \frac{16}{5} \frac{1}{r^3} P_2 \text{ respectively.}$$

By giving A and B definite values, and choosing values of $r$, the corresponding $P_2$'s can be calculated and the value of $\theta$ determined from the tables. Hence any equipotential surface can be easily determined; and lines drawn to cut these surfaces orthogonally are the lines of force. Another problem which had been tried, consisted in finding the directions of the lines of force near a circular coil of rectangular cross-section when an electric current circulates in the coil. This was treated approximately by first calculating the potential at 6 points along the axis in the neighbourhood of the coil, and then finding by Gauss' method the coefficient $A_0$, $A_1$, $A_2$, &c., of an expression in ascending powers of $z$ which agreed with the calculated potentials at the points chosen. The formula, $V = A_0 + A_1 r P_1 + A_2 r^2 P_2 t$, &c., or its corresponding expressions in inverse powers of $r$ was then assumed to give the potential at any point in the space considered. By giving V definite values a series of equipotential surfaces were determined, and the lines of force drawn. On putting the calculations to the test of experiment, the approximate solution of this very difficult problem was found to be very nearly correct.

DISCUSSION.

Prof. A. W. RÜCKER observed that these tables would be of the utmost value to all physicist who require to make calculations involving spherical harmonics. He himself, in the course of his magnetic work, had reluctantly abandoned some calculations of the kind owing to the enormous labour which would have been involved in calculating the numerical values of the functions. The calculations would have been made with ease if he had had access to tables such as those which Prof. Perry had presented to the Society.

Mr. G. W. DE TUNZELMANN thought that the publication of these tables, which could be consulted as easily as the ordinary tables of trigonometrical functions, ought to do much to dispel the mystery which had hitherto been associated with the term spherical harmonic in the minds of practical engineers.

Prof. J. V. JONES stated that it was of great interest to him as a teacher to learn that Prof. Perry had been able to introduce the subject successfully to elementary classes.

## THE BOARD OF TRADE OVERHEAD WIRE REGULATIONS.

The following two memorials, which have recently been forwarded to the Board of Trade upon the subject of the regulations relating to overhead conductors, may prove of interest to our readers :—

London, November 6, 1890.

To the Right Hon. Sir MICHAEL EDWARD HICKS-BEACH, Bart., M.P., President of the Board of Trade.

SIR: We, the undersigned companies, firms, and persons, interested in the supply of electricity in the United Kingdom, beg respectfully to memorialise your Board with reference to Regulation No. 9 of the regulations for the protection of the public safety, &c., prescribed by the Board of Trade under the provisions of the Electric Lighting Act of 1882.

With reference to this regulation the undersigned beg leave to state that it is the general experience based upon numerous actual tests, that for pressure up to 2,000 volts, whether alternating or continuous current, a thickness of one-tenth of an inch of dielectric is unnecessary in conductors of small section. For conductors having a relatively large sectional area we are satisfied with the expediency of the Board of Trade requirements; but for conductors having a relatively small sectional area, the disproportion between the conductor and the installation is so excessive as not only to render the use of such conductors prohibitory, in view of their high price, but actually dangerous in the presence of snow and high winds, on account of the very large surface presented in proportion to the total weight of the conductor and its covering.

Four of the principal companies interested in this branch of work, viz., The Brush Electrical Engineering Company (Limited), Messrs. Crompton and Company (Limited), The India rubber and Gutta-percha Company (Limited), and Messrs. Laing, Wharton, and Down Construction Syndicate (Limited), were represented at the experiments carried out at the works of Messrs. Crompton and Company, at Chelmsford, by your adviser, Major Cardew, and their representatives were so thoroughly convinced by these experiments of the reasonable character of their request for a modification of the exist-

Digitized by Google

ing rule, that the above-mentioned Companies heard of the receipt by Messrs. Crompton and Co. of the letter from the Board of Trade, dated May 30th, with the greatest astonishment and regret.

The undersigned beg leave, therefore, most respectfully to request the Board of Trade to give the decision therein communicated their favourable reconsideration, and to suggest that this rule may be modified in accordance with the following :—"Every high-pressure aerial conductor must be continuously insulated with a durable and efficient material, to be approved of by the Board of Trade, and to a thickness of not less than one-seventh part of the actual conductor diameter in cases where the extreme difference of potential does not exceed 2,000 volts ; but for all higher voltages this thickness must be increased in direct proportion to the increase in difference of potential. In no case must the thickness of insulation be less than one-sixteenth of an inch, and the cables must have an insulation resistance of not less than one megohm per mile per volt of electromotive force when tested in water at 60°Fahr. (after immersion of at least 60 consecutive hours). This insulation must be further efficiently protected on the outside against injury or removal by abrasion. If this insulation or protection be wholly or partly metallic, it must be efficiently connected to earth, so, however, as not to cause undue disturbance to other electric lines or works by electrostatic induction or otherwise."

The undersigned are willing and anxious to conduct any additional tests which the Board of Trade may wish or suggest, in proof of the contentions herein stated. The undersigned make these representations while fully recognising the necessity in the interests, not only of the public, but also of the electrical industry generally, that all overhead electric lines should be carried out in the safest possible manner.—We have the honour to be, Sir, your most obedient servants,

(Signed) THE BRUSH ELECTRICAL ENGINEERING COMPANY (LIMITED).
MESSRS. CROMPTON AND CO. (LIMITED).
THE INDIA-RUBBER AND GUTTA-PERCHA COMPANY (LIMITED).
THE LAING, WHARTON, AND DOWN CONSTRUCTION SYNDICATE (LIMITED).

London, November 6, 1890.

To the Right Hon. Sir MICHAEL EDWARD HICKS-BEACH, Bart., M.P., President of the Board of Trade.

SIR: We, the undersigned companies, firms, and persons, interested in the supply of electricity in the United Kingdom, beg respectfully to memorialise your Board with reference to Regulations Nos. 2 and 12 of regulations for the protection of the public safety, &c., prescribed by the Board of Trade under the provisions of the Electric Lighting Act of 1882.

With reference to these regulations the undersigned beg leave to bring before the Board the fact that in conjunction with overhead conductors having a small sectional area of copper, the use of suspending wires is not only unnecessary but exceedingly dangerous to public safety, on account of the large surface presented to wind and snow, and the great strain put upon the supports. It is admitted that this does not apply with so much force to the use of suspending wires with conductors of relatively large sectional area, but the undersigned are strongly of opinion that both in the interests of the electrical industry, and in those of public safety, it is advisable that overhead conductors up to a sectional area of hard drawn copper, equivalent to 7 No. 16 S.W.G. should be run without suspending wires. The undersigned beg leave, therefore, most respectfully to request the Board of Trade to give their favourable reconsideration to the foregoing regulations, and to suggest that they may be modified in accordance with the following :—

*Clause* 2.—"Every aerial conductor shall be attached to supports at intervals not exceeding 200ft. where the direction of the conductor is straight, or 150ft. where this direction is curved, or where the conductor makes a horizontal angle at the point of support. If suspending wires are used, as required in Clause 12, the above intervals may be increased to 250ft. and 200ft. respectively.

*Clause* 12.—Every aerial high pressure conductor shall be efficiently suspended by means of non-metallic ligaments to suspending wires, so that the weight of the conductor does not produce in it any sensible stress in the direction of its length, and the insulated conductors and suspending wires where attached to supports shall be in contact only with material of highly insulating quality, and shall be so attached and guarded that in case they break away it shall not be possible for them to fall away clear of the supports. Provided that where the aerial high-pressure conductor is equal to, or less than, 7 No. 16 S.W.G., the suspending wires shall not be compulsory if the conductor be of hard drawn copper or other material of equal strength.

The undersigned are willing and anxious to conduct any tests which the Board of Trade may wish or suggest in proof of the contentions herein stated. The undersigned make these representations while fully recognising the necessity in the interests, not only of the public, but also of the electrical industry generally, that all overhead electric lines should be carried out in the safest possible manner.—We have the honour to be, Sir, your obedient servants,

(Signed) THE BRUSH ELECTRICAL ENGINEERING COMPANY (LIMITED).
MESSRS. CROMPTON AND CO. (LIMITED).
THE LAING, WHARTON, AND DOWN CONSTRUCTION SYNDICATE (LIMITED).

## OVERHEAD ELECTRIC LIGHT CONDUCTORS.

The following illustrations (Figs. 1 and 2) represent three varieties of aerial conductors. No. 1 is that required by the Board of Trade. No. 2 is a compromise which has been suggested by Mr. Crompton. No. 3 is an ordinary conductor such as has been in vogue up to the present for the class of work for which the Board of Trade now demands No. 1.

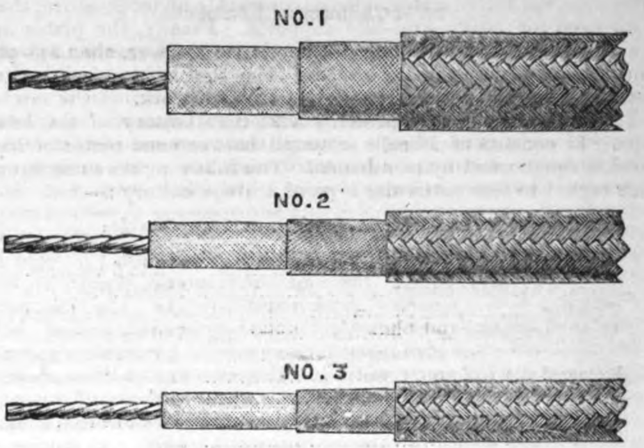


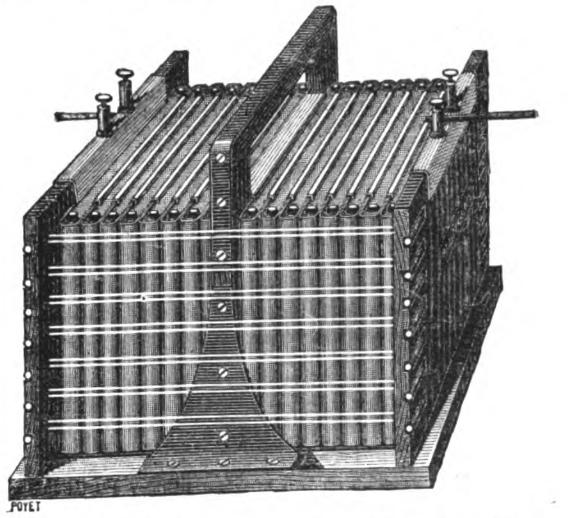

FIG. 1.—Cables with covering partly cut away.

FIG. 2.—Cross section of cables.

No. 1. $\frac{7}{20}$ cable. Insulated according to Board of Trade regulations. Thickness of rubber, ·121" Diameter over serving, ·489".
No. 2. $\frac{7}{20}$ cable. Medium insulation. Thickness of rubber, ·07". Diameter over serving, ·355".
No. 3. $\frac{7}{20}$ cable. L quality. Thickness of rubber, ·042". Diameter over serving, ·306.

## THE REYNIER ELASTIC ACCUMULATOR.

On p. 186 of our issue of June 20, 1890, our Paris correspondent supplied a few general facts respecting a new accumulator brought out by M. Emile Reynier, and the following additional data have now been sent us by the inventor :—



Reynier's Elastic Accumulator.—Type : Horse-Power-Hour.

In the original design each cell was contained in a varnished sheet-iron vessel lined with india-rubber, and was composed of two positives and one negative, separated by sheets of porous silica, the two end sheets being fluted to increase the space available for the electrolyte, the quantity of which was, however, small. In the latest type of cell M. Reynier uses containing vessels of pure lead, the necessary flexibility being obtained by surrounding the lead

Digitized by Google

**cell with an expansible corrugated case. A number of cells are connected in series, and placed between two rigid end-pieces drawn tightly together by strong springs. This arrangement gives the active material considerable artificial elasticity, which enables one to attain a high rate of discharge and to obtain a high output for a given weight. The expansions and contractions of the plates can take place freely without disintegration owing to the action of the springs. There is a difference in length of as much as 6 per cent. between a completely discharged and a fully charged battery. Moreover, the active material being constantly under pressure, there is no need for heavy grid-like supports. Finally, the plates and the cells being held together in this elastic manner, they are able to withstand severe shocks, and are from that point of view alone peculiarly suited to the exigencies of traction work.**

**The annexed figure represents a storage battery of the latest type. It consists of 16 cells mounted between end-pieces of hard wood, strengthened by iron bands. The following are some figures with regard to this particular type of storage battery :—**

| | | |
|---|---|---|
| E.M.F (full) | | 32 volts |
| E.M.F. (at terminals) | | 28 ,, |
| Discharging current | | 3 to 6 amperes. |
| Average available energy | | 150 watts. |
| Capacity | | 30 ampere-hours. |
| Work (available) | | 740 watt-hours. |
| External dimensions | Length | 16 |
| | Breadth | 12″ |
| | Height | 12″ |
| Total space occupied (less than) | | 1·5 cubic feet. |
| Total weight | | 110lb. |
| Weight per watt-hour | | ·15lb. |
| Watt-hours per lb. of cell complete | | 6·73 |
| Volume per watt-hour | | 3 cubic inch. |

**It may be added that the figures for the total weight and total volume include everything, and that the battery is very solidly constructed in view of its employment in electric tramway and similar work.**

## DINNER OF THE INSTITUTION OF ELECTRICAL ENGINEERS.

The second annual dinner of the Institution of Electrical Engineers was held on Thursday evening, November 20th, at the Criterion Restaurant, under the presidency of Dr. John Hopkinson, F.R.S. Amongst those present were the Postmaster-General, the Attorney-General, the President of the Royal Society, the Astronomer Royal, Dr. Coleman Sellers, Sir Arthur Blackwood, K.C.B.; Sir H. Trueman Wood, Major Marindin, R.E.; Sir Robert Rawlinson, K.C.B.; Mr. George Berkeley, Mr. J. Tomlinson, jun., Captain Wharton, R.N.; Prof. W. G. Adams, Mr. Alabaster, Prof. Ayrton, Mr. Aylmer, Dr. Borns, Mr. Bidwell, Sir Albert Cappel, Major Cardew, R.E ; Mr. Collett, Staff-Commander Creak, Mr. Crompton, Mr. Crookes, Mr. Dowson, Sir James Douglas, Mr. Eck, Dr. Fleming, Prof. Foster, Prof. Forbes, Herr Fritsche, Sir Douglas Galton, Mr. Graves, Mr. R. Kaye Gray, Mr. W. E. Gray, Mr. C. H. Gray, Capt. Holden, R.A.; Dr. E. Hopkinson, Prof. Hughes, Colonel Jackson, Sir Henry Mance, Mr. Mordey, Prof. Perry, Mr. Preece, Mr. von der Pfordten, Sir David Salomons, Mr. Alex. Siemens, Mr. Spagnoletti, Major-General C. B. Stotherd, R.E. ; Mr. Stroh, Mr. W. Swan, Prof, S. P. Thompson, Prof. J. J. Thomson, Prof. W. C. Unwin, Major-General Webber.

The PRESIDENT, in giving the toast of "Her Most Gracious Majesty the Queen," said that it was one peculiarly acceptable to electrical engineers, for during Her Majesty's reign the science of electrical engineering had not only attained to its present development, but had found its beginning.

The PRESIDENT, in giving "The Prince and Princess of Wales and the rest of the Royal Family," said they all knew how willingly and ably the Prince of Wales represented Her Majesty on all ceremonial occasions. The other day he was present at the opening of the Forth Bridge ; and again lately he had been at the opening of the City and South London Railway, a work which had been peculiarly interesting to electrical engineers from the mode of its propulsion.

The PRESIDENT next gave "The Army, the Navy, and the Reserve Forces," coupled with the names of Major-General Stotherd, C.B., R.E., and Captain W. J. L. Wharton, R.N.

Major-General STOTHERD, in reply, said that it was necessary to spend a great deal upon the Army and the Navy of late years to keep them in a state of efficiency. Amongst the things which cost money were the scientific inventions which had been introduced into the Army within his recollection. When he was at Chatham, some years ago, he had the pleasure of initiating the field telegraph system of our Army and the system of submarine mines which had since been adopted. When first formed, many of the members of the Institution offered very useful information and assistance in developing our system of military telegraphs and torpedoes and submarine mines. He could not refrain from mentioning the name of Sir William Siemens, who in particular had taken very great interest in developing the apparatus when submarine mines were first adopted. Sir Francis Bolton, also a member of the Institution, organised a very excellent system of visual telegraphy. This country was the first to use the electric telegraph for warlike purposes. In the Crimea they carried a line from Balaclava to the front. After that, in 1866, the electric telegraph was very extensively used in the German army.

Captain WHARTON, R.N., returned thanks for the "Navy," and referred to the vast changes that had taken place in the *matériel* of the fleet in the past 30 years, and the criticism and controversy that was naturally called forth by the experimental condition of ships and guns, but deprecated illogical strictures such as had recently been current on the "Serpent," which was a perfectly seaworthy ship, though of a class not liked by seamen for their discomfort. He hoped that evidence would be forthcoming at the court martial to clear the memory of officers of that ship from any imputation of careless navigation.

The PRESIDENT then proposed "Her Majesty's Ministers." He said, whether they agreed or not in the judgment of Her Majesty's Ministers in matters of policy, they would all agree in according to them credit for a very honest desire for the good of the country. He could not ask them all to wish long life to the Ministry ; but he did ask them all to join him in wishing health and long life to every member of that Ministry. He coupled with the toast the name of Mr. Raikes, Her Majesty's Postmaster-General. A very important part of the work of his department was entirely dependent upon the electrical engineer.

The Right Hon. H. C. RAIKES, M.P., in returning thanks, said :—Mr. President, it is I am aware, no small honour to return thanks for the toast of Her Majesty's Ministers in such a company and on such an occasion as this. And yet I feel some little diffidence in addressing myself to the task when I remember that it has been previously performed by no less a personage than the head of the present Government, the Marquis of Salisbury (cheers). He was your guest last year ; and he is not only the head of Her Majesty's Government, but he is what I cannot pretend to be, a somewhat expert electrician himself. I have near me another friend of mine who also belongs to Her Majesty's Government, the Attorney-General, who is also, I daresay, known to many gentlemen here, not less as an electrical expert than as a profound lawyer, if he will forgive me for saying so. I remember upon one very important occasion I had recourse to his advice, when I found, in my humble opinion, that his electricity was at least as good as his law. At all events, his electrical skill enabled us so to steer out of a difficulty in which otherwise we might have had to fall back upon his law. I feel that you have done me this honour, perhaps, to-night, for the cause indicated by your President in his speech. It is, no doubt, the fact that the department which I am called upon to preside over has closer relations with electrical engineering than any other great department of the State. It is not necessary that I should refer in detail to the enormous amount of telegraphic business which has grown up during the nineteen years through which the department of the Post Office has been charged with its administration in this country ; but it is perhaps interesting to know that in that time the annual number of telegrams has grown from 10,000,000 in 1871 to 62,000,000 in 1889, that it has more than sextupled in the course of those eighteen years, and you can easily understand how important it is for our department to be kept *au courant* with all the latest developments of electrical science. It is not without some feeling of pride that I recall the fact that the Post Office has, I believe, given to this institution no less than three of its presidents—Mr. Scudamore, Mr. Preece, and Mr. Graves. They, I believe, each in turn occupied that chair which you, sir, fill to-night, and I am happy to think that they have been able to render great services to the science of electricity, at the same time that they have not been thereby induced in the smallest degree to neglect their public duty to the department which they so efficiently serve. But it is not the Post Office alone that has relations with electrical engineering. Second only to the Post Office—if indeed second—is the Board of Trade in its relations to your science. The Board of Trade has, amongst other things, the special charge of lighthouses ; and the Board of Trade has had the opportunity of testing, and I believe of utilising, more than one of the considerable discoveries of your President in that branch of electrical science. We can only regret that in the neighbouring country of Spain, on whose shores that terrible catastrophe happened the other day, there is not, as far as I am aware, either a Board of Trade or an Institution of Electrical Engineers. If they had the advantages we possess we might hope and believe that the lights at Cape Villano might have been in such a state as to have prevented the loss of that good ship and all those brave men. Now, the Board of Trade is not only interested in the question of lighthouses, but it also has to do with the great question of electric lighting. I know that many gentlemen, and I dare say the majority of those here present, have the opinion that electric lighting has been perhaps unduly arrested in this country by the jealousy of Parliament or of the departments of the Government (hear, hear). Well, I can quite understand that feeling, but I confess that I do not share it. I think that above all things when you have a young science it is desirable that you should give that science time to feel its feet, and to, in some degree, appreciate what it can do before you rush headlong into employing it. I cannot but think that Parliament has been wise in holding its hand for some years before taking decided steps for licensing and extending the use of the electric light, because no doubt it has given time for experiments greatly to improve the science and to secure for the public, now that they are beginning to appreciate and make use of it, a very much better article in the way of electric light than they would have obtained probably if they had rushed into it eight or ten years ago. Then the Board of Trade has

Digitized by Google

another connection with the electrical engineers with respect to electricity as a motive force. The recent opening of the new subterranean railway in South London has given us all an opportunity of testing, by actual experience, how this most interesting experiment will work, and it will be the special duty of the Board of Trade to keep its eyes open to study the working of the new system and to report upon it in an independent way, which will enable the public generally to judge for themselves how far that experiment may be imitated elsewhere. Then the Admiralty has its relations with electrical engineering, because from day to day it is becoming more and more necessary to have recourse to electricity in handling those great monsters of the deep, which are the fighting ships of our day, and which are so ponderous and so unwieldy that ordinary skill might be powerless to handle them. The War Office, as you know, has its own dependence also on electrical engineering, for no man nowadays could take the field for a campaign unless he had obtained the very best service that was to be obtained for the supply of information. Therefore, you see that all those departments of State are separately very much beholden to the Electrical Engineers. I may tell you, on behalf of them all, as I address you this evening, that I tender to you the grateful thanks of Her Majesty's Ministers for the great services which you have rendered to them. I know that it is almost impossible, in dealing with the operations of a body like yours, to over-estimate the enormous changes which, through your instrumentality, are affecting our daily life. I am not going to say, as I believe some enthusiasts say, that you have actually annihilated time and space ; but you have so far modified time and space that it is impossible for those who live in this our day to attach to those words anything like the sense in which they were used, even by the preceding generation. And you are perpetually finding out new fields. It is not merely that you have covered all those various grounds to which I have already referred, but you are making for yourselves a great field in manufactures ; and even in the healing art electricity is coming to play a very important part. It is impossible to forecast the enormous future that lies before this particular branch of science. You seem to me to have taken to yourselves the attributes of the whole of the Pantheon, the whole of those influences which in ancient times were supposed to dominate our sublunary life. But if I had to single out among those mythological deities any one which might seem more appropriately to be the patron or patroness of your science, I would say that you seem to me to have borrowed in a special degree the attributes of that goddess who we remember—probably those of us who still retain the rudimentary features of our school training—adopted a threefold name and a threefold aspect. If you will forgive me I will merely quote those two lines with which our Latin grammar has made us familiar –

"Terret, lustrat, agit Proserpina, Luna, Diana,
Ima, suprema, feras, sceptro, fulgore, sagittâ."

As I was coming down here I thought perhaps I might venture to string together this little paraphrase of those lines, which I would render thus :—

"Your threefold goddess, with her magic spells,
By turns alarms, enlightens, and impels,
While hangs the pale exchange upon her strings,
Her lamp cheers cities and her touch gives wings."

(Applause.)

Mr. LATIMER CLARK next proposed "The Learned Societies." He said it was absolutely unnecessary in a meeting such as that to give any commendation or recommendation to that toast. They all knew perfectly well what the learned societies had done for their own and other branches of science. They knew that they had given lustre to the times in which they lived. They had to a large extent perhaps done benefits to them greater than to any body of men he could recall. The learned societies of this country and of other countries had been enabled to pursue not only the love of science and the desire to gain knowledge, but also they had been enabled to attain, or to endeavour to attain, absolute truth ; and, as far as he could see, no other human agency was able to seek after truth with such a pure ambition and motive as the "Learned Societies." Whatever might be the consequences to themselves or to others, they sought truth, absolute truth, and truth only.

Sir GEORGE STOKES, Bart., M.P., in responding for "The Learned Societies," said it was a very wide subject indeed if they took in all the societies which deserved that name. But from the nature of this institution, and from the speech of the gentleman who had proposed the toast, he supposed they did not mean on the present occasion to include under that term literary and philological societies, but to confine themselves more especially to scientific societies. But here again the field was somewhat limited, because he perceived that there was another toast which would be proposed in due time, which would be "The Kindred Societies"—societies kindred to the Electrical Engineers. Now, he certainly should himself regard the Institution of Electrical Engineers as a scientific society, and therefore he was still further limiting the term scientific society in relation to this toast. It was quite true that there were societies whose object was the abstract discovery of scientific truth, apart from its applications, and no doubt that those discoveries formed the groundwork of subsequent applications. There were many societies devoted to particular branches of science with which electrical engineering was brought more especially into contact. It was brought into contact even with abstract mathematics. It was brought into contact, again, with chemistry, for the strange agent that they had to deal with, and turned so much now to practical account, electricity, was intimately, as they knew, bound up with chemistry. It was not the first time that he had responded to such a toast as that ; it was not the first time that he had responded to that very toast at the hospitable board of that very society. There was a certain circumstance which led him to look more, perhaps, to the future than to the past. No doubt his name had been connected with this toast in consequence of the honourable office which for the present he was filling, but his tenure of that office was now drawing to a close. In a few days he should cease to hold it. Who his successor might be he ought not to say, because that was determined by the votes of the Fellows, and those votes were given by ballot. Yet he thought it was what he might call an open secret that in all human probability his successor would be one who was somewhat his junior in age, but whom he might look up to as his master in science, and more especially in electrical science. His probable successor—he supposed he ought not to say more than that—would be one who was well acquainted with them, and who had already filled the post which his friend on the right occupied at that very moment. He rejoiced to think that his probable successor would be a gentleman such as he had described, and one who was connected with that institution.

Mr. W. H. PREECE, past President, next proposed "The Kindred Societies." He said the toast that had been placed in his hands was that of the kindred societies ; and after the remarks that had just been made by the President of the Royal Society, he had considerable difficulty in defining to them who those "Kindred Societies" were, and in arranging those societies in some system of method and of order. He took them thus : that the kindred societies were those who, like themselves, were occupied in the application of the great principles that were discovered by the learned societies. Now, in attempting to arrange those kindred societies in any order, he had no library to refer to. He had simply before him the *menu* of the capital dinner which they had enjoyed, and he took it that they could speak lightly, perhaps foolishly, of some of those societies under the different heads that they had taken their food. For instance, "soup." What society was it that could be arranged under the head of "soup?" They heard sometimes of papers that were "thick," papers that were "thin ;" they had subjects that were "hot," and subjects that were "cold." They had occasionally papers brought before them that were "spiced ;" but there was one society where they also had papers that formed the subject of admirable discussions, that were weekly submitted to them with a promptitude that was astonishing, and those were the papers which so often formed the introduction to subjects that were brought before them, and they heard of them in the room of the Society of Arts. Then who were they who dealt with the subject of fish. They had in the fish the wonderful property of applying energy with the greatest possible efficiency, and all their Mechanical Engineers were doing their very utmost to apply the principles of fish to this application of electric lighting. When they came to *entrées*, they dealt with those light and gentle things which formed a kind of substratum for something better to come ; and here they must classify the Naval Architects and Iron and Steel Institute, because they dealt with such things as shells, explosives, torpedoes, and gentle things of that class. But when they came to meat—the solid substratum on which they all existed, that institution that applied the great forces of nature to the wants of mankind, the Institution of Civil Engineers—then they came to deal with that society to which they were so intensely indebted for their home and for many kindnesses. Now, when they came to the next head, that of the "sweets," he could only think of the British Association ; and in connection with the British Association, the only thing that came to his mind was a plum-pudding, for a plum-pudding was made out of many sections ; and there was one section, Section G, out of which electrical engineers very often pulled some very good plums. But when they came to the "dessert," the *finale*, then he could only speak of themselves, for there they had only lightness and grace. They wafted sighs from Indus to the Pole. They sent messages of peace and goodwill along the silent wires from zone to zone. They carried health and comfort to their homes, their establishments, and they were doing all that they possibly could to utilize the great forces of nature that were now running to waste. Here they were assisted by everyone of those "kindred societies." There was not a single society that he had named that was not helping them to make use of those forces to further the object which they had in view, namely, to apply the great forces of nature to the wants of man. There was one society that he had forgotten, that kindred society that picked up crumbs that fell from the rich man's table, and he did not think that they ought to leave out of the kindred societies the old and young students who were practising to take part in their future discussions. There was one point that he must add supplementary to the remark made by the President of the Royal Society, and that was, that he was going to divulge the open secret. The open secret that he was going to divulge was this, that there was every reason to believe and hope that the next President of the Royal Society would be one who belonged to every kindred society he had named, who was their President last year, and whom next year they should hope to have amongst them to respond as President of the Royal Society to the toast, and that was Sir William Thomson (cheers). He proposed to couple with this toast the representative of the Institution of Civil Engineers, one of its past Presidents, Mr. George Berkley.

Mr. GEORGE BERKLEY, in responding, said that he felt that the health of the Kindred Societies being proposed showed that there was a genial, kind, and cordial feeling among those societies, and he felt deeply that the existence of that cordial and good feeling was essential to their success. He might refer to the communications that had taken place within the last few years between the engineers of America and the engineers of Great Britain. Two years ago they had a visit from 250 of those engineers. They were delighted to see them, to entertain them, with a hospitality which he was sure was appreciated. He had just returned from a visit to America with at least 250 members of the Iron and Steel Institute. He need not tell them that they had been received with the most generous and magnificent hospitality, and that intercourse had produced on both those visits the best possible feeling between the engineers of the two great countries. Prejudice had been cast aside ; breadth of views had been obtained ; great knowledge of the conditions under which the two countries and the engineers

Digitized by Google

of those countries worked had been acquired. He could not but feel that that sort of intercourse was of great value, not only to their profession, but to the two countries that had been represented on those occasions. He also for one moment wished to refer to the question of the electrical progress in the two countries. No one could come back from America without feeling that their dear old country was somewhat behindhand in the adoption of the advantages which electricity presented to them, and he trusted; and had no doubt, that we shall soon make up lost ground, and be equal to our good friends on the other side of the Atlantic (applause).

The PRESIDENT next proposed "Our Guests," coupled with the names of Sir Richard Webster, Q.C., M.P., Attorney-General, and Prof. Dr. Coleman Sellers, member of the International Niagara Commission. He saw amongst their guests that evening there were two gentlemen who had attained to the highest eminence in different lands and different walks of life. Sir Richard Webster was a gentleman whom many of them had learnt to fear as cross-examining counsel almost as much as to admire when he was on one's own side. Sir Richard Webster, he had no doubt, would tell them that he knew nothing about electricity. They had had that already contradicted that evening. They would find that he knew a very great deal about it, indeed, and he was happy to say that he had begun to admit that he knew something about electricity, for he had consented to join their institution. Dr. Coleman Sellers, having attained to the highest eminence in other branches of engineering, had now devoted his talents to electrical engineering, and had applied them to a particular problem. That problem was the utilisation of the vast energy which was going to waste in the Falls of Niagara.

Sir RICHARD WEBSTER, in response, said: You have heard from no less an authority than the Postmaster-General who knows me as an old friend, and I regret to say you have heard him remark that my law is as bad as my electricity. I confess I shall go out of this room a sadder and, I trust, a wiser man, determined by some process or other to imbibe, if not a little more law, yet a little more electricity, which may conduce to a "higher standard" up to which I may direct my law. My excellent friend, Dr. Hopkinson, has spoken of me in very kindly terms. It is the fact that there are many in this room whom I have met in friendly combat. I have always liked to see them on my side if I could, and if they were against me I regarded it as a temporary misfortune, so far as I was concerned. I confess that I never knew before that I was going to join this Society because I was an electrician. I was asked by no less a person than Sir David Salomons, whether I would consent to be a *member*—to be put up. "Why," I said, "I thought you only admitted great electricians;" to which he replied, "Oh, yes; we let in duffers like you as well" (laughter). Well, on those terms I felt that there was some possibility of my not being blackballed. It is not for that reason only that I consented, for I have a very great desire to improve my knowledge of electricity, and I think if I was to dine here more frequently, and sit between Mr. Latimer Clark and Mr. Preece, that some "secondary currents" might possibly find their way into my miserable "insulated body." I suppose I ought to say perfectly "insulated body," so far as electrical bodies are concerned. I confess—what with the rheostats, the volts, and amperes, and relays, and all those dreadful words, which no sooner come into my head than they go out again—I have made but a sorry figure, and I have tried to find out the reason. Years ago I studied "secondary batteries," or tried to, and thought that they just fitted my constitution; but my excellent friend, Mr. Crompton, said to me: "You are no good; you charge very well, but you discharge much too rapidly" (laughter). Then I tried to understand "transformers" and "high potentials;" but it was no good, and I assure you, although I am speaking on behalf of myself, I believe I represent the feelings of the guests at the same time in this matter. I am at the present time in a state of despondency, because, studying those abstruse problems, I met Prof. Forbes, and I explained to him my condition; and after looking at me, he said: "Why, it is no good. You are wound the wrong way; you want re-winding" (laughter). Well, gentlemen, I am afraid that some of you electricians will think me past praying for. Still, I have hope that some yet to be discovered subtle agency will possibly do something for me; and I have thought that I might venture to ask for admission within these sacred portals. I am sure that many of the guests for whom I have been supposed to speak appreciate what I am going to say. I can assure Dr. Hopkinson that I address him as an old friend, and that it gives me great pleasure to be here, and I am sure that the influences, electrical or otherwise, which have been applied to our constitutions, will have left good impressions, and we shall be glad to be your guests on any future occasion.

Dr. COLEMAN SELLERS also responded. He was glad to have the opportunity of meeting face to face men whom he had only known by name. There had been some words spoken about the manner in which the English engineers appreciated the courtesies extended to them in America. He could assure them there was nothing which gave the Americans so much pleasure as to meet their friends from England in the United States, and to pay back in some slight measure the many favours which had been granted to them when they came to England. This summer he spent his holiday in London—not London-on-Thames. When there, he was met by a telegraph message from New York, asking him to report on a special subject, which was the comparative cost of the transmission of power by electricity as compared with the primary generation by steam at any fixed location. He was told to go to Niagara Falls, and he visited the place and reported. That report had been submitted to some engineers in America, and it was of such a nature that certain capitalists decided to go into the thing, and a syndicate was formed to advance the money and to endeavour to carry out Sir William Thomson's prophesy, that in the near future New York and other cities were to draw their power and heat and light from the great Falls of Niagara, where so much power was now going to waste. The Company that he represented now in England was proceeding in a very moderate way. They did not think of taking from the Falls more than a trifle of 120,000 horse-power. It required some millions of dollars, they might say, to extract that power, but in order that it should be done in the wisest and best manner, it was proposed that he should come to England. He had not been sent to raise money for this enterprise. The Company having charge of this attempt to utilise the Falls of Niagara had sent him to Europe to get the means to carry it out, and to get the brains necessary to do it. In America they thought they knew a great deal, but they had the knowledge of the fact that they knew a very little. They wished to start this Company on a basis of economy, and on the very highest plane of the arc. That this was an enterprise worthy the consideration of engineers was shown by the readiness with which such men as Sir William Thomson and Prof. Unwin gave themselves to it in the capacity of being members of the International Niagara Commission. Such men would not be induced to go into it but for the great interest there was in the gigantic scheme, and therefore he felt somehow as if when he was among the engineers of England he was with his own personal friends. He looked about him and saw faces different in no way from those faces he saw in America; they were all of the same blood. It happened for himself that it had been more than two hundred years since his people had arrived in America, and yet there was not one drop of blood in his body that was not English. They were brothers, and as brethren, they must work in this great invention.

The Right Hon. CECIL RAIKES, M.P., Postmaster-General, then proposed "The Institution of Electrical Engineers," coupled with the name of the President. The right hon. gentleman said: Gentlemen, your kindness has devolved upon me the duty of proposing that which you have just heard is the toast of the evening. I can only regret that, with the modesty which always accompanies true genius, you have thought it right to place the toast of your noble selves at the back end of the evening's programme, yet I think it right just to dwell for one or two minutes upon the facts connected with this institution, which, I think, are full of significance and interest. As the last speaker has pointed out, you are a young society. It was only in 1871 that this institution was founded, and I find that in that year you numbered what was a very respectable number for a beginning, no less than 268 members; but that in the year which is just elapsing that number has risen to 1,738, an increase of 1,470—that is to say, more than five times as many members of this society in the present year than there were at the time when it commenced. But what is even more remarkable is this: I find that in the first year of your existence you had two only very courageous young men, who enrolled themselves as students in this institution, but that the number has increased until in the present year there are no less than 102. That while the members of the Society have increased in the ratio of 5 to 1, the students have increased in the ratio of 50 to 1. Of course, that points a very obvious moral. The amount of work for electrical engineers has been increasing with giant stride, and there is every reason to anticipate that in the immediate future it will increase at even a greater rate. I find, whilst on the subject of the students, that a gentleman who has been referred to this evening as a true friend of this institution, Sir David Salomons, has founded an exhibition for a student in electrical engineering, and I feel very little doubt that at no distant time his example will be followed on a very large scale by those who come to realise, as he has done, how greatly this science in the future will conduce to the welfare and prosperity of our country. You are still indebted to the older but friendly Institution of Civil Engineers for certain privileges and advantages which they have been pleased and proud to offer you. I think that it is a very gratifying fact to find the elder sister holding out her hand to the younger sister, and encouraging her in the great efforts which she is making in her own particular branch of applied science. Thanks to the electrical engineers, there is now a system of submarine cables of not less than 120,000 miles in length, and there are in the limits of these islands no less than 2,000,000 miles of the telegraph system. That did not, he believed, include the telephonic system; but although that was a burning question—as to which, perhaps, he should say as little as he possibly could—there could be no doubt that with the expiry of the telephone patents, in the course of the next year or two, a fresh field would be opened for the inventive genius of Electrical Engineers. Now, having very amply endeavoured to render my tribute to the great work that you have done, that you are doing, and you will do, you will allow me to pass to the more personal part of the toast, as I have to connect with it the name of your excellent President. A few years ago we were told that the old Universities were quite played out; that what we taught at Oxford and Cambridge was of no practical use to any sort of man who went out into the world to make his own career. I think recent events have rather falsified that assertion. I should think that this is the day of Senior Wranglers. My excellent friend and colleague, the President of the Royal Society, is, of course, a Senior Wrangler. That might under any state of affairs have been perhaps expected. But Senior Wranglers have shown that the training which they receive at Cambridge may be utilised in other walks of life. The two most efficient additions to the Equity Bench of late years have both been Senior Wranglers, and the President of your Society, who sits here, is also, as you know, a Senior Wrangler. In your President you have a very happy representative of that union of moderate pursuit of the ordinary recreation of life with the most studious and persistent endeavour to fit himself for the highest place in its higher branches. I beg to ask you to drink the health of your Institution, may it long flourish and extend its borders. I ask you to join with the toast the health of your President, Dr. Hopkinson (applause).

The PRESIDENT, in reply, said: The place and value of such a Society as ours is not to be entirely measured either by the number of its members or by its income, but rather by its usefulness in recording new knowledge and disseminating that knowledge abroad. Measured by this standard, surely our Institution must take very high rank. With the recent rapid

Digitized by Google

development of heavy electrical engineering, it may readily be supposed that our Institution has had a very important work to do, and I venture to claim that that work has been right well done. In spite of electric lighting having been hampered by the low price of gas and the electric transmission of power in some measure by the absence of water power, the work that has been done in this country, I venture to say, has been well done. The study which Englishmen have devoted to the science of electricity in its application to lighting and the transmission of power has placed this country in the foremost rank in this connection. I am sure that we occupy a post as eminent in this connection as in the past time was the case in connection with ocean telegraphy. I thank you, Sir, for the kind way in which you proposed the toast of the Institution. I thank you also for the very kind way in which you have spoken of myself this evening (applause).

The company then separated.

## AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *November* 14, 1890.

**New York Elevated Roads.**—Nothing has been done recently concerning the application of electric power to the elevated roads, although the West End Railway Company of Boston, which is about to build an elevated line, proposes to use electric traction exclusively.

**Edison Arc Light Machine.**—This Company is about to enter the arc lighting field with a machine of its own. Until very recently it has carefully avoided exploiting an arc system ; but about a year and a half ago it obtained the right to use the Sperry arc machine for its installations, and the present outcome is a near relative of that excellent machine. The same general form of construction has been employed, but the interior pole-pieces, always a questionable advantage in the Sperry system, have been dispensed with, and the regulator has been somewhat changed, although the same principle of shifting the brushes has been adhered to. The first of these new machines will be installed within a few days. The Edison Company's stock was attacked vigorously on Wall-street this week. During the period of depression it had held up remarkably, but finally, in the general attack on the Villard securities, it dropped more than 20 points. The confidence of the general public, however, in its real value was shown by a very sharp rebound within 48 hours, so that at present writing it has nearly regained the former quotations.

**A Westinghouse Power Plant.**—This Company has been displaying its usual activity in exploiting its street railway system. One of the most novel applications of the Westinghouse apparatus is now being installed in Telluride, Col. It is a mining country, where plenty of water-power is available, but the distances over which power must be transmitted are great. There is now being erected a Westinghouse power plant on the alternating system to transmit at first 100 horse power over about three miles, and later large additional amounts up to distances as great as fifteen miles. The generators used are the Westinghouse standard alternating type, and the motors are similar machines, to be run synchronously, and started by independent self-starting motors on the same circuit. Once up to speed, the large alternators will take their load with the greatest readiness. The power circuit will be of bare copper wire carried on rather high poles, and inasmuch as the country is sparsely settled, such a proceeding is safe. The plant is driven by Pelton water-wheels, under a head of nearly 500ft.

**New York Street Lighting.**—The electric lighting situation in New York City remains for the present unaltered. Mayor Grant, who has rendered himself thoroughly obnoxious to electrical interests during the last two years, has unfortunately been re-elected, so that the difficulties of the past will be in no wise lessened during the coming administration. The difficulties with the subway system are growing to be particularly annoying, and it is possible that even the present City Government may be compelled to take some measures for the relief of the electric companies from subway extortion. So great has been the demand for electric lighting that at a recent secret meeting of the Board of Electrical Control it was found necessary to allow the erection of certain pole lines.

## SCANDINAVIAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

COPENHAGEN, *November* 22, 1890.

The State telephone between Stockholm and Malmö, according to a telegram just received, has to-day been tested with satisfactory results. This is a very important installation right across the broadest part of Sweden, and the Swedish capital is now in telephonic connection with the two principal towns on the west coast, Gothenburg (240 miles) and Malmö (340 miles). I may have occasion to refer again to the Stockholm-Malmö line in a future letter. The manner in which the telephone is extending in Sweden is well worthy of attention. At the beginning of the present year the State telephones in Sweden comprised 3,338 separate lines, with an aggregate length of 8,843 kilometres. The number of telephones was 3,925, of which 135 were at telegraph or central telephone stations, and 3,790 were subscribers'. Together with private telephones, the total length of telephone lines was 46,090 kilometres at the beginning of the year, and there were 463 central stations and 18,854 subscribers. Of the above central stations the State owned 39. During last year the State expenditure upon telephones amounted to 416,813kr. (1kr. = 9½d.), and altogether up to the end of the year 1,386,535kr. The more important State telephone installations last year were the Stockholm, Gothenburg, Uddevalla lines, with an aggregate length of 624 kilometres.

During the year the State telephones received 46,021 telegrams, and were the medium of delivering 43,847 telegrams ; the number of subscribers' conversations amounted to 6,728,313, and conversations against special payment amounted to 56,468. The State telephones last year yielded 369,023kr. gross receipts, working expenses amounted to 180,187kr., and 58,168kr. were applied to a sinking fund. The surplus was thus 130,669kr.

Several Scandinavian towns have lately claimed the honour of having the largest number of telephones in proportion to their population of any town in Europe or, perhaps, even in the world. Christiania first entered the list, thinking her 2,600 subscribers, out of 140,000 inhabitants, that is, between 18 and 19 to every 1,000 inhabitants, was at the top of the tree. Stockholm has, however, 6,318 telephone subscribers out of 240,000 inhabitants, or 26 subscribers to every 1,000 inhabitants, but even this has been beaten by a small place. Ballnös, which, with barely 1,000 inhabitants, has 52 telephone subscribers.

The application of electricity is, however, by no means confined to the telephone, installations of various kinds having of late been taken in hand. I have already mentioned one electric railway opened in Sweden not long ago, and this is likely soon to be followed by several others. Concession has been given for an electric railway in Stockholm, from the Gustaf Adolf-square to Djursholm, and another has already been taken in hand between Karlslund and Örebro. Electricity is also likely to be gradually adopted as a means of power in a number of industrial establishments, owing to the many waterfalls which exist in Sweden. At some mines in the Vörmland district electricity is about to supersede steam. There is a waterfall at some 10,000ft. distance, which has hitherto been useless, but which will now be utilised, and the installation will also comprise one for electric light in the mines. At Ballnös, Sweden, a small electric central station has been erected, the water of the Ljusnan river supplying the power. The turbine is of 35 horse-power, and the dynamo can supply current to 400 16-candle lamps. The brewery, the inn, the railway, &c., will be lighted, and there are two arc lamps for the street.

## CORRESPONDENCE.

### AN IDEAL PHYSICAL LABORATORY FOR A COLLEGE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR : The enclosed note from Prof. Ewing, modifying one of my statements in connection with "An Ideal Laboratory" on p. 32, is worth inserting.—Yours truly, OLIVER J. LODGE.

*Extract.*

"By-the-way, I see you say apropos of laboratories, that absence of magnetic materials is a troublesome fad. I agree, with an important qualification. You should have no iron about the place *that is liable to large variations of temperature.* No iron hot water pipes ; no iron grates ; no iron stoves. When I began working in Japan I had what they call a drum stove made of sheet-iron, that got red hot now and then. In a few minutes it would wholly change the magnitude and direction of the local magnetic field, making magnetometer and galvanometer work impossible for many yards round. Naturally it had to be put out, and one had to take to working in one's ulster." J. A. E.

University College, Dundee, Nov. 15, 1890.

Digitized by Google

## PHYSICS v. METAPHYSICS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I do not think you have said, in your leading article for this week, a word too much against those pseudo-philosophers who are as poor metaphysicians as they are bad physicists. All true metaphysicians would be delighted to have "fashionable philosophy" and "amateur metaphysics" slaughtered once and for all.

It seems to me as if there were some hope of agreement between you and true metaphysicians, if you will not so much keep off each other's grounds as respect each other's points of view, and make allowance for each other's terminologies. As you suggest the hypothesis that electricity is the mode of action of something, the metaphysicians may claim to take matter as the mode of action of consciousness.

Mr. Heaviside's *obiter dictum* that "there are only two things going, matter and energy . . . . . . all the rest are moonshine," would be instantly swooped upon by metaphysicians as a bit of unsurmountable dogmatism, and an over-stepping of his province, particularly if he meant that where these two things are going is the whole universe, including man and the mind of man. "Consciousness returning into itself," or some such (to Mr. Heaviside, possibly) gibberish phrase, would be the strictly metaphysical-scientific way of expressing the effects which you call matter and energy. It is merely the tendency of knowledge to simplify, to reduce many forces on to a few, or many gods to one. It may be hoped, therefore, that the great division or dualism of physics and metaphysics, both alike capable of being true philosophies and true sciences, will in time be overcome, if the students of each will be patient with one another and humble of themselves.—Yours, &c., I. F.

November 26th.

## BOURSEUL'S SPECULATIONS ON THE TELEPHONE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to the last clause of Mr. Latimer Clark's letter to your paper, published in your issue of October 31, 1890, in which he says it would "be interesting to find the original source from which Count du Moncel derived his account of Bourseul's telephone," I am glad to be able to furnish him the information desired.

Bourseul's original letter on this subject, dated August 18, 1854, and having his signature appended to it, is to be found in *L'Illustration*, Paris, August 26, 1854, p. 139. This information is not quite novel, but since so distinguished a chronologist as Mr. Latimer Clark has overlooked, I may be pardoned for believing that it will be fresh also to many readers.

I cannot, however, coincide in the opinion of Mr. Latimer Clark that if Bourseul "had only put his ideas to the test of experiment, we should have had the telephone in 1854." If he will look over the Du Moncel account once more, he will see that Bourseul says, "I *have* made some experiments in this direction." But Bourseul contemplated a transmitter which would, as he says, "alternately make and break the currents from a battery." Reis exhaustively explored this plan, and failed. Bell forsook this plan and worked in an opposite direction, and succeeded; and it was because he forsook the idea of intermittences that he succeeded. It is easy to speculate, but difficult to achieve; and although the world knows that before Bell there was no speaking telephone, and that as soon he made known the art of the electrical transmission of speech they appeared by thousands; yet it is true that the failures of the men who were working in the direction of failure, and failed, are set up on a pedestal of equal height as the success of the man who worked in the direction of success, and succeeded.—Yours truly, THOMAS D. LOCKWOOD.

Boston, Mass., U.S.A., November 12, 1890.

## OIL INSULATION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As the employment of oil insulation for use in connection with currents of high potential seems to be exciting some interest at the present time, the following experiments on the relative sparking distance between bare conductors in air and immersed in resin-oil respectively, which I have recently made in connection with some apparatus for Lord Armstrong, may, perhaps, be worth publishing.

A 12in. induction coil, kindly lent for the purpose by Mr. Apps, was employed to produce the sparks, the terminals of this coil being connected to a movable point and ball forming the air gap electrodes, and also in parallel with these to a point and disc contained in a large vertical test tube filled with resin-oil, the point being at the bottom and connected by a wire sealed through the glass, and the disc being fitted to a sliding rod so that the distance between the two could be varied as required.

As shown below, this variation was made by tenths of an inch up to half an inch, and then by half inches at a time, the air electrodes being in each case adjusted till the spark took place indifferently through either oil or air.

| Spark in air (inches). | Spark in oil (inches). | Ratio. |
|---|---|---|
| 1· | ·1 | ·1 |
| 1·125 | ·2 | ·177 |
| 1·5 | ·3 | ·2 |
| 1·5 | ·4 | ·266 |
| 1·75 | ·5 | ·285 |
| 2·75 | 1·0 | ·363 |
| 5·125 | 1·5 | ·292 |
| 7·875 | 2·0 | ·253 |

On increasing the oil gap above 2″ the spark preferred to perforate the glass in two places and run down outside the tube rather than pass through the oil.

Though the above results seem to be somewhat irregular, they were carefully obtained, and it appears from them that for potential of this amount the sparking resistance of resin oil is from ten times to rather less than three times that of air. These results, especially those obtained with the higher potentials, seem to show that the insulation resistance of resin-oil is not altogether so high as has generally been believed, though it is probably high enough for all commercial purposes.

Some experiments were also tried with ordinary paraffin oil, and the opposition that this substance offered to the sparking was found to be about one-half that of resin-oil as above.

I may mention in conclusion that according to De la Rue a 1in. spark in air represents a difference of potential of 23,400 volts, and 163,600 volts for 7in.—Yours truly,

London, November 24, 1890. A. A. CAMPBELL SWINTON.

# LEGAL INTELLIGENCE.

### Dickins and Another v. Metropolitan Electric Supply Company (Limited).

In the Queen's Bench Division on Wednesday last, the case of Dickins and Another *v.* Metropolitan Electric Supply Company (Limited) came before Mr. Justice Stephen and a special jury. This was an action brought by Messrs. Dickins and Jones, drapers, &c., carrying on business in Regent-street, against the defendant company to recover damages for alleged breach of a contract to supply the plaintiffs with electric light. The defendants denied the alleged breach, and relied upon the provisions of a statute which they said justified their action.

Mr. Jelf, Q.C., and Mr. McCall appeared for the plaintiffs, while Mr. Lumley Smith, Q.C., and Mr. R. S. Wright represented the defendants.

Mr. McCALL, in opening the case for the plaintiffs, said that prior to 1888 his clients' premises were supplied with electric light from the Grosvenor Gallery. Subsequently they were supplied by Mr. Pritchett, of Rathbone-place, the price being so much for each lamp according to the candle-power. The contract was that the light was not to be cut off unless three months' notice were given. Afterwards the defendant company sent a notice to the plaintiffs to the effect that they had purchased Mr. Pritchett's business, and submitted to them certain terms, which were never actually signed. The plaintiffs continued to supply the light and to collect the amounts due in respect of it until the light was cut off. About September, 1889, the plaintiffs were informed that, owing to an Act of Parliament which had been passed, and of certain Provisional Orders included in the Act, the defendant company would no longer be able to supply that particular district, and they were advised by the defendants to communicate with Major Waller, of the London Electric Light Supply Corporation. The defendant company, however, added, "Of course, we will continue to supply you until we are turned out by force." The plaintiffs' manager called upon

Digitized by Google

the defendant company, and they arranged to continue the supply until the new company was in a position to supply the district. In October complaints were made by the plaintiffs with regard to the light, and then the defendant company replied that they were only lighting plaintiffs' premises on sufferance, and that they might be turned out at any moment. On November 16th, without any warning whatever, the supply was cut off, and the plaintiffs' premises were left in darkness. The defendant company, in answer to the action, said they were justified in doing what they did by reason of a clause contained in an Act of Parliament passed in 1889, confirming certain Provisional Orders made by the Board of Trade, under the Electric Lighting Acts, 1882. Section 6 enacted "that the undertakers shall not at any time after the commencement of this order supply energy or (except for purposes of this order) erect or lay down any electric lines or works beyond the area of supply, otherwise than under the authority of Parliament or under a license granted by the Board of Trade under the principal Act. Provided that where the undertakers were, on May 28, 1889, supplying, or under any binding agreement to supply, energy to any premises beyond the area of supply, they may continue to supply energy to such premises until September 29, 1890, or, in case any such notice as hereinafter described is served upon them, until such earlier quarter-day as may be mentioned in such notice." In consequence of the action of the defendant company, the plaintiffs had to light their premises with gas for some time, and their goods became greatly damaged.

Mr. HENRY DICKINS, senior partner in the firm of Messrs. Dickins and Jones, gave evidence in support of counsel's opening statement. He added that nearly the whole of his premises were supplied with the electric light. He received no notice that the light was to be cut off on November 16th. He had sustained considerable loss in consequence of the action of the defendant company. The gas injured the stock and made the premises dirty. He had had to pay Messrs. Verity £484 for electric light plant. Witness, in cross-examination, said he was aware that London had been divided into districts for electric lighting purposes, that the defendant company were restricted to Marylebone, and that two other companies supplied the district, of which Regent-street formed part. Mr. Lane, his manager, did not inform him that the existing cable, which brought the electricity from Rathbone-place, was not according to the new regulations. He did not know that unless the defendant company complied with the Board of Trade's regulations they had no power to supply them with electric light. He offered to pay £25 towards a new cable.

Several *employés* of the plaintiffs were called to show the serious effect which the alleged breach of contract had upon the plaintiffs' business and goods.

Mr. JOHN COLES, manager to Messrs. Verity, gave evidence to the effect that he superintended the fitting up of the electric light apparatus at the plaintiffs' premises. The work was completed by the commencement of February last. If the plaintiffs had received three months' notice, his firm could have fitted up the necessary apparatus for them within that period. In cross-examination, witness said he could have fitted up the apparatus within two months.

This concluded the plaintiffs' case.

Mr. LUMLEY SMITH, on behalf of the defendant company, submitted that there was no evidence of any contract to support the plaintiffs' case. Mr. Pritchett had not been supplying the electric light under any contract, because the form of the contract was never agreed to. Either party could at any moment, at will, have determined the arrangement. The defendant company went on supplying the plaintiffs with electric light upon the same terms as Mr. Pritchett had supplied them, but they were not bound to give plaintiffs any notice, as the plaintiffs had failed to agree to the form of contract sent into them by the defendant company.

Mr. JELF argued that there was ample evidence of a binding agreement between the parties. If no notice was mentioned in the contracts a reasonable notice must be inferred. Three months' notice was mentioned in the written bargain which the defendant company sent in to the plaintiffs, and he (the learned counsel) thought that was a fair notice.

Mr. LUMLEY SMITH said if the plaintiffs had refused to accept the light, the defendant company could not have compelled them to do so.

Mr. JELF said the contract was accepted and acted upon, though it was not signed.

His LORDSHIP said there never was a written contract between the parties at all, and he did not think there was any evidence of a contract arising from a matter of fact. Therefore he should enter judgment for the defendant company, with costs.

A stay of execution pending an appeal was granted.

### London Electric Supply Corporation v. Crookshank.

In the Queen's Bench Division, on Wednesday last, Mr. Justice Day, sitting without a jury, had before him the case of the London Electric Supply Corporation *v.* Crookshank, which was an action by the plaintiffs to recover from the Committee of the Pall Mall Club the sum of £120 for electricity supplied to the Club under a contract. The plaintiffs' case was that the defendants agreed to pay for the electricity supplied to the Club at the rate of £1 per annum for each lamp of 10 candle-power until a meter was fixed, and that then they were to pay the meter rate. The charge per lamp was considerably under the market value of the current supplied. There was a good deal of delay in fixing a meter at the Club, as the plaintiffs had some difficulty in obtaining a good instrument. A meter was finally fixed, and when the plaintiffs sent in their account for the electricity consumed according to the meter rate, the defendants refused to pay, and ultimately the plaintiffs cut off the supply. The defendants denied that the contract was that they were to pay the meter rate.

Mr. R. T. Reid, Q.C., and Mr. Lynch appeared for the plaintiffs, while Mr. Winch, Q.C., and Mr. Lyttelton represented the defendants.

At the conclusion of the evidence his LORDSHIP said it was greatly to be deplored that persons who made bargains which were not to be carried out at once did not take the trouble to put them into writing. He (the learned judge) had looked at the correspondence very carefully, but that did not disclose a contract by the defendants to take the electricity by meter. Though there was no doubt that the defendants had had a benefit which the plaintiffs did not intend to confer upon them, he was bound to decide the case according to the evidence put before him. He did not find that there was any agreement by the defendants to take the electricity according to the meter scale, and therefore he entered judgment for the defendants, with costs.

### Woodhouse and Rawson Electric Supply Company of Great Britain.

In the petition for the winding up of this Company, Mr. Graham Hastings, Q.C., who represented the petitioner, applied on Saturday that it might stand over, as the parties were negotiating for a settlement.

Mr. BUCKLEY, Q.C., who appeared for the Company, not raising any objection,

Mr. Justice STIRLING allowed the petition to stand over for a fortnight.

## TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

TENDERS WANTED.—The Pretoria Lighting Company (Limited) announce in our advertisement columns that tenders for (1) five multitubular boilers, (2) five engines, and (3) complete electric lighting plant, will be received until noon on Saturday, December 20, 1890, at the offices, 29 and 30, Holborn-viaduct, London, E.C., where plans of Pretoria and of the proposed works can be seen.

ROYAL NAVAL EXHIBITION, 1891.—By an advertisement in our columns to-day, intending exhibitors are reminded that all applications for space must be received by the 30th inst. Particulars may be obtained of the hon. secretary, Capt. Alfred Jephson, R.N., 6, Craig's-court, London, S.W.

MESSRS. BENTON AND STONE.—This firm have now removed from Mandril Tube Works to their new premises, Aston Brook Tube Mills, Birmingham.

REMOVAL NOTICE.—Messrs. Nalder Bros. and Co. notify their removal from Horseferry-road, Westminster, S.W., to more commodious premises at 16, Red Lion-street, Clerkenwell, E.C. Their new telephone number is 6,770.

FOWLER-WARING CABLES.—The Fowler-Waring Cables Company have sent us specimens of the cables used in the South London Railway. The main cable consists of 61 strands of No. 14 S.W.G., forming a core of nearly three-quarters of an inch diameter, the sectional area of copper being ·3067 square inch. It is served with about 170 mils thickness of insulation, and is protected by a lead covering of about 130 mils, and is finally taped and compounded, the overall diameter being about 1⅛in. Specimens have also been sent us of a 30-wire lead-covered telephone cable, the conductors being No. 18. This Company is devoting much attention to the production of wires for aerial and house purposes, and are laying down a large plant at their Woolwich works for all kinds of wires and cables, lead-covered, rubber-covered, vulcanised, &c.

LINESMAN'S TOOLS.—Messrs. W. Kücke and Co., of Elberfeld, Germany, are the makers of a handy wallet containing twenty-six tools in constant use by linesmen, making, when folded up for carrying, a compact arrangement weighing only 3¼lb.

## PATENT RECORD.

### APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

November 3, 1890.

17,976. G. QUICK. Bournemouth. Improvements in means for firing ordnance charges by electricity.

17,987. W. R. VARNEY. Weston-super-Mare. Improvements in electro-medical appliances.

18,034. G. F. REDFERN. London. An improved electric switch (A. Schirner, Germany).

November 10, 1890.

18,076. J. Y. JOHNSON. London. Improvements in sockets or holders for incandescent lamps (J. W. Collier, United States).

18,088. J. E. KINGSBURY. London. Apparatus to be employed at telephone switch-boards (The Western Electric Company, United States).

Digitized by Google

November 11, 1890.

18,103. C. E. Knowles. Manchester. Improvements in electric switches.

18,158. C. H. Gray. London. An improved electric pressure indicator.

18,163. M. Humm. Forest Hill. An appliance for the administration of electricity to the human body in Turkish baths.

18,180. Sir C. S. Forbes, Bart. London. Improvements in primary batteries, and in apparatus connected therewith.

18,186. H. H. Lake. London. Improvements in electrical measuring instruments (E. Weston, United States).

18,195. A. E. Cotterell. Moseley. Improvements in telephonic apparatus for minimising or overcoming inductive and other undesired electrical disturbances in telephonic circuits.

November 12, 1890.

18,206. H. Davis and A. H. Stokes. London. Improved communicator for dynamo-electric generators and motors.

18,217. D. Maclean. Sydenham. Improved protector for telegraph, telephone, and other electric instruments.

18,247. J. D. F. Andrews. London. Improvements in fittings for electric lamps and their conductors.

18,243. J. A. Mays. London. Improvements in electrolysis.

November 13, 1890.

18,266. H. J. Davies and L. B. S. Dutson. Walsall. Improvements in electric tramways and electric conduits.

18,270. J. M. M. Munro. Glasgow. Improvements in electrical conduits and conductors.

18,292. B. M. Drake and J. M. Gorham. London. Improvements in switches for electrical purposes.

November 14, 1890.

18,339. W. R. Lake. London. An improved process and apparatus for the production of oxygen and hydrogen by electrolysis (H. Dehuard, France).

November 15, 1890.

18,409. L. A. Davies. London. The improvement of electrical switches and other electrical apparatus.

18,412. D. Robertson. Glasgow. Improvements in electric batteries and lighters for cigars and other purposes.

18,423. J. P. Bayly. London. An improved coupling for electric wires (J. Hinphey and B. Matthews, United States).

18,470. A. F. Purdy. London. Improvements in telegraph keys. (Date applied for under Patents' Act, 1883, Sec. 103, 15th April, 1890, being date of application in United States.)

November 17, 1890.

18,491. R. Kennedy. Kilmarnock. Improvements in dynamo-electric machines.

18,523. H. Zerener. London. Improvements in apparatus for heating, welding, or gasifying solid bodies by electricity.

18,537. E. S. Cook. London. Improved method of signalling on railways, and appliances connected for electrically operating same.

18,554. H. J. Pierce. London. Improvements relating to the fixing in insulating bases of blocks for connecting electrical conductors.

18,555. H. J. Pierce. London. Improvements in electrical switches.

18,556. H. J. Pierce. London. Improvements in electrical switches.

18,557. H. J. Pierce. London. Improvements in electrical switches.

18,558. H. J. Pierce. London. Improvements relating to electrical pendants and other portable or movable electrical devices.

November 18, 1890.

18,576. R. H. C. Nevile. Westminster. Improvements in apparatus for controlling electric currents.

18,587. J. Platt. Gloucester. Improved form of electric locomotive (F. W. Dean, United States).

18,589. W. H. Waddell. London. Improvements in electric railway signals.

18,625. H. H. Lake. London. Improvements in and relating to apparatus for use in electric welding, forging, and other metal-working operations (H. Lemp, United States).

18,631. H. H. Lake. London. Improvements relating to the welding of metals by electricity (E. Thomson, United States).

18,638. E. Hartmann and W. Braun. London. Improvements in electricity meters.

18,660. A. J. McGeoch. London. An improved terminal for electric lamp holders.

18,661. J. T. Niblett. London. Improvements in the construction of plates for secondary batteries.

18,663. An improved instrument for removing the covering from insulated wires.

November 19, 1890.

18,695. J. H. Holmes. Newcastle-on-Tyne. Improvements in armatures for dynamo-electric machines.

18,699. W. H. Thomson and H. von Kohler. London. Improvements in electric circuit closers or push buttons.

November 20, 1890.

18,776. A. T. J. Cutmore and F. H. Bointon. London. Electric telegraphic communication between termini, intermediate stations, &c., and railway trains or vehicles in motion.

18,791. O. Imray. London. Improvements in fixing for exposed telegraph wires to insulators (J. U. Baptista, Brazil).

18,796. J. Benford. London. An improved locking sash fastener and electrical alarm and indicator for windows, doors, and like purposes.

November 21, 1890.

18,836. W. Friese-Greene. London. Improvements in meters for measuring electricity.

18,858. W. C. Hunt. London. Hunt's hygienic electric boots and shoes.

18,890. J. Y. Johnson. London. Improvements in automatic telephone connectors (The Automatic Electric Exchange Co., United States).

## SPECIFICATIONS PUBLISHED.

1889.

17,142. Bollman. Electro-magnetic transformers, &c. (Price 6d.)

17,424. Andrews. Electric conductors. (Price 6d.)

18,193. Rylands. Insulators, &c. (Price 11d.)

19,199. Badcock and Others. Electric Batteries. (Price 6d.)

19,525. Scott and Others. Electricity Meters. (Price 8d.)

19,831. Dorman and Smith. Electric Switches. (Price 8d.)

19,951. Bayley. Electrical Switches. (Price 8d.)

20,393. Jenkin. Lighting trains by electricity. (Price 8d.)

20,764. Thompson (the Westinghouse Electric Company). Electric generators. (Price 8d.)

20,856. Fitzgerald and Hough. Voltaic Batteries. (Price 6d.)

20,885. Price. Electric, &c., lamps. (Price 6d.)

1890.

232. Hopkinson and Others. Electric Motors, &c. (Price 8d.)

1,280. Baker. Electrical switches. (Price 8d.)

1,903. Thompson (The Electrolibration Co.) Treating disorders of the human system. (Price 8d.)

3,082. Langhans. Incandescent electric lamps. (Price 4d.)

6,032. Dewey. Electric heating apparatus. (Price 8d.)

6,037. Dewey. Electric railway vehicles. (Price 8d.)

8,242. Lake (Lemp). Electric welding. (Price 6d.)

8,393. Drake and Others. Electrical switches. (Price 8d.)

11,440. Mansfield. Electric railways. (Price 1s. 3d.)

12,830. Lake (Johnson and another). Secondary batteries. (Price 8d.)

13,421. Thompson (Coffin). Welding metals electrically. (Price 8d.

13,751. Huntington. Electric switches. (Price 6d.)

13,790. Lake (Curtis). Electric conductors. (Price 11d.)

14,186. Perkins. Electric switches. (Price 8d.)

14,191. Dewey. Electric railways. (Price 8d.)

14,817. Kennedy. Distribution of electrical energy. (Price 8d.)

15,456. Thompson (Coffin). Welding metals electrically. (Price 6d.)

15,482. Lake (Crosby Electric Company). Electric batteries. (Price 6d.)

# COMPANIES' MEETINGS & REPORTS.

## The Montevidean and Brazilian Telegraph Company (Limited).

An extraordinary general meeting of this Company was held at the offices, Langthorn House, Copthall-avenue, on the 25th inst., Dr. Cameron, M.P., in the chair, to consider the following resolutions :—

"1. *That the Company be wound up voluntarily under the provisions of the Companies' Acts.*

"2. *That George Fraser, F.C.A., be and he is hereby appointed the liquidator to conduct such winding up.*

"3. *That the Agreement submitted to this meeting, dated November 3, 1890, and expressed to be made between this Company, of the one part, and the Western and Brazilian Telegraph Company (Limited) of the other part (being an Agreement for the sale and transfer to the Western Company of the whole of this Company's undertaking), be and the same is hereby approved. And that the liquidator be and he is hereby authorised, in pursuance of Section 161 of the Companies' Act, 1862, and of all other powers enabling him in that behalf to carry said Agreement into effect with such modifications (if any) as he may think expedient.*

"4. *That the liquidator be and he is hereby authorised to receive, and when received, to distribute amongst the holders of Preferred Shares in this Company the rent accruing to this Company from the Western and Brazilian Telegraph Company (Limited), for the year ending December 31, 1890.*"

"5. *That the shares in the Western and Brazilian Telegraph Company (Limited) to be received as the consideration for the sale and transfer to them of this Company's undertaking shall be appropriated as follows:—*

"*To the shareholders in this Company in exchange for their shares at the rate of one share in the Western and Brazilian Telegraph Company (Limited) for each two shares in this Company.*

"*To the holders of Debentures of this Company in exchange for such Debentures at the rate of ten shares for each £100 of Debentures.*

Digitized by Google

*"To the liquidator in satisfaction of his remuneration and to the Directors and officers of this Company as compensation for the loss of their offices, 155 shares.*

*"The remaining shares to be sold, and the proceeds, after payment thereout of the expenses of the liquidation other than the liquidator's remuneration, to be distributed amongst the shareholders in this Company pro rata according to the number of shares held by them respectively."*

The SECRETARY having read the notice convening the meeting, as above,

Mr. CRISP (the Solicitor) read the proposed agreement between the Company and the Western Company.

The CHAIRMAN then said: I think I may take it that the very small attendance of this meeting shows that the shareholders have sufficient confidence in the Directors and are sufficiently satisfied with the arrangement which you have just heard read, for, though they have not turned up in large numbers at the meeting, they have sent us proxies representing 7,108 out of a total number of 8,314 Preferred shares and 599 out of a total number of 600 Deferred shares, giving a total very considerably more than three-fourths of the entire capital of the Company. That shows that the shareholders have taken a lively interest in the matter, though they are not largely represented in this room personally. Before this agreement can ultimately be adopted it must, as you know, be confirmed by a meeting to be held about a fortnight after this date, and in order that the shareholders, whom we shall ask again to support us at that meeting, may understand exactly how the matter stands, I propose making a statement on the whole subject, which we shall circulate among those who are not present to-day. In the first place, I would beg to remind you that if anyone feels inclined to cavil at the results of the working of this Company, the present Board is in no way responsible for those results. The present Board may be said to have come into office, and the present staff, the Secretary, and the solicitors, fifteen or sixteen years ago when the Company was in a very bad way financially. They had a very considerable amount of disagreeable work to undertake, and their first duty was to rescue the Company from bankruptcy. To show you the financial straits in which the Company then was, I may mention that although we attempted to raise money by an issue of Eight per Cent. Debentures, it was so insufficiently taken up that the Secretary and myself had to come to the assistance of the Company and advance a considerable sum of money in order to enable them to tide over the difficulties in which they then were. I would also point out that we have never had any opportunity of developing the resources of the Company or of pushing it in any way. We came into office finding ourselves bound hand and foot by agreement with the Platino Company, and, through them, with the Western and Brazilian Company. For some time past, as the shareholders are aware, negotiations have been going on between us and the companies with whom we have been working for the purpose of selling this Company to them. In 1885, the Western and Brazilian Company made us an offer, which was reduced to writing, which was agreed to by our Board, subject, of course, to ratification by the shareholders. We understood that the matter was practically settled. We called an extraordinary meeting of our shareholders, and that agreement was approved by them. We did not, however, by the advice of our solicitor, call the confirmatory meeting until the agreement had been ratified by the other company. For some reason or other, however, the Board of the other company changed their mind, and did not submit the agreement for confirmation to their shareholders at all. It is not for me to explain why they did not do so. It is possible that an explanation may be found in a change of policy which they have since adopted, which has consisted in the issue of a large number of new shares, and, with the funds so provided, to undertake in the first place the purchase of the business of the Platino Company, and now that of this Company. In the circular we issued in 1885, we pointed out to the shareholders that our shares were not negotiable on the Stock Exchange. Great inconvenience (the circular stated) had arisen in consequence of shareholders wishing to dispose of their shares, and suggestions had been made by large proprietors that the Company should be either reconstituted or merged in one or other of the larger telegraph companies of which it formed a portion. We further explained that a dispute existed between the Platino Company and the Western and Brazilian Company as to the right of one of those companies to participate in a portion of the earnings of the other company, that in that respect our interests were mixed up, and that had a suit come on we should have been parties to it; also that various subjects of friction had arisen which made it desirable that we should amalgamate. The terms offered to us in 1885 were that we should receive one share of the Western and Brazilian Company for three shares in our Company. They, on the other hand, were to bear all the expenses of the liquidation, the expenses of compensation for abolition of office, and they were also to pay off our Debenture debt. I think we have every cause to congratulate ourselves upon the agreement of 1885 not being carried out. It approved itself, however, to our shareholders. I do not think we had a single objection to it, and had it been carried out by the Western and Brazilian Company they would have acquired us on considerably better terms than those now under consideration. It is extremely satisfactory to me to know from the proxies that the shareholders' approval has been so general, because in the circular which we issued inviting those proxies we were obliged to put the case in its very mildest form. That circular was issued before the agreement had been ratified by the shareholders of the Western and Brazilian Company, and we were afraid that if we boasted of having made anything like a good bargain some of the shareholders in that company might object to the proposal, and that difficulties might be thrown in the way of carrying out the agreement. The Western and Brazilian Company have now confirmed the agreement at a meeting of their shareholders, and one may therefore explain to our shareholders exactly what the thing means. Putting the two offers on the same basis, by allowing for the liquidation of the mortgages, payment for compensation, and all those things, and simply taking the matter as regards the shareholders, under the offer of 1885 our Company would have received 2,972 shares in the Western and Brazilian Company, or one for every three of our shares, and the shares of the Western and Brazilian Company at that time were worth about £6 each. That is the figure at which we quoted them in our circular to the shareholders. In other words, there would have been available for distribution among our shareholders a sum of £17,832. Under the present offer we are to receive one share in the Western and Brazilian Company for every two of ours. In other words, excluding what is necessary for paying off the Debentures, compensation, &c., we are to receive for distribution among our shareholders 4,457 Western and Brazilian Shares, which are quoted at between 10 and 11, but say, for safety, 10. In other words, they have a value of £44,570 against the £17,832 of the 1885 offer.

A SHAREHOLDER: How much of our Debentures have been paid off?

The CHAIRMAN: I will come to that, but let me make my statement in my own way. In other words, the increase in the market value of the consideration we are now to receive, as compared with what we were willing to receive in 1885, is £26,738; and when you remember that the total amount divisible by the 1885 offer would have been £18,000, an increase of £26,000 on that amount may, I think, be termed a very fair bargain, and one showing sufficient interest in the concerns of the shareholders by those who were carrying it out. A gentleman has called my attention to the fact that, as we have mentioned in our own circular, our Company is in a better position now than it was in 1885, and I want to put the matter in the fairest light to our shareholders. Our Company has advanced in value, and we have paid better dividends by a long way latterly. But why has our Company advanced? Simply because the Western and Brazilian Company has advanced. Our earnings simply consist of a certain fixed percentage of the Western and Brazilian Company's earnings from a certain portion of their system, and any increased value of our Company—any increased dividend we have been able to pay—has simply arisen through the increased earnings of the Western and Brazilian Company, in whose shares we are to be paid. The increase in the value of our Company, however, has not been so great as in the case of the Western and Brazilian Company, because we do not participate in all the earnings of that company. They have a considerable revenue from land lines. I am now talking of the Western and Brazilian and the Platino Companies together, for they are now practically amalgamated. They have considerable earnings from land lines, in which we do not participate, and they derive advantages in rebates from other companies from which we do not benefit. Therefore, though it is clear that our Company must increase with the increase in value of the Western and Brazilian Company, yet our improvement is not to the same extent as theirs. The Western and Brazilian Company has increased in value more than we have, but for the sake of comparison we put that point out of the question. Assuming that we had increased in value to exactly the same extent as the Western and Brazilian Company, what do we find? When the shares of the Western and Brazilian Company were offered to us in 1885 they stood at £6 in the market, and they now stand at £10. Assuming our shares to have increased proportionately in value, and to have been worth what we were willing to accept for them in 1885—£2—they would now, by rule of three, be worth £3. 6s. 8d., but we are going to get £5 for them, or £1. 13s. 4d. a share for something not in any way connected with the increased revenue of our Company. What is that for? Our diminished indebtedness! We can measure the diminished indebtedness precisely. Our indebtedness has been since that date diminished by £5,380. Our diminished indebtedness between 1885, when we made our other arrangement with them, and the date at which we made our arrangement in 1890, amounts to £5,380, and in respect of that we are to have an increase of £1. 13s. 4d. per share, irrespective of any growth in value derivable from increased revenue. Well, £1. 13s. 4d. a share on our shares would amount to £14,850, showing a net increase in the price we received, beyond anything to justify it in the growth of value of our revenue or the diminution of our indebtedness, of £9,470, or close upon £10,000. I think that that shows we have made a very good bargain for the shareholders, and that their interests have not suffered through the agreement of 1885 not having been carried out. To put the matter still in another light—to show the advantages offered to the shareholders—the highest dividend we have ever been able to pay them has been 4s. 6d. per share. Half a share in the Western and Brazilian Company, which they will receive in exchange for their share, instead of paying 4s. 6d., will yield them a dividend of 6s. 9d. That I think ought to be satisfactory. It may be said that our revenue has increased. As I have told you before, our revenue can only increase through the increase in that of the Western and Brazilian Company, and if such an increase takes place you will benefit by it as shareholders in the Western and Brazilian Company. In addition to all this you will have shares which you can go on the market and sell, instead of being obliged to keep them in your safes as has been the case since you have been a Company. I do not think I have much more to say. I have mentioned the number of proxies in favour of our proposal, and we have only had, as far as I am aware, one shareholder who has intimated disapproval. That gentleman intimates his disapproval on two grounds. In the first place, under the agreement, we have intimated, in fact, to the shareholders that it would be necessary, and that we proposed to pay in dividing the assets of the Company, the Ordinary shareholders the same amount as we shall pay to the holders of the Preferred shares. Well, some of you may think that that is an inequitable mode of dealing with the assets of the Company; but we have no option in this matter. We are bound by the Articles of Association as to the way in which we should distribute the assets. The 4th Article reads thus: "The Preferred shareholders mentioned in the Memorandum of Association shall claim such preferential dividend as hereinafter mentioned, but in the distribution of assets

Digitized by Google

on a winding-up of the Company, they shall rank on an equal footing with the Ordinary shares mentioned in the Memorandum of Association." Now that I have read that, I think you will at once see that we have no power of making any other arrangement with regard to the Ordinary shares than that laid down in the Articles of Association. The second point on which exception has been taken by the one shareholder who has previously been hostile on the subject was the proposal in regard to the compensation of the Directors and officers of the Company. That is a delicate matter, and in considering it the Board felt constrained to take up what was an equitable and strong position. In 1885, in our negotiations with the Western and Brazilian Company, that company proposed to take upon itself the claim for compensation on the abolition of our offices. The secretary and myself had a long interview with the representative of the Board of the Western and Brazilian Company, at which the agreement was discussed. We had a great deal of wrangling about the terms that were offered to the shareholders. The interview lasted over several hours, and the interests of the shareholders at that meeting were, on our part, most vigorously fought and contested ; but with respect to the proposal for compensation upon the abolition of our offices, which was made by the Western and Brazilian Company, there was not one word of comment or dispute on our part. The Western and Brazilian Company made their offer, and it was accepted without one word of comment. That offer was embodied in the agreement which was approved at an extraordinary meeting of the shareholders in this Company, and we thought that on the present occasion we could not do better than propose to you the terms of compensation which had been offered by the Western and Brazilian Company when that company were going to pay them out of their own pockets. Those terms had been approved at the extraordinary general meeting of our shareholders in 1885, and they are the terms we are going to propose to you. It might fairly be argued, on the one hand, that as so much better terms have been obtained for the shareholders, better terms might be given to the officers ; but the remuneration of the officers is, of course, a fixed charge, and we never thought of making any such claim. I think if you are going to have compensation you could not have it fixed in a more impartial or sounder manner. It was fixed by the Western and Brazilian Company without the smallest haggling on our part when the Western and Brazilian Company was going to pay the compensation out of its own pocket. It might be said to us, "You are not entitled to any compensation at all," as some of our offices are only from year to year. So far as the Directors are concerned the question of compensation does not concern them much. Mr. Joicey is an original shareholder, and he and his friends hold over £30,000 in shares in the capital of the Company. I recently persuaded him to come upon this Board, but it was only under the threat that if he would not come and attend to his own interests I should not continue to do so for him. You cannot conceive that a man having £30,000 interest in a capital would care to spoil any bargain by what compensation he might receive out of a petty office like this. I have now to come to the secretary of the Company. After the last agreement was not carried out it became necessary for us if we were to conduct the negotiations with the Western and Brazilian Company to do so in a more or less reserved manner. A certain offer had been made to us by that company, subject to ratification by their shareholders. They had not had it ratified by their shareholders, however, and if we had gone running after them it would have appeared as if we were very anxious to get rid of our Company on any terms. The secretary acted as a sort of plenipotentiary in the matter. I do not know what the experience of others may be in other cases, but I venture to say that Mr. Fraser will do what is right, and will act for the benefit of his employers without regard to his own interests. I do not, however, think it would be encouraging to a man to say to him, "You go and negotiate and bring your own office to an end, and rest content with having done so, for we cannot consider the question of your compensation at all." I do not see how we could have left the point in that way. If we had done so we should, I believe, have been sacrificing the interests of the shareholders, for the merit of working out the whole details of this arrangement is due to Mr. Fraser. He brought us the information ; he was constantly in communication with the Board on the matter, but it was to his tact and pertinacity, I think, that we are indebted for the very great improvement in the terms we have obtained on the present occasion. I do not think that there is anything further to say except this, that under the law any member who disapproves of the agreement need not accept the shares. If the shareholder of whom I spoke as intimating, so far, his disapproval is present now, I hope that what I have said will partly explain matters to him, and will show him that his interest has been carefully guarded. It is proper that I should say a few words regarding the rights of a dissentient shareholder. The solicitors have, by the instructions of the Board, carefully looked into this matter, and have removed any doubt that might have existed in their minds, though I do not think they entertained any doubt. This is what they have written to us, "The sole right of a dissentient shareholder in such case is to require the liquidator to purchase his shares at a price to be fixed on by arbitration." I do not think that any shareholder would be likely to improve his position much by arbitration, and I do not think we need have to fear encountering any dissentient shareholders. I will, therefore, without further preface, propose the resolutions.

A SHAREHOLDER: Is there any objection to stating how you are to be compensated?

The CHAIRMAN replied in the negative, and pointed out that the terms were embodied in Resolution No. 5.

Mr. JOICEY, M.P., seconded the motion, observing that he was the largest shareholder in the Company. There was, he said, one point which the Chairman had omitted to refer to which he (Mr. Joicey) looked upon as rather a serious one—namely, the gradual disappearance, practically, of the property, as their concessions terminated in the course of about 22 years. He was a man who had had some experience in this matter, and he knew the difficulty there very often was in getting a concession renewed. While the Chairman had instituted a comparison with five years ago, they must not forget that their property was practically five years less value at the present time. He thought that the very fact that by a transference of this property to the Western Company they would get a marketable security ought to make them all very well satisfied with the proposed bargain.

Mr. NEILD inquired how long the Western and Brazilian Company's concessions had to run?

The CHAIRMAN replied that he could not state this information. In making the proposed arrangement they were considering the market value of the shares.

Mr. F. GORE BROWNE observed that the bargain appeared to him to be a very good one, and as representing some executors who had been anxious to get rid of their shares for a long time, he would not be disposed to submit to arbitration, and get his shares valued by an arbitrator whom he would confidently expect to give a lower value than he could obtain by accepting the Western Company's shares, and afterwards selling them in the market. It appeared that the Western Company paid this Company last year by way of rent or share of profits £3,783, and they now offered them practically £80,000 of nominal capital to buy this Company out. That £80,000 at 4½ per cent.—the rate of dividend which, he believed, the Western Company were now paying—gave £3,600. It was true that the Western Company thus made a small saving of £183 on the amount they would give to this Company ; but as a set-off against that, this Company would save their current working expenses. The arrangement seemed to him to be a reasonable bargain between the two parties, doing justice to both.

Mr. MACKINNON also supported the proposal.

The CHAIRMAN put the resolutions *en bloc*, and they were unanimously agreed to.

On the motion of Mr. F. GORE BROWNE a vote of thanks to the Chairman was passed, and the meeting then separated.

## The Swan United Electric Light Company (Limited).

The eighth ordinary general meeting of the shareholders was held at the Cannon-street Hotel on the 25th inst., under the presidency of J. S. Forbes, Esq.

The SECRETARY and MANAGER (Major S. Flood Page) read the notice convening the meeting.

The CHAIRMAN said: Gentlemen,—The report and accounts have been printed and circulated ; I suppose, therefore, I may take them as read. If that is your wish I will proceed to make the usual remarks upon them. I think, in view of the fact that we only meet you yearly, and that possibly in the course of the current year we have a good many fresh proprietors, I had better begin with the balance-sheet, and explain what the position of this Company really is, for to the uninitiated it is somewhat complicated. You will remember that its title is the Swan United Electric Light Company, and it is a union of two parts. The owners of the British patents and the owners of the foreign patents put them together and formed the Swan United Company, and in the course of time you will also remember that that union was dissolved. In fact, there was a sort of divorce because another competitor had cropped up—the Edison Company—and the position of the Swan United Company was so far altered that they made over their better half to the Edison, and retained for themselves their foreign connections. Now, with that little introduction, which I shall be able to apply as I go through the balance-sheet, you will ascertain really upon what basis your property rests to-day. If you will kindly follow the capital account you will see what the share capital of this Company is. It is so many partially paid shares, amounting in the aggregate to £375,071. Well, of these shares a number representing £3,530 had been taken up by people who omitted or declined to pay up their calls. Those shares were, therefore, forfeited, and, of course, to that extent are to the good of the Company. That is the barebones of that side of the account ; all the other items which follow have nothing to do with that essential part, the capital of the Company. You will see where it has got to. On the opposite side of the balance-sheet you will see "By cost of patent rights, &c.," represented by shares in Edison and Swan United Electric Light Company (Limited), £208,478, and the French Company, £30,489 ; and over and above these two solid assets, as typified by those figures, we have got patents held by the Company for Germany and other sources of income which are open to you as possessors of the patent either in England or abroad, outside Europe. Now comes the importance of this second operation—the absorption by the Edison and Swan Company of the British business of the Swan United. You will see that it stands at £208,478. You will find, when you come to deal with the dividends, what a very happy investment that has turned out so far as it goes at present. The bulk of the dividend which we propose to you to divide will have been derived from the interest coming to you in respect of those shares in the Edison and Swan Company. Well, with regard to the French Company, you know what we did there. We were in litigation with a powerful body of people in France, and France meant Russia, Austria, and some other countries ; and the Edison Company and the Swan Company were doing in France what we were about to do in London when, fortunately, the two concerns were fused. They were litigating in regard to the patents. We thought it was wise to avoid litigation as regards ourselves, and we came to terms, and a Company was formed of the Edison and Swan. Some amount of money was subscribed by the two companies, and they were each credited with a further amount of capital in respect of what was called the goodwill of the patents, our portion being £30,489, cash paid. Two million of francs is the nominal capital of the Company ; one million francs represented the sovereigns paid to carry on the business, and the other million of francs the goodwill and patents. Now, the other item of assets or property lies in

Digitized by Google

the unknown; the residuum, the German patents, with all they mean, and certain other rights which the Swan Company have got as the result of an agreement—the outcome of negotiations. For instance, they have a very large area out of Europe which they can supply with lamps if they can obtain customers. When I come to deal with the profit and loss account you will see how the capital is affected as regards your property and your income. Now, perhaps, I had better go through the items in the balance-sheet. It is apparently in its wrong place, because it contains items carried from the profit and loss account which should be dealt with, in fact, before the balance-sheet. The first item is sundry creditors, £3,477. On the opposite side the sundry debtors amount to £26,733. It seems a good deal of money to be owing, but the bulk of that is represented by the dividend payable by the Edison and Swan Company to ourselves—£25,000 out of the £26,000. Therefore the sundry debtors and sundry creditors about balance themselves. Then there is a balance from the previous account. The older shareholders, at any rate, will remember that for some years we paid no dividend, and, what is a great deal worse, for some years the balance at the end of the year was against the undertaking. There were losses instead of gains, and we determined to do, as a matter of prudence, what probably the law would insist upon our doing if the point was raised, namely, to write down out of the profits of the following years all losses suffered in the earlier years of the Company. The first time we had a balance to the good was on September 30, 1887, when £1,720 was brought in, and in the following year, 1838, we had a further credit balance of £8,332. The proprietors fully concurred with the Directors in recommending that both those amounts should be held in hand. We had litigation pending in Germany, with possible damages, and we thought it better to build up the credit of the concern by storing the earlier gains until our Company was more fully developed. In 1889 our profit had increased to £21,011, and, as you will remember, for the first time in the history of the Company, in 1889 we distributed a dividend. In the balance-sheet this balance from previous accounts amounts to £31,094, less dividends paid November 20, 1889, £22,203, which, you see, leaves £8,886 to be carried forward. Now, where the profit and loss comes in you will find balance Sepember 30, 1890, £35,590, and if you will cast your eye down the profit and loss account on the debtor side, and add this balance for the year to £8,806, you will see that the unexhausted profits up to September, 1890, come to £44,477, less the interim dividend at the rate of 6 per cent. per annum paid on May 21, 1890—£11,104, leaving £33,373 to be disposed of. The item of stock, which, of course, is an asset of the Company, and which amounts to £11,124, represents a very great number of manufactured lamps; and the value in the shape of platinum, bulbs, and material is entered here at a figure very much below selling value. We have thought it prudent in this account from time to time to put down the stock carried forward at approximately the manufactured price, leaving the question of profit, although it is pretty secure as a deferred stake, because it is possible that something may arise—though it is hardly within the bounds of probability—to prevent the sale of this stock of lamps at a value exceeding its manufactured price. Well, now, if any gentlemen would like to inquire into the substantial asset of the Company they will see what it is by the figures given with respect to the Edison and Swan and the French Companies, and they will also see the other items of capital investments in Consols, stock, cash in hand, and so forth. By turning to the profit and loss account you will see what the items of stock are. The purchases, as you will notice, are £9,115. That means partly materials and partly lamps. I may mention that we had from time to time the advantage of working in amity with the Edison and Swan Company. As we were united with them in our mutual interests we were able to play into each other's hands, and it happened that a demand set in for lamps in Germany which they could not supply. Fortunately, we were able to supply these lamps for them, and this item embraces the lamps so purchased and the material used up in the factory at Kalk, near Cologne, where, over and above the lamps so supplied, are manufactured a considerable number. The next item is office expenses, Directors' fees, rent, salaries, income-tax, &c., £3,513; wages and expenses at factory, £5,046. That is, wages and expenses as distinct from material or lamps. Depreciation, the item already referred to, is £490. Sales—ledger reserve—£150. This is in case we make bad debts. We have no anticipation of doing so, only we like to be on the right side. On the other side of the account there is the item by sales, less commissions and allowances, £12,317, and also the item of transfer fees and interest, £1,763. Now, these two items are realised from what may be called the open asset of the Swan Company—the power to make lamps in Germany, or to make or license somebody else to make and export lamps; and the interest on investments—£5,000 in Prussian Consols, and £29,000, in round numbers, in English New Two and Three-quarter per Cent. Consols. Then we come to the income depending upon the fixed investments, namely, the dividend on shares in La Compagnie Générale, £1,771; and dividends on shares in the Edison and Swan United Electric Light Company, £30,655, which is a big figure. In fact, this sum comes to 8 per cent. upon the whole of your capital. That is a very important thing, and I dare say those gentlemen who have taken sufficient interest in the affairs of the Edison and Swan Company to attend their meetings or read their reports will know, humanly speaking, that the future of that Company is likely to be fairly prosperous. We have, as you know, got protection for a certain number of years, but our policy has not been founded upon protection at all. It is founded upon, at the end of the protected period, having such a character and *clientèle* and capacity for production that nobody else can have any chance of competing with us. Well, we must work to that standard. As long as the protecting period lasts there is no doubt that the dividend upon the Edison and Swan Company may be looked for as a tolerable one. Well, now, the French Company, although they have only started very recently have a fine factory, but they have not succeeded in doing as well as we do in the production of lamps. First of all, they do not make nearly so many as we do, and, of course, it takes a certain time to develop a very efficient and at the same time a very economical lamp. The processes are so very multifarious and technical that it requires considerable practice to get into the best groove. Of course, there is the advantage of their having the Edison and Swan interested more or less in them as partners, and we are enabled to give them the benefit of our large experience at our great works at Ponder's End, where, of course, we have had from the beginning the advice of the best technical men, including Mr. Swan, than whom there is no greater authority. At Ponder's End we have succeeded in producing lamps of an efficient kind at moderate prices, and our French friends have had the benefit of our experience. They paid 6 per cent. to the end of December, their year ending later than ours. We ought to have had some dividend in respect of the period succeeding that, but we have thought it prudent not to put it into the account until we have got it. France is still engaged in litigation about the patents, because there are in France, as in other places, a great number of people who like to avail themselves of the fruit of other people's brains without paying for it, and so in France there are plenty of infringers. We blame the lawyers in England, and the law's delay is a household word among us; but our experience of Germany in this respect is only capped by our experience of France as to the difficulty of getting the law to settle anything. The proceedings are going on there, and are likely to go on, and until the litigation is finished we do not know the value of our business. I think I have now about exhausted the balance-sheet and the profit and loss account, and the report as well, as it only contains in other words what I have been telling you. The credit balance of £44,477 is brought out in paragraph two. That sum you will find in the balance-sheet is diminished by the interim dividend, already paid, by £11,104. We propose to pay a dividend at the rate of 10 per cent. for the entire year, and to carry forward £8,451, which is very nearly the amount of the accumulated undivided profits which was brought into the year's accounts, and, therefore, the payment of 10 per cent. means the distribution, as nearly as possible, of the year's profits. The decision in the patent suit in Germany was given in favour of this Company in the Court of Appeal, in Berlin, during the summer. We were beaten in the first Court, although the Patent Department in Germany, after being consulted on the matter, gave a report in our favour. But the judge did not take quite the same view of the matter, and we had to appeal, and in that appeal we succeeded in obtaining a decision that the Swan Patent is not an infringement of the Edison, we were decreed by the Court of Appeal not to be infringing it. Of course, if we did it would be rather a serious matter. We should then have either to make terms with the Edison Company or shut up shop; but we are going to continue making the lamps, and selling them, and also realise a profit on them, until the decision of the Supreme Court at Leipsic is given. Only then shall we know if we shall be able to go on making our lamps in Germany or not. In Paris they are contesting the validity of the French patents, and we hope to get a decision there next spring. Meanwhile, they are going on making the lamps and selling them. Whilst these judicial proceedings in France and Germany are pending, everybody in these countries are making lamps, and selling them, with the result that the price is affected. Under the circumstances the companies in these countries have to bear the burden of defending their suits, and at the same time to lower their price for the lamps in order to keep pace for the time being with the infringers. What has happened here may happen there, namely, when we got hold of notorious infringers they had, at the end of the litigation, to reimburse us a good solid sum for the lamps that they had sold. I have no subject for further comment, unless any question shall elicit anything fresh; and I will now move,

"*That the report and accounts for the year ending September 30, 1890, be received and adopted.*"

Mr. F. R. LEYLAND seconded the motion.

In reply to questions and remarks of Mr. Mills, the CHAIRMAN stated that the dividend payable this year had, of course, been earned in the current year by the Edison and Swan Company, which would hardly pay a dividend unless it had been earned. Certain shareholders, of whom their own Company was the largest, were entitled out of the profits of each year to a dividend of 7 per cent. before the Deferred shareholders received anything; and this 7 per cent. was cumulative. For a number of years no dividend was paid to the Edison and Swan shareholders, and for a number of years it was only partly paid. Against those years were booked up the future profits over the heads of the Deferred shareholders. The amount was still very large, he believed considerably over £100,000, and that had to come back out of the profits of each year over and above the 7 per cent. referred to. When this incumbrance was paid off, the Deferred shareholders would participate in the profits over 7 per cent. to the extent of one-fourth. There was, it was true, a large amount of stock carried forward compared with the amount of stock brought forward: but they had increased the manufacture not in reference merely to the year, but with some forecast for the future. However, they had already sold about one-half the number of lamps embraced in the item in question at a price pretty nearly representing the whole amount at which the stock was valued in the books. He could not agree that the office expenses, £3,513, were too high. Of this amount the Board received £1,500, and their services were very cheap at that price (hear, hear, and laughter). They had very great interests to safeguard. As to their having too much money in hand, they could not return any of it to the shareholders merely of their own free will. They would have to reduce the amount of the capital of the Company, and to go to the Court of Chancery and all that sort of thing. Moreover, he did not believe they would have any too much money, in view of the development of their business in Germany, should they succeed in the litigation in establishing their

Digitized by Google

contention. At present they were working in that country with a very small capital, having thought it more prudent and wiser in every respect, in the existing uncertainty, to retain the money in Consols, rather than expend it in establishing large works in Germany. The patents would expire in between three and four years. There was not the least chance that they would be renewed, and honestly he believed that they would be a great deal better without them. Hitherto the electric light had only been "creeping along," but there were evidences now that it was making enormous progress, and their lamp was the key of the position.

The motion was then unanimously adopted.

The CHAIRMAN next proposed the following resolution :—

"*That in addition to the interim dividend at the rate of 6 per cent. per annum for the six months ended March 31, 1890, already distributed, a dividend at the rate of 6 per cent. per annum be, and is hereby declared on the shares of the Company for the half-year ended September 30, 1890 (making 6 per cent. for the year), and of 4 per cent. for the 12 months ended September 30, 1890, free of income-tax ; to be distributed in accordance with the provisions of Clause 77 of the Articles of Association.*"

Mr. LEYLAND seconded the motion, which was carried unanimously.

Resolutions were afterwards unanimously passed re-electing the retiring Directors—Mr. F. R. Leyland and Mr. Quilter, M.P., and the auditors, Messrs. Welton, Jones, and Co.

Mr. H. H. DOBREE then proposed a hearty vote of thanks to the Chairman and Directors.

Mr. MILLS, in seconding the motion (which was carried unanimously), said he had not had the least intention in his previous remarks of criticising the Directors' remuneration.

The CHAIRMAN, in reply, stated that whenever the litigation in Germany was closed, the necessity for keeping the Edison and Swan Company and the Swan Company as two separate undertakings would cease, both these heads would be put under the same umbrella, and this would materially reduce the expenses.

The proceedings then closed.

---

## Reuter's Telegraph Company (Limited).

Notice is given that a special meeting of this Company will be held at 24, Old Jewry, on Saturday, December 6th, at 12 o'clock noon, when the subjoined resolutions will be proposed and submitted to the Company :—

"1. That the capital of the Company be increased to £100,000 by the creation of 2,500 new shares of £8 each, and that the Directors be forthwith authorised, under the provisions of clause 26 of the Articles of Association of the Company, to issue such shares.

"2. That, subject to the provisions of the Company's (Memorandum of Association) Act, 1890, the provisions of the Memorandum of Association of the Company, with respect to the objects of the Company, may be altered as follows, that is to say, by expunging sub-sections 2 and 3 of clause 3 of the Memorandum of Association, and by inserting in lieu of the sub-sections so expunged the following sections :—

"(2) To carry on and extend the said business and generally to carry on, acquire, obtain, and supply telegraphic, telephonic, or other news and intelligence, and to issue, publish, and circulate, and otherwise utilise, with a view to the profit or advantage of the Company, the same news and intelligence.

"(3) To carry on in the United Kingdom, and in any part of the world, the business of general advertisement contractors and advertising agents in all its branches.

"(3A) To construct, purchase, hire, or otherwise acquire, or work telegraphs and telephones for any of the purposes hereinbefore mentioned."

## Electric Construction Corporation (Limited).

The following is the report of the Directors to be submitted to the shareholders at the ordinary general meeting to be held at Worcester House, Walbrook, London, E.C., on Monday, December 8, 1890, at twelve o'clock noon :—

The Directors beg to submit the accounts of the Corporation up to September 30, 1890, showing a profit of £52,639. 3s. 2d. This may be considered as eminently satisfactory, having regard to the facts that (1) the Corporation did not enter into full possession of all the properties acquired until October 31, 1889 ; and (2) the Corporation has not during the past year had the benefit of the increased power and economy of production to be derived from the new Bushbury Works, to which special reference is hereafter made.

*Profit and Loss Account.*—From the profit of £52,639 3s. 2d., the Board have written off the whole of the preliminary expenses of the formation of the Corporation, amounting to £4,348 7s. 6d., and they have also carried to capital account a considerable sum resulting from licenses and resales of patents. No patents have been sold or licences granted which can, in the opinion of the Directors, prejudice the profit earning power of the Corporation, and possibly a certain portion of the amount so applied to capital might have been regarded as divisible profits ; but, having regard to the large amount of the capital of the Corporation at present represented by patent rights, the Directors are satisfied that the shareholders will support the more prudent policy which has been adopted.

*Application of Profits.*—From the profit balance of £48,290. 15s. 8d. the Directors recommend :—(1) That the sum of £15,000 be placed to reserve account against depreciation ; (2) That a dividend of 6 per cent. be declared and paid upon the capital which has been from time to time called up, and paid in respect of the ordinary shares of the Corporation, from the date of allotment on June 7, 1889, to September 30, 1890, inclusive, carrying forward the balance to the current year's account.

*Bushbury New Works.*—At an early date after acquisition of the Elwell-Parker business, the Directors satisfied themselves that the existing Wolverhampton (Commercial-road) Works were inadequate to cope with the large and increasing orders for electrical goods, and particularly for those of the heavier class now in demand for central stations. A very advantageous site was secured at Bushbury, near Wolverhampton, immediately adjoining and in direct communication with the London and North-Western Railway Company. Works have been there erected which, it is believed, will enable the Corporation to supply electrical work of any class ; but, having regard to the manner in which the business of the Corporation has developed, provision has been made for still further extensions should the necessity arise. The cost of the construction of these works, with the necessary land, sidings, and machinery, has, of necessity, been great ; but the Directors are satisfied that the capital of the Corporation has been well expended.

*Increase of Capital.*—In the prospectus of the Corporation it was stated that "as the business and profits of the Corporation increase, the Directors will from time to time propose the issue of additional capital, but care will be taken that the holders of the original capital shall be entitled to a preference or priority of allotment in subsequent issues." To secure the full advantage and profits of increasing business it is desirable that a considerable addition should be made to the resources of the Corporation. In the opinion of the Directors a Debenture issue would be more economical and advantageous to the present shareholders than an increase of capital either by ordinary or preference shares. Subject to any expression of opinion on the part of the shareholders at the general meeting, the

PATENT

SILICIUM BRONZE AND SILICIUM COPPER WIRE.

The best for overhead Telephone and Telegraph Lines,

AND ALL ELECTRICAL PURPOSES.

Hard Drawn High Conductivity Copper Wire.

ROLLED AND DRAWN PHOSPHOR BRONZE.

PHOSPHOR BRONZE BEARINGS, BUSHES, AND OTHER PARTS OF ELECTRICAL MACHINERY.

PHOSPHOR BRONZE — VULCAN — PHOSPHOR — DURO METAL

SOLE PROPRIETORS of the British, Indian and Colonial Patents,

THE PHOSPHOR BRONZE COMPANY (Limited),

87, Sumner Street, Southwark, London, S.E.

WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

Digitized by Google

Directors therefore propose to make a sufficient debenture issue. Care will be taken that shareholders desiring to subscribe to these debentures shall have the opportunity of doing so.

*Directors.*—In accordance with the Articles of Association, four of the Directors, viz.: Sir Daniel Cooper, with Messrs. Balfour, Courtenay and Dibley, retire from the Board, all of whom are eligible, and offer themselves for re-election. The Directors regret that the pressure of his professional engagements has compelled Sir Douglas Fox to resign his seat at the Board. Sir Henry C. Mance, C.I.E., has consented to give the Corporation the benefit of his great experience and scientific knowledge as Chairman of the Board.

*Auditors.*—Messrs. Broads, Paterson, and Co., the present Auditors of the Corporation, retire, and offer themselves for re-election.

## Blackpool Electric Tramway Company (Limited).

The annual meeting of the shareholders of this Company was held on Saturday last at Blackpool, the Chairman of the Company, Mr. Alderman Richard Horsfall, J.P., being in the chair.

In moving the adoption of the report (given below), Mr. HORSFALL said it was his pleasure to meet them again as Chairman of the Company, and congratulate them upon their balance-sheet. He did not know that he had anything to say except that they were working satisfactorily and that all their machinery was in good working order. The finances were good, and the Directors felt they came before them with a thorough, sound, and honest balance-sheet. He had great pleasure in moving the adoption of the report and balance-sheet, which allowed a dividend of 7½ per cent.

Mr. T. H. MORRIS, J.P., Halifax, seconded. He thought the Directors had much satisfaction in confirming what had been said. Their plant was in good order, and their prospects were never more satisfactory than they were at the present moment. The dividend had been honestly and satisfactorily earned, and the depreciation put by (£1,000) was only for the contingencies of the Company at a future date.

The report having been unanimously adopted, and the retiring Directors and auditor having been re-elected, the CHAIRMAN, in responding to a vote of thanks to the Directors and officers, said he was not of opinion that the Corporation would take over the concern at the end of the first seven years' term, which expires next year.

The following is the Directors' report:—"The revenue account shows a balance in hand for the year of £2,455. 9s. 3d. Adding to this £231. 5s. 10½d. from last year makes an available amount of £2,686. 15s. 1½d., of which the Directors recommend the following disposal: Dividend of 7½ per cent. on the called-up share capital, free of tax, £1,501. 17s. 6d.; depreciation and reserve fund, £1,000; balance to next year's account, £184. 17s. 7½d. The depreciation and reserve fund, with the addition of £1,000 as above recommended, will be £4,418. 15s. 1d. The number of passengers carried this year was 812,299. The number of miles run during the year was about 92,000. The retiring Directors are Messrs. Ormerod, Shaw, and Smith, who are eligible for re-election. Mr. Broadbent's services as Managing Director have been secured again for the coming year."

## NEW COMPANIES REGISTERED.

**ANGLO-MEXICAN SAW-MILLS COMPANY (LIMITED).**—Registered by Mr. James Curtis, 1, Old Jewry-chambers, E.C., with a capital of £5,000 in £1 shares. Objects: To carry on in Mexico the business of saw-mill proprietors, and to acquire all necessary rights of using steam, electricity, or water power in connection therewith; and to acquire and deal with patent machinery, apparatus, and materials for the production and distribution of electricity.

**CHAGFORD AND DEVON ELECTRIC LIGHT COMPANY (LIMITED).**—This Company was registered on the 18th inst., with a capital of £2,000, in £1 shares, to adopt an agreement of 12th inst., with Edmund Eaton and G. H. Read, for supplying electric light to Chagford, Devonshire. Registered without special articles by Mr. J. Fleming, 27, Martin's-lane.

**"ELECTRICITY AND ELECTRICAL ENGINEERING" NEWSPAPER COMPANY (LIMITED).**—This company was registered on the 18th inst., with a capital of £500, in £10 shares, to establish and work a newspaper in the interest of electrical science in all branches. The subscribers are:—Wm. Swan Sonnenschein, 62, Russell-square, publisher; H. Wigham, Uplands, East Sheen, publisher; R. O. Smith, 73, Eaton-square, publisher; F. C. Tilney, 126, Corbyn-street, N., clerk; Julius Maier, Ph.D., 23, Melrose-gardens, W.; F. D. Summers, 13, Oberstein-road, Wandsworth, private secretary; G. Newnes, M.P., Wildcroft, Putney-heath. Registered without Special Articles. Solicitors, Messrs. Bowman and Co., 21, Bedford-row.

**ERNEST SCOTT AND MOUNTAIN (LIMITED).**—Registered by Slaughter and May, 21, Great Winchester-street, E.C., with a capital of £70,000, in £10 shares. Object: To carry into effect (1) an agreement, made October 11th, between Ernest Scott, trading as Ernest Scott and Co., and E. H. Turner; (2) an agreement of the same date, made between E. H. Turner and Ernest Scott; (3) an agreement of the same date, made between E. H. Turner and William C. Mountain; to carry on the business of electrical and general engineers, machine and engineering tool makers, &c. There shall not be less than three nor more than five Directors. The first to be appointed by the subscribers to the Memorandum of Association. Qualification, £1,000. Remuneration, £200 each.

**ELECTROLYTIC SYNDICATE (LIMITED).**—Registered by the Metropolitan and Provincial Syndicate (Limited), Lonsdale Chambers, 27, Chancery-lane, with a capital of £100,000 in £1 shares. Object, to carry into effect the following agreements:—(1) An agreement made October 25th between William Elmore and Alfred Wells; (2) an agreement made October 24th between Arthur Cooper and Alfred Wells; (3) an agreement made October 25th between John Fraser and Alfred Wells; (4) an agreement made October 23rd between Woodhouse and Rawson United (Limited) of the first part, William Elmore, Frank Elmore, and A. S. Elmore of the second part, and Alfred Wells of the third part; to carry on as principals or agents business as miners, metallurgists, and smelters. The first subscribers are:—J. J. Atkinson, Cosgrove Priory, Northants; W. Elmore, 47, Clapham-road, S.W.; J. T. Cooper, Cregg, Nightingale-lane, S.W.; F. Safford, 2, Garden-court, Temple; S. Evans, Lonsdale Chambers, Chancery-lane; W. J. Tipputt, 11, Maiden-lane, E.C.; W. J. Peck, Redcar House, Redcar. Registered without Articles of Association.

**FINANCIAL EXCHANGE AND BUREAU (LIMITED).**—Registered by Robertson and Farmer, 8, Leadenhall-street, E.C., with a capital of £10,000, in 99 ordinary shares of £100, and 50 Founders' shares of £2 each. Objects: To carry on business as principals or agents for, and in the sale, purchase, negotiation, or dealing with industrial concerns, railways, loans, concessions, gas, water, electric, and all other works.

**SOUTH MOLTON SHIRT AND COLLAR MANUFACTURING COMPANY (LIMITED).**—This Company was registered on the 7th inst., with a capital of £5,000, in £10 shares, to manufacture shirts, collars, and cuffs, and to supply electricity for lighting and other purposes! Solicitors, Messrs Riccard and Son, South Molton, Devon.

## CITY NOTES, &c.

**BRAZILIAN SUBMARINE TELEGRAPH COMPANY.**—The receipts of this Company for the week ended November 21st amounted to £5,637.

**STOCK EXCHANGE.**—The Committee have appointed Tuesday, December 2nd, a special settling day in Elmore's French Patent Copper Depositing Company (Limited)—shares Nos. 1 to 66,750.

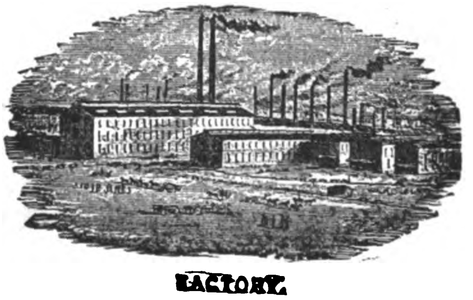
**WESTERN AND BRAZILIAN TELEGRAPH COMPANY.**—The traffic receipts of this Company for the week ending November 21, 1890, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited) were £4,421.


THE NON-CONDUCTOR OF ELECTRICITY.

**VULCANISED FIBRE,**
PATENTED.

This new material is supplied in two qualities, Flexible and Hard.
The FLEXIBLE is a substitute for Leather, Rubber, Gutta Percha, &c., and is extensively used by Brass Founders, Axle Makers, Hydraulic, Sanitary, and other Engineers, Pump Makers, Carriage Builders, &c.
It makes the best Hot and Cold Water Packings, and for Axle Washers of all kinds it is unequalled.
The HARD is a substitute for Metals, Hard Wood, Ivory, Vulcanite, Ebonite, &c., and is a good Insulator.
Sold in sheets, 5ft. 6in. by 2ft. 6in., varying in thickness from 1-50in. to 1in.

FLEXIBLE, 2/- per lb.; HARD, 2/8 per lb.


FACTORY.

**MOSSES & MITCHELL, 70, Chiswell-st., London, E.C.**


Digitized by Google

# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name. | Previous Week's Price, Nov. 19. | | Price Wednesday, Nov. 26. | | Rate per Cent. Yielded. £ s. d. | Dividend Due. | Business Done During Week Ending Nov. 26. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **TELEGRAPHS.** | | | | | | | | |
| 1,381,330 | Stock | 15/0 | Anglo-American | 48 | 49 | 48½ | 49½ | 5 16 2 | Jan., Apr., July, Oct | * 48¾ | 48½ |
| 2,809,310 | Stock | 30/0 | Do. Preferred | 84 | 86 | 84½ | 85½ | 6 14 6 | " " | 85½ | 84½ |
| 2,809,310 | Stock | .. | Do. Deferred | 12¾ | 13¼ | 13 | 13½ | .. | .. .. | 13½ | 13 |
| 25 ,000 | £100 | 4% | African Direct, 4 per Cent. Debentures | 97 | 100 | 98 | 101 | 3 19 3 | January and July .. | .. | .. |
| 130,000 | 10 | 3/0 | Brazilian Submarine | 11 | 11½ | 11 | 11½ | 6 10 5 | Mar., June, Oct., Dec. | 11½ | 11 |
| 84,500 | 100 | 5% | Do. 5 per Cent. Bonds | 101 | 103 | 101 | 103 | 4 17 1 | January and July .. | .. | .. |
| 75,000 | 100 | 5% | Do. 5 per Cent. Bonds (2nd Series, 1906) | 104 | 108 | 104 | 108 | 4 12 7 | June and December | .. | .. |
| $7,216,000 | $100 | .. | Commercial Cables | 102 | 104 | 102 | 104 | 5 15 5 | April and October .. | 103½ | 103 |
| £ .6,000 | £10 | 8/0 | Cuba Submarine | 11½ | 12 | 11½ | 12 | 7 1 8 | February and August | 11¾ | 11½ |
| 6,000 | 10 | 10% | Do. Preference 10% | 17 | 18 | 17 | 18 | 5 11 1 | " " | 17¾ | 17½ |
| 12,931 | 5 | 2/4½ | Direct Spanish (£4 paid) | 3¾ | 4½ | 3¾ | 4½ | 5 12 11 | April and October .. | .. | .. |
| 6,000 | 5 | 10% | Do. Preference 10% | 8½ | 9½ | 8½ | 9½ | 5 5 3 | " " | .. | .. |
| 60,710 | 20 | 3/6 | Direct United States | 9¾ | 10¼ | 10 | 10½ | 6 13 7 | Jan., Apr., July, Oct. | 10½ | 10⅞ |
| 400,000 | 10 | 2/6 | Eastern | 13⅝ | 13⅞ | 13⅝ | 13⅞ | 4 13 8 | " " | 14 | 13¾ |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference | 14¾ | 15¼ | 14½ | 15 | 4 0 0 | " " | 14⅞ | 14½ |
| 1,200,000 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock | 103 | 106 | 103 | 106 | 3 15 6 | May and November | 105½ | 104½ |
| 200,000 | £100 | 5% | Do. 5 per Cent Debentures, 1899 | 106 | 109 | 106 | 109 | 4 11 9 | February & August | 106½ | 105½ |
| 250,000 | 10 | 2/6 | Eastern Extension | 13¾ | 14¼ | 13¾ | 14 | 5 0 0 | Jan., Apr., July, Oct. | 14 | 13¾ |
| 320,000 | 100 | 6% | Do. 6 per Cent. Debentures, 1891 | 100 | 102 | 100 | 102 | 5 17 8 | February & August | 101½ | .. |
| 91,800 | 100 | 5% | Do. 5 p. c. (Aust'n. Gov. Sub.) Debs. 1900 | 102 | 105 | 102 | 105 | 4 15 3 | January and July .. | 10 ½ | 103½ |
| 145,300 | 100 | 5% | Eastern & S. African 5 per Cent. Mor Deb., 1900 | 101 | 104 | 101 | 104 | 4 16 2 | " " | .. | .. |
| 180,227 | 10 | 1/9 | Globe Telegraph and Trust | 8½ | 8¾ | 8⅝ | 8¾ | 5 9 10 | Jan., Apr., July, Oct. | 8¾ | 8⅝ |
| 180,042 | 10 | 6% | Do. 6 per Cent. Preference | 14¼ | 14¾ | 14½ | 14¾ | 4 2 9 | " " | 14½ | 14½ |
| 150,000 | 10 | 5/0 | Great Northern | 15¾ | 16¼ | 15¾ | 16¼ | 4 12 4 | Jan., April, and July | 16½ | 15¾ |
| 15,000 | 100 | 5% | Do. 5 per Cent Debentures, 1881 | 101 | 104 | 101 | 104 | 4 16 2 | January and July .. | .. | .. |
| 230,000 | 100 | 5% | Do. 5 per Cent. Debentures, 1883 | 104 | 107 | 104 | 107 | 4 13 6 | March & September | 106 | .. |
| 17,000 | 25 | 37/6 | Indo-European | 35 | 37 | 35 | 37 | 6 15 2 | May and November | 36½ | 36½ |
| 38,348 | 10 | 4/0 | London Platino-Brazilian | 6 | 7 | 6 | 7 | 5 14 4 | " " | .. | .. |
| 100,000 | 100 | 6% | Do. 6 per Cent. Debentures | 105 | 108 | 105 | 108 | 5 11 1 | March & September | .. | .. |
| 9,000 | 8 | 4/0 | Reuter's | 8½ | 8¾ | 8½ | 9 | 5 11 1 | April and October .. | 8⅝ | 8½ |
| 3,381 | £100 Cert. | 6% | Submarine Cables Trust ....x April Coupon, 1890 | 110 | 114 | 110 | 114 | 5 5 3 | " " | .. | .. |
| 15,609 | £10 | 6/6 | West African | 8½ | 9½ | 8½ | 9½ | 5 5 3 | January and July .. | .. | .. |
| 290,000 | 100 | 5% | Do. 5 per Cent. Debentures | 98 | 101 | 98 | 101 | 4 19 0 | March & September | .. | .. |
| 30,000 | 10 | 3/0 | West Coast of America | 4 | 5 | 4 | 5 | 10 0 0 | January and July .. | .. | .. |
| 150,000 | 100 | 8% | Do. Debentures 8% | 102 | 107 | 102 | 107 | 7 9 7 | June and December | .. | .. |
| 88,321 | 10 | Nil. | West India and Panama | 3 | 3½ | 2¾ | 3½ | .. | .. | 3½ | 2⅞ |
| 34,563 | 10 | 6/0 | Do. 1st Preference 6% | 11½ | 11¾ | 11½ | 11¾ | 5 2 2 | May and November | .. | .. |
| 4,669 | 10 | 27/6 | Do. 6 p. c. 2nd Pref. | 11 | 12 | 11 | 12 | .. | " " | .. | .. |
| 64,174 | 15 | 6/0 | Western and Brazilian | 10½ | 11 | 10¾ | 11½ | 5 6 8 | " " | 11¼ | 10⅞ |
| 27,873 | 7½ | 1/6 | Do. 5 per Cent. Cumulative Preferred | 6¾ | 6¾ | 6½ | 7 | .. | – | 6⅞ | 6¾ |
| 27,873 | 7½ | 4/6 | Do. 5 per Cent. Deferred | 4½ | 5 | 4½ | 5 | .. | .. | 4⅝ | .. |
| 200,000 | 100 | 6% | Do. 6 per Cent. Debs., Series "A" | 103 | 106 | 103 | 106 | 5 13 2 | February & August | .. | .. |
| 250,000 | 100 | 6% | Do. 6 per Cent. Mort. Debs., Series "B" | 103 | 106 | 103 | 106 | 5 13 2 | " " | .. | .. |
| $1,336,000 | $1,000 | 7% | Western Union 7 per Cent. 1st Mortgage | 120 | 125 | 120 | 125 | 5 12 0 | May and November | .. | .. |
| £175,100 | £100 | 6% | Do. 6 per Cent. Sterling Bonds | 99 | 103 | 99 | 103 | 5 16 6 | March & September | 100½ | 100½ |
| | | | **TELEPHONES.** | | | | | | | | |
| 224,850 | 14/0 | 0/5¼ | Consolidated Telephone Const. & Maintenance. | 7/16 | 9/16 | 7/16 | 9/16 | .. | May and November | .. | .. |
| 220,000 | £1 | .. | Oriental (11s. paid) | [illegible] | [illegible] | [illegible] | [illegible] | 4 8 3 | Yearly | .. | .. |
| 433,984 | 5 | 3/0 | National | 4⅜ | 4⅝ | 4⅜ | 4⅝ | 6 6 4 | June and December | 4⅝ | 4 9/16 |
| 15,000 | 10 | 6/0 | Do. 6 per Cent. Cumulative 1st Pref. | 12¼ | 12¾ | 12¼ | 12¾ | .. | " " | 12 7/16 | .. |
| 15,000 | 10 | 4/9¾ | Do. 6 per Cent. Cumulative 2nd Pref. | 9¾ | 10¼ | 9¾ | 10¼ | 5 14 3 | " " | 10 | .. |
| 209,750 | 1 | .. | South of England, Ordinary | [illegible] | [illegible] | [illegible] | [illegible] | .. | – | .. | .. |
| 20,000 | 5 | 2/0 | Do. 6 per Cent. Cumulative Pf. (£3 10s. pd) | 2¼ | 3 | 2¼ | 3 | .. | .. | .. | .. |
| 58,000 | 5 | 1/0 | United River Plate | 3 | 4 | 3 | 4 | .. | January and July .. | .. | .. |
| 146,128 | Stock | .. | Do. 5 per Cent. Debenture Stock | 90 | 95 | 90 | 91 | 5 9 11 | .. | .. | .. |
| 3,200 | 100 | .. | Do. 7 per Cent. Debentures | .. | | .. | | .. | – | .. | – |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | | | |
| 200,000 | £5 | .. | London Electric Supply | 2¼ | 2¾ | 2 | 2½ | .. | .. | .. | .. |
| 43,900 | 10 | .. | Metropolitan Electric Supply (£8 paid) | 6½ | 6¾ | 6¾ | 7¼ | .. | – | 6¾ | 6⅞ |
| 42,853 | 5 | .. | Westminster Electric Supply (£3 paid) | 2¼ | 2¾ | 2½ | 2¾ | .. | .. | .. | – |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | | | |
| 63,416 | 3 | .. | Brush Electrical Engineering | 1¼ | 1¾ | 1 | 1¼ | .. | .. | 1⅜ | – |
| 63,416 | 2 | 0/10 | Do. 6 per Cent. Preference | 1⅛ | 2 | 1¼ | 1¾ | 6 17 2 | June and December | .. | .. |
| 20,000 | 5 | .. | Crompton and Co., 7 per Cent. Pref. Shares | 5½ | 5¾ | 5½ | 5¾ | 6 1 9 | January and July .. | .. | .. |
| 17,130 | 5 | .. | Edison and Swan United | .. | | .. | | .. | .. | .. | .. |
| 45,000 | 10 | 6% | Electric Construction | 8 | 8½ | 7¾ | 8½ | 7 5 5 | .. | 8½ | 7¾ |
| 70,000 | 2 | 10/0 | Elmore's Patent Copper Depositing | 3¼ | 4 | 3¼ | 4 | .. | .. | 4⅛ | 3¾ |
| 20,000 | 5 | .. | Fowler-Waring Cables (£4 paid) | 2¼ | 3¼ | 2¼ | 3¼ | .. | .. | .. | .. |
| 41,600 | 10 | 10/0 | India Rubber, Gutta Percha & Telegraph Works | 18 | 19 | 18 | 19 | 5 5 3 | February & August | 18⅜ | – |
| 200,000 | 100 | 4½% | Do. 4½ per Cent. Debentures, 1896 | 100 | 102 | 100 | 102 | 4 8 3 | March & September | .. | .. |
| 78,949 | 5 | 6% | Swan United (£3. 10s. paid) | 5 | ½ | 4½ | 5 | 7 0 0 | May and November | 4⅜ | .. |
| 37,350 | 12 | 12/0 | Telegraph Construction and Maintenance | 43 | 45 | 43 | 45 | 5 6 8 | March and July..... | 45 | 43½ |
| 150,000 | 100 | 5% | Do. 5 per Cent. Bonds, red. 1894 | 100 | 102 | 100 | 102 | 4 18 0 | January and July .. | 100½ | .. |

JABLOCHKOFF'S **DISTRIBUTION PATENT**

(BEING A PATENT FOR "PRODUCING AND DIVIDING ELECTRIC LIGHT," No. 1996 of 1877.)

**THE ELECTRICAL ENGINEERING CORPORATION, LIMITED,**

(STATTER'S) Are Proprietors of the above Patent, and Warn the Public against Infringement. (UNITED).

*The following are Licensees:—*

Brush Electrical Engineering Company, Limited.
Crompton & Co., Limited.
S. Z. de Ferranti.—London Electric Supply Corporation, Limited.
W. T. Goolden & Co.
Hammond & Co.

Wilson Hartnell.
Johnson & Phillips.
Laurence, Paris & Scott, Limited.
Nalder Brothers & Co.
Paterson & Cooper.
Ernest Scott & Co.
Siemens Brothers & Co., Limited.

3, PRINCE'S MANSIONS, VICTORIA STREET, WESTMINSTER.

PERCY E. SCRUTTON, *Secretary.*

Digitized by Google

# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 655.—Vol. XXVI. FRIDAY, DECEMBER 5, 1890. Price Fourpence.

## NOTES.

The election of Sir William Thomson to the Presidency of the Royal Society is an event of so much interest to the electrical world, that its premature disclosure at the Institution of Electrical Engineers' dinner was a thing to be expected, and not to be blamed. Sir William is the foremost representative of the electrical, and indeed, of physical science of his time. His elevation is well timed in every respect, and will serve as much as anything else to lend interest and prestige to a subject which deserves all the attention it can command just now, both from the public and from the scientific world.

It is difficult to express the disappointment and regret with which we learn that the mischief caused by the fire at the Grosvenor Gallery has not yet ceased. A set of transformers was arranged with fire-proof precautions, and nearly all the circuits were running on Wednesday, November 26th. The transformers were not those which are destined to distribute the current from Deptford to the supply circuits, but were a number temporarily banked together, some being new and others being some of those which had survived the fire, and which had been repaired as thoroughly as possible. On Tuesday last one of these hastily repaired transformers became overloaded and burned out; the load was thus transferred to the others, which "went," one after the other, in the manner familiar to those who have attempted to run glow lamps on an arc circuit. It is expected that one circuit will be resumed to-day. We have not sufficient information as to the magnitude of the damage as compared with that which was produced directly by the fire, and it is only a small comfort to know that the disaster was due neither to the high pressure, the Ferranti mains, or to any other peculiar feature of this bold but unlucky concern.

The discussion on the Accumulator Papers at the Institution of Electrical Engineers on Thursday last, although productive of some important remarks, was not very satisfactory from a practical point of view. It could not be expected to be very fruitful in this respect, since those who were most qualified to speak with authority were also those most restricted from doing so by commercial considerations. Several specimens of grids and plates were exhibited in illustration of recent improvements in manufacture, and also to show the great durability of accumulator plates if only proper care is taken. Mr. Drake's remarks about the use of dense acid (S.G. = 1·350) were especially interesting, because if cells containing such acid have remained in good condition for over six years it becomes an important question whether any increase of efficiency would result from using acid of other than the normal density.

The question of acid density seems a very important one from the theoretical point of view. Mr. Hibbert considers that the changes in the voltage of the cell are mainly due to alterations in the density of the acid at the surfaces of the plates. The chemical actions going on within the cell are very complex, and have not been rendered any clearer by the discussion at the Institution, or at that which took place the following day at the Physical Society in connection with a paper on accumulators by Gladstone and Hibbert. Electrical Engineers cannot enter deeply into the theoretical reasons for and against the views of Dr. Frankland as to the formation of complex sub-sulphates during the charge and discharge. They will be inclined to follow Dr. Gladstone in his belief that there is no conclusive chemical evidence for the existence of such compounds. According to Gladstone and Hibbert, the percentage of lead to sulphate actually found agreed much more nearly with the ordinary substance $PbSO_4$ than with the subsulphate of Dr. Frankland; and this view was confirmed by Mr. Robertson, who undertook the chemical analyses referred to in the Paper by Prof. Ayrton. The simple theory, however, cannot explain the rapid alteration in volts at some parts of the charge and discharge, nor does it account satisfactorily for the fact that cells may be left with safety only when fully charged.

One of the most satisfactory features of the paper, and of the discussion which took place on the first evening, was the simplicity of the chemistry of the subject. It is well known that many electrical engineers have held aloof from the investigations of secondary batteries, not only on account of the complexities of the chemical actions, but because chemists cannot agree amongst themselves as to the changes which take place, or as to the constitution of either plate at any given moment. The hopes which were raised in the minds of many, that the time had now come when the chemistry may be stated in a simple manner, are sadly disappointed, and we are threatened with mysterious sub-sulphates, into the consideration of which the majority of engineers have neither time nor inclination to enter. It is apparent to all who have had to do with accumulators in practice that it is no more necessary to

Digitized by Google

deal with the notion of $S_2Pb_3O_{10}$ either in the construction or in the use of a battery, than to use quaternions in designing or running a dynamo. It is to be hoped that the chemists will clear this matter up shortly, or electrical engineers will be driven to take refuge in some provisional hypothesis from which it will be difficult to drive them.

THE Paper by Mr. WEBSTER on the electrical treatment of sewage suffered from the absence of actual figures relating both to the treatment and cost, owing to a delay in the publication of the official report on the experiments at Salford, and it was placed at an additional disadvantage owing to the absence of the author through ill-health. While the question is one of literally vital importance to this country, the question of cost must remain as the leading factor in any comparison with other systems. The figures given by the author need some further explanation. It is not clear how 400 indicated horse-power can be generated, continuously we presume, for £2,500 per annum. Taking the volts at 1·8, this 400 horse-power for ten million gallons corresponds fairly well with ·37 ampere-hour per gallon, and is equivalent to 6,600 kilowatt-hours a day. At three half-pence per kilowatt this amounts to about £41 per day. One penny per horse-power hour, as suggested in the discussion, comes to £40 per day, or £14,600 per annum. It is very remarkable that if an attempt be made to imitate an electrolytic action by chemical decomposition, the action is not so great. It has been shown that a certain quantity of chlorine given off by the decomposition of common salt by an acid is not so efficient as the same quantity produced by electrolysis. Similarly, attempts have been made to treat sewage by the salts of iron which Mr. Webster's process produces, but the results are not so good.

THE pretty experiment shown by Prof. SILVANUS THOMPSON to the Physical Society, on Friday last, in illustration of Prof. EWING'S theory of magnetism is important in view of future magnetic researches, as well as in connection with mere lecture purposes. Now it is known that small encased magnetic needles can be easily procured in quantities at a reasonable cost we may expect that the behaviour of groups of such magnetic elements, under the influence of magnetic force, may become the subject of experimental study. The mathematical investigation of such actions is quite hopeless, as it would involve the calculus of probabilities, and life is as a rule too short. Experiments on the influence of different groupings of needles can, however, very quickly be made. Prof. THOMPSON has, indeed, already succeeded in using the method to explain the fact, first observed by himself, that the two forms in which magnetite exists exhibit different powers of retentiveness for magnetism. The simple explanation is that the homogeneous variety acts like a number of magnetic needles far apart compared with their length, while the heterogeneous specimens act as if the magnetic elements composing them were close together.

INFORMATION on the life and efficiency of glow lamps is becoming a matter of considerable importance now that the manufacture of cheap lamps has assumed so important dimensions. We alluded to this subject only three weeks ago in connection with the reduced price of lamps in the United States. We publish this week an abstract of a paper by Professor NICHOLS, which clearly describes some of the imperfections to which glow lamps are liable, and which may be expected to assume very serious proportions when lamps are made for sixpence and sold for a shilling as may be expected two or three years hence. The defects are well known, but at present their magnitude is not a matter of great importance, partly because we have no choice, and partly because we believe that the one make of lamp which is for sale is a good one, if the eight-candle hundred-volt lamp be excepted.

THE second part of Professor NICHOLS' paper relating to that radiation which Professor E. WIEDEMANN has called "Luminescence," is of great interest both to the physicist and to the lamp maker. The connection between the dazzling brilliance of the flame of burning magnesium and the radiating power of the oxide of that metal in an as it were passive state, is not at first sight apparent. It appears that we have hitherto been too prone to follow the theory of exchanges in considering the emissivity of incandescent solids; at the same time it must be remembered that not one of the numberless inventions of refractory materials for mixing with or for superseding carbon, have yet proved to be of any real value.

OUR friends across the Channel have always been noted for the degree to which they place patriotism before pocket, and one result of carrying this highly commendable principle to excess is to be seen, we think, in the *projet de taxation*, which will be found in another column. The French electrical industry, already considerably cockered in one way and another, is, if we are to believe the statements of its representatives, in a very parlous condition; a high "compensatory" import tariff being absolutely essential to its continued existence. Doctors sometimes recommend a judicious course of "roughing it" to delicate indivduals, and we are inclined to think that something analogous would benefit the French electrical industry almost as much, and the unfortunate consumer considerably more, than a hot-house *projet de taxation*.

THE voltmeter of Mr. WESTON, of the permanent magnet type, is, we believe, as excellent in its accuracy and sensitiveness as any one of that class of instruments can be, but, like most voltmeters, it is subject to a serious temperature error. The method of correcting by switching in resistances, as described in our Notes, is, however, a rather barbarous device, if we may use so strong an expression. The automatic compensation by winding two circuits with wires of different temperature coefficients is not only simple, but perfectly successful. We understand that voltmeters when thus compensated do not vary one-tenth per cent. from the moment they are put on to the time they attain their maximum temperature, nor are they affected by variations of external temperature, but we believe that there is but little demand for them.

Digitized by Google

MANY of those who have followed the latest discoveries of electrical science appreciated the opportunity which was afforded on Sunday afternoon for making the acquaintance of Dr. HEINRICH HERTZ, of Bonn. A more pleasant and informal way of introducing a distinguished visitor than that adopted by Prof. AYRTON, at the Langham Hotel, it is difficult to imagine.

**The British Guiana Cable.**—We are informed that the Trinidad-Demerara cable is now repaired.

**Dublin.**—Extensive damage was done to the Dublin telephone wires by the heavy snow fall of the past week.

**The Aron Meter.**—Dr. Aron's electricity meter received a gold medal at this year's Exhibition at the Palais de l'Industrie, Paris.

**King's College, London.**—The Council of this College are ready to receive applications for the appointment of Demonstrator in Electrical Engineering.

**The Stations of the Metropolitan Supply Company.**—The automatic cut-outs described in our last issue are on the dynamo circuits, and not on the exciter circuits.

**Barnsley.**—The Town Council has adopted the minutes of the Park and Lighting Committee, which recommended the adoption of the proposed contract with the Westinghouse Electric Company.

**University College, Nottingham.**—The Committee of this College invite applications for the post of Junior Demonstrator in Physics. Further particulars will be found in our advertisement columns.

**The Telephone in Spain.**—The regulations hitherto in force that telephone lines were not to exceed 10 kilometres in length have been abolished, and concessions for longer lines will now be granted.

**The Ferranti System in France.**—The central lighting station on the Ferranti system, which came into operation at Troyes in August last, now supplies 2,000 lights, and is paying its way very satisfactorily.

**University College, Dundee.**—In consequence of Prof. J. A. Ewing's election to the Professorship of Mechanism and Applied Mechanics in Cambridge University, the Chair of Engineering at the above College will shortly be vacant.

**City and South London Railway.**—The Austrian Minister of Commerce has resolved to send two engineers to London to study the City and South London Railway, with a view to utilising the system on the projected Vienna Metropolitan Railway.

**Institution of Civil Engineers.**—At the last ordinary meeting of this Institution, it was announced that 14 Associate Members had been transferred to the class of members. Amongst the names we notice those of Dr. E. Hopkinson and Mr. Alexander Siemens.

**Old Students' Association.**—At the ordinary general meeting of this Association held yesterday, at Finsbury Technical College, a Paper was read by Mr. Hamilton Kilgour, member, on "Notes on Economy of Conductors in Systems of Distribution of Electrical Energy."

**Bristol.**—The Western Counties and South Wales Telephone Company have, as an experiment to the end of the year, connected the Bristol Messengers' Association to their exchange. By this arrangement subscribers can immediately obtain the services of a respectable and responsible messenger.

**Whitechapel Board of Works.**—On the recommendation of a large committee, to whom the matter had been referred for consideration, this Board has resolved to light the district by electricity, and to apply for a Provisional Order. It is proposed to employ the heat from the local destructor to generate steam.

**Chelmsford.**—At the last meeting of the Town Council, several members complained of the occasional extinction of both arc and incandescent lamps. It was decided that the Town Clerk should be instructed to write to Messrs. Crompton and Co. for an official explanation of the reason of the lights going out.

**Paddington Vestry.**—At the last meeting of this Vestry Colonel Barchard presented a report of the Electric Lighting Committee, and announced that the Metropolitan Electric Supply Company had deposited £20,000, and taken a site at St. Peter's Park, Amberley-road, and that the Company would commence work immediately.

**Hampstead Vestry.**—This Vestry has resolved to oppose all applications for electric lighting powers, and has empowered the Electric Lighting Committee to spend not more than one hundred guineas in obtaining a plan and estimate from an expert, with a view of guiding the Vestry as to the advisability of undertaking the work itself.

**Copper.**—The copper supplies for November have been somewhat smaller, while the deliveries have increased substantially, the total for the month amounting to 11,230 tons, as compared with 10,206 tons in October. The result is a further shrinkage in the stock, which now stands at 65,440 tons, whereas a year ago the total amounted to 99,984 tons.

**S. S. "Silvertown."**—This telegraph steamer, owned by the India Rubber, Gutta Percha, and Telegraph Works Company, is reported to have arrived at Coronel (Chile), on November 25th. It will be remembered that she carries the submarine cable for extending the Central and South American Telegraph Company's lines from Lima, where they at present terminate, to Iquique and Valparaiso.

**Platinum.**—The greatly-increased price of platinum, to which we referred in a recent issue, has naturally given rise to strenuous efforts, not only to find a satisfactory substitute, but to discover new mines. A few months ago Mexico was reported to be rich in platinum ores, and now the *Ballarat Courier* announces that ore has been found in Australia containing nearly 160lb. of platinum to the ton.

**O.S.A. Smoking Concert.**—A most enjoyable concert was held at the Masons' Hall Tavern, Basinghall-street, on Friday evening, November 28th. The programme included violin solos by Mr. Gatehouse and songs by Mr. Howden Tingey, Mr. John Barton, Mr. Gordon Heller, and a musical sketch by Mr. F. Charlton Fry. We understand that after Christmas there will be a series of entertainments of a similar nature.

**The Spanish-Morocco Cables.**—The firm of Pirelli, of Turin, have obtained the contract for the construction and laying of the cables connecting Spain with the Spanish stations on the coast of Morocco. According to *La Lumière Electrique* the contract price is £160 per mile, the money to be paid in ten equal annual instalments. During these first ten years the cables are to be maintained at the contractor's expense.

**Royal Institution.**—The Friday evening meetings of this Institution will begin on January 23rd, when a discourse will be given by Lord Rayleigh on "Some Applications of Photography;" succeeding discourses will probably be given by Lord Justice Sir Edward Fry, Professor J. W. Judd, Professor A. Schuster, Dr. E. E. Klein, Mr. Percy Fitzgerald, Dr. J. A. Fleming, Dr. Felix Semon, Professor W. E. Ayrton, and others.

**Electric Snow Ploughs.**—Twenty-five new electric snow ploughs, much heavier than those in use last winter, have been ordered by the West End Railway Company of Boston, and four of them are already completed. The new plough somewhat resembles a small freight car. It is six feet wide and eight feet long; the cab is eight feet long and seven and a-half feet high. The electrical equipment comprises two 15 horse-power motors.

**Sophia.**—Considerable discontent is said to have been expressed by the Bulgarian press at the manner in which the tenders for the electric lighting of Sophia have been dealt with by the committee charged with this matter. This committee is reported to have merely opened the tenders and accepted the lowest without further inquiry. A Budapest firm, presumably Messrs. Ganz and Co., are said to have sent in the lowest tender.

Digitized by Google

**University College, Aberystwyth.**—The workshop accommodation of the Physical Laboratory in the University College of Wales, Aberystwyth, has recently been considerably extended, and arrangements are being made for a course of instruction in electrical engineering. The recent additions include one of Messrs. Crossley's D high-speed engines, specially adapted for electric lighting, a Crompton dynamo (shunt and compound-wound), and a Crompton DD arc lamp, &c.

**Woking.**—The central station of the Woking Electric Supply Company is on the north side of the London and South-Western Railway, in the vicinity of the London and Basingstoke Canal, where substantial brick buildings have been erected, comprising boiler-house, engine and dynamo house, offices and stores, containing at present a plant capable of supplying 2,000 lights. The electrical plant comprises two Kingdon 60-unit 2,000 volt alternators. The mains are laid along the roadsides in stoneware pipes.

**The Tommasi Accumulator.**—An accumulator has been brought out by M. Donato Tommasi, the distinguishing feature of which is the use of hollow cylindrical perforated electrodes. Each cylinder is filled with active material, and closed at the bottom by an insulating plug, into which is screwed a rod running up the centre of the cylinder and terminating in a flat projection. The lids of the cells are slotted, and the cylinders are hung in rows from these metal-edged slots by means of the projections on their central conductors. Each row of cylinders constitutes an electrode.

**Long-Distance Telephony.**—A group of French and Belgian capitalists is offering to undertake the construction of a telephone trunk line between Berlin and Warsaw, a distance of about 360 miles. The estimated cost of the line is £360,000. The syndicate proposes to hand over the line after a certain number of years to the Russian Government. The charge is to be 6 francs for the first minute's conversation, and for every subsequent minute 25 per cent. less than the charge for the preceding minute, thus: two minutes' conversation for 10fr. 50c.; three minutes conversation' for 11fr. 50c., and so on.

**Local Authorities and Electric Traction.**—The North Metropolitan Tramway Company have received the consent of the London County Council to run electric cars over the northern portion of their line, which is controlled by the Council, during the term of seven years. The tramway company have also given notice of a Bill which they intend to introduce into Parliament, asking Parliament to compel the Local Authorities to conform to the Act, as passed last Session. At present the West Ham Local Authorities decline to grant more than one year's license, subject to 24 hours' notice.

**Electric Traction in Boston.**—Some idea of the magnitude of the operation of the electrical equipment of the West End Street Railway may be gained from the fact that from February 1, 1889, to July 31, 1890, the mileage of the motor cars was 3,121,689, and the mileage of towed cars 732,003.80, making the total mileage of cars dependent upon electricity for propulsion 3,853,692. During the seven days from August 10th to August 16th the electric cars carried on an average about 100,000 passengers per day, and at no time were there more than an average number of 150 cars in daily service.

**Long-Distance Business Communications by Telephone.**—A late experience of *The Electrical Engineer* has, says our New York contemporary, done more to inform us of the benefits of long-distance telephoning than any quantity of outside testimony could do. The business manager of the journal being away in Philadelphia, he called up the New York office, whereupon a big batch of morning mail was read to him and replies were dictated to a stenographer in New York. So successful was the experiment it has since been repeated more than once, and has become a practice on every such occasion.

**Poona.**—At the recent meeting of the Cantonment Committee, says the *Indian Engineer*, the scheme for the electric lighting of Poona was brought up for discussion. Messrs. Woodhouse and Rawson, of London, have offered to form a syndicate at home to raise two-thirds of the capital required, if the Cantonment Committee will guarantee the remaining one-third. The matter has been referred to a sub-committee for a report. In the meantime Government will be asked to say whether, if electric light is introduced into Poona, they would wish to have the barracks and public buildings similarly lighted.

**The American Government and the Telegraphs.**—In President Harrison's recent message to Congress the following passage occurs:—"I believe that the use of the telegraph by the Post Office upon proper terms is quite desirable. The Government does not own and does not operate railroads, and should not, I think, own or operate telegraphs. It would be quite practicable, however, to contract with telegraph companies as now with railroads to carry at specified rates what the senders designate. I recommend legislation to enable the Post Office Department to fairly test such use of the telegraph."

**The Electric Railway Advertiser.**—A significant indication of the progress of electrical traction in the United States may be found in the issue of a new weekly paper which contains a good deal of interesting matter, and is devoted to this branch of engineering. We find our recent editorial note on the Birmingham Tramway quoted with the following comment:—"There was a time when a similar misfortune was experienced in this country, and possibly the time is not yet wholly gone by. The adoption of electricity on street railways implies a complete change in road-bed construction, and any person that says the contrary is either an ignoramus or a liar."

**Dundee.**—At a meeting last week of the Committee of the Dundee Gas Commission a letter from the Board of Trade to the Clerk of the Gas Commission was read, in which attention was called to the provisions of section 10 (1) of the Dundee Electric Lighting Order, and to the necessity of obtaining the approval of the Department to the system upon which energy was to be supplied; and to request that as soon as the undertakers were in a position to do so they should furnish the Department with a description of the system of supply they propose to adopt. The Clerk was instructed to reply that notification would be made to the Board of Trade as soon as a system of supply was decided on.

**The General Electric Power and Traction Company.**—We hear that the General Electric Power and Traction Company are now offering to supply cars and the electrical equipment to tramway companies, and to maintain the motors, switches, gearing, and accumulators at a mileage rate, the tramway company operating the road at their own expense. The result of the experience at Barking enables the General Electric Traction Company to undertake electric plant maintenance at such a price that, including the cost of generating the power, &c., traction by accumulator cars will be less costly than that by horses. The company is at present in negotiation with some of the largest tramway companies in the country on these lines.

**Electric Lighting Provisional Orders.**—Up to November 30th 76 electric lighting orders had been advertised and the plans deposited. Of these 17 seek power to light various portions of London and the suburbs. As regards the proposed orders which relate to the metropolis the areas sought to be lighted are the City of London, St. Saviour's, Southwark, St. Giles's, Camberwell, Paddington, St. Mary, Islington, Hampstead, Whitechapel, Hackney, Shoreditch, St. Martin-in-the-Fields, St. Margaret and St. John, Westminster, St. Luke, Chelsea, St. George's, Hanover-square, and portions of the parishes of Clerkenwell, Wandsworth, Putney, Clapham, and Balham. The total number of orders which reached this stage last year was 159.

**The Paris Telephone System.**—Our esteemed contemporary, *L'Electricien*, devotes considerable space in a recent issue to detailing the improvements which have been made in the Paris Telephone System since it has been taken over by Government. One of these improvements is that subscribers are no longer obliged to go to the nearest office in order to pay their subscriptions, but may pay them at their own houses, though 25 centimes extra is demanded for this privilege. More substantial benefits are the reductions of rentals and the increased rapidity in effecting connections, and that these have been appreciated is evident by the large augmentation of the

Digitized by Google

*clientèle.* On October 1, 1889, there were 6,300 subscribers to the Paris Exchange, on October 1, 1890, there were 7,800, an increase of nearly 24 per cent.

**The Weston Temperature Compensator for Electrical Measuring Instruments.**—In order that temperature variations may be compensated for Mr. Weston, says the *Electrical Engineer* of New York, provides a thermometer with them, the bulb of which is elongated and curved round the exterior of the coil. The thermometer-tube is bent and curved under the scale-plate. By means of this thermometer the temperature of the coil is shown under the regular scale-plate of the instrument. Provided with each instrument and inserted in its circuit is a series of resistances, which can be switched in or out as desired by turning a handle. The contact-plates of these resistances are marked in degrees of the thermometer. In practice, therefore, it is simply necessary to note the indication of the thermometer and place the switch on the contact-plate corresponding to that indication in order to keep the resistance of the circuit in the instrument uniform.

**The De Beers' Mine Central Station.** — The installation for the lighting of the underground workings of the Central Diamond Mine has just been completed, under the superintendence of Mr. R. Oliver G. Drummond. From the second annual report for the year ended March 31st, we find the De Beers' mine circuit had been running about 15½ months, night and day, with the exception of a short stoppage on Sundays, and there had been no cessation to the light during working hours, except once, when the engine had to be stopped for ten minutes. The plant, from which the Central Mine is worked, is situated within the mining area of the De Beers' mine, and the Company have obtained the right to run their wires through the busiest thoroughfares of the city, so that they have every facility for lighting the Club, Public Library, Post Office, Court House, and their own private central offices in the Diamond Market. The Masonic Temple is already lighted from the De Beers station, and, although more than a mile distant, by a system of electrical signals and switches each ceremony isme thodically illuminated, according to ancient custom, without the slightest hitch.

**The Corporation and the City and Guilds of London Institute.**—At a meeting of the Common Council on Thursday last week, Mr. Lee moved the adoption of the report of the Coal and Corn and Finance Committee, recommending a grant of £500 out of the City's cash to the above Institute. Mr. Deputy Bedford considered that the voting of this amount would be a waste of money, and moved an amendment to that effect. Mr. Sly, in opposing the recommendation, referred to the small number of students at South Kensington, and said that those who were to blame ought to be ashamed of their efforts, and ashamed of the result. Mr. Morrison supported the action of the Committee, and stated that they would bring up a report which would be satisfactory, he believed, to every member of the Court, and to every one outside it. Mr. Shaw appealed to the Court to continue in the good work it had been doing in support of the cause of technical education in London. Alluding to what was being done at Finsbury College, he said so great was the number of students that there was not room for one more, but arrangements were being made whereby extra accommodation could be secured for another 50 students. There were 108 day students, and 1,006 evening students. The amendment was negatived by 85 votes to 31.

**Railway Rates.**—A general meeting of the Mansion House United Association on Railway Rates was held at the Guildhall on Friday afternoon last. Alderman Sir James Whitehead presided. The Corporation of London, the London Chamber of Commerce, numerous county councils, municipal corporations, local authorities, trading and agricultural organisations, and mercantile firms were represented. The report made to the Board of Trade by Lord Balfour of Burleigh and Mr. Courtenay Boyle, and the classification of merchandise and schedules of *maximum* rates and charges proposed by the Board to be applicable to nine of the leading railway companies, together with the figures supplied by the railway companies to the Board of Trade respecting the alleged effect of the proposals, were considered by the meeting, which unanimously resolved that (1) it is equitable that the railway companies' present powers should be reduced; (2) that *maximum* rates should approximate more nearly than at present to the actual charges. The meeting further resolved (1) that this Association is unable to accept the proposals of the Board of Trade as being "just and reasonable," and will use every means in its power to prevent their authorisation in their present form by Parliament; (2) that Parliament be respectfully urged to require the railway companies to prepare and issue returns showing the rates charged for the conveyance of staple articles of merchandise, and the tonnage of articles carried at these rates during the year 1889 between the most important trade centres in the United Kingdom.

**Mr. Cyrus W. Field.**—Mr. Cyrus Field, who was one of the most prominent originators of the work of connecting England with the United States by telegraph cable, on the 2nd instant celebrated his "golden wedding." The occasion was gladly availed of by his friends in this country to present him with an illuminated address to commemorate that event, and recall the part he played, in conjunction with Sir John Pender and others, in connection with the bridging of the Atlantic by the electric wire. The result was the signing of the address given below by a number of distinguished persons not necessarily connected with telegraphy, as well as by those who were associated with the laying of the first ocean cable. The contents of the address and the names of the signatories were appropriately telegraphed over one of the Atlantic cables on Tuesday last, the fiftieth anniversary of Mr. Field's marriage :—

"To Cyrus W. Field, Esq., Gramercy Park, New York.

"Dear Sir,—We, the undersigned, who have known you for many years, and some of whom have been long and intimately associated with you, desire to express to you and to your amiable and devoted wife our earnest and heartfelt congratulations on your golden wedding day, the 2nd December, 1890. We earnestly wish you both many years of health and happiness, enjoying the fruits of your useful and well-spent lives, and seeing on every side the wide-spreading development of the Submarine Telegraph enterprise in which you, Mr. Field, have laboured so long, so zealously, and so successfully. This great work, pursued by you with unflagging energy and perseverance for many years through the greatest difficulties and hindrances, has now become a first necessity of national and commercial life, and you have the profound satisfaction of knowing that its objects and its results are and ever have been peaceable and beneficent in their character. We ask you to accept this message of our goodwill and good wishes which will be sent to you both over and under the sea.

Very faithfully yours, Argyll, Frederic W. Farrar, Monck, W. E. Gladstone, W. H. Russell, Douglas Galton, Tweeddale, F. A. Bevan, H D. Gooch, W. Thomson, G. Shaw-Lefevre, J. Russell Reynolds, John Pender, James Anderson, W. Cunard, William Ford, George Elliot, Geo. Henry Richards, W. Shuter, Henry Clifford, Henry C. Forde, W. Andrews, H. Weaver, G. von Chauvin, J. H. Carson, Samuel Canning, Richard C. Mayne, W. S. Cunard, Julius Reuter, H. A. C. Saunders, G. W. Campbell, H. M. Stanley, of Alderley; Margaret Anderson, John H. Puleston, George Cox Bompas, James Stern, H. L. Bischoffsheim, Louis Floersheim, T. H. Wells, J. H. Tritton, W. H. Preece, C. W. Earle, Catherine Gladstone, J. S. Forbes, Caroline Roberts van Wart, G. W. Smalley, Gerald Harper, William Barber, George Grove, Jane Cobden, Thomas B. Potter, Charles Burt, Robert C. Halpin, Edward Satterthwaite, Frank H. Hill, J. C. Parkinson, Richard Collett, W. Leatham Bright, C. W. Stronge, Latimer Clark, R. T. Brown, William Payton, Henry Dever, Lewis Wells, John G. Griffiths, Robert Dudley, Kenneth L. M. Anderson, Julian Goldsmid, John Chatterton, John Temple, Jane E. Lloyd, Frances Baillie, Montague McMurdo, Willoughby Smith, Philip Rawson."

The following reply was received from Mr. Field :—

"All my friends here were much pleased with the address; please thank for me everyone that signed it. I wish that I could thank them in person. Mrs. Field joins me in all kind wishes."

As a further memento of Mr. Field's connection with the first cable across the Atlantic, a piece of teak from the "Great Eastern" has been handsomely mounted as a walking-stick for presentation to him. On the top a small sketch of the "Great Eastern" has been engraved, and on a band encircling the stick, "Portion of the 'Great Eastern,' broken up 1890. Cyrus W. Field, Esq."

Digitized by Google

## ELECTRICAL DISTRIBUTION BY TRANSFORMERS FROM CENTRAL AND ECCENTRIC STATIONS.*

BY DR. J. A. FLEMING, M.A.

*(Continued from page 44.)*

### THE THOMSON-HOUSTON TRANSFORMER SYSTEM.

§ 1. In the United States one of the most widely known of all the electric lighting companies is that of the Thomson-Houston Company, having its headquarters in Boston, United States. Commencing in 1880, and having in 1882 only a small factory at New Britain, Conn., this corporation has developed its electrical manufactures at a steadily increasing rate, and has at the present time an immense factory at Lynn, Mass., occupied in the production of electric lighting plant for arc and incandescent lamps, as well as for electric locomotion. In the United States over 50,000 arc lamps are operated by the well-known Thomson-Houston continuous current arc light dynamo, in some 600 or more stations. The ingenuity and remarkable inventive skill of Professor Elihu Thomson has been also brought to bear on the development of an alternating transformer system, with the result that nearly 100,000 incandescent lamps are in use (1890) in the United States in connection with a transformer system as devised by him. The alternating dynamo employed in the Thomson-Houston transformer system presents some interesting peculiarities.

Fig. 1 shows the general form of all the dynamos for generating alternating currents manufactured by the Thomson Houston Electric Company. The field magnets are of cast iron, and are made in two parts, the lower one bearing the pedestals for the armature bearings. Each casting carries projecting inward from it one-half the total number of radial pole pieces. The number of polar projections varies from eight in some of the smaller sizes to twenty-two in the largest. The armature is a laminated iron cylinder, and has applied to its surface a set of flat coils which form one layer of double-insulated copper wire of square cross section. This armature winding, then, consists of a number of flat oval coils, equal in number to the number of polar projections, wound in a lathe on special formers. There is a space of three-quarters of an inch or more in the centre of each coil which, in some machines, is filled with insulating slip or core, and in others with a second separate coil used for exciting the field of the dynamo. The armature coils are securely bound to the armature core by brass wire, and are covered with insulating strips of mica. These coils are either connected all in series and in series with the external circuit, as is shown in Fig. 2, in the case in smaller sizes of high potential machines, or they are wound, as shown in Fig. 3; *i.e.*, two groups in multiple, consisting of an equal

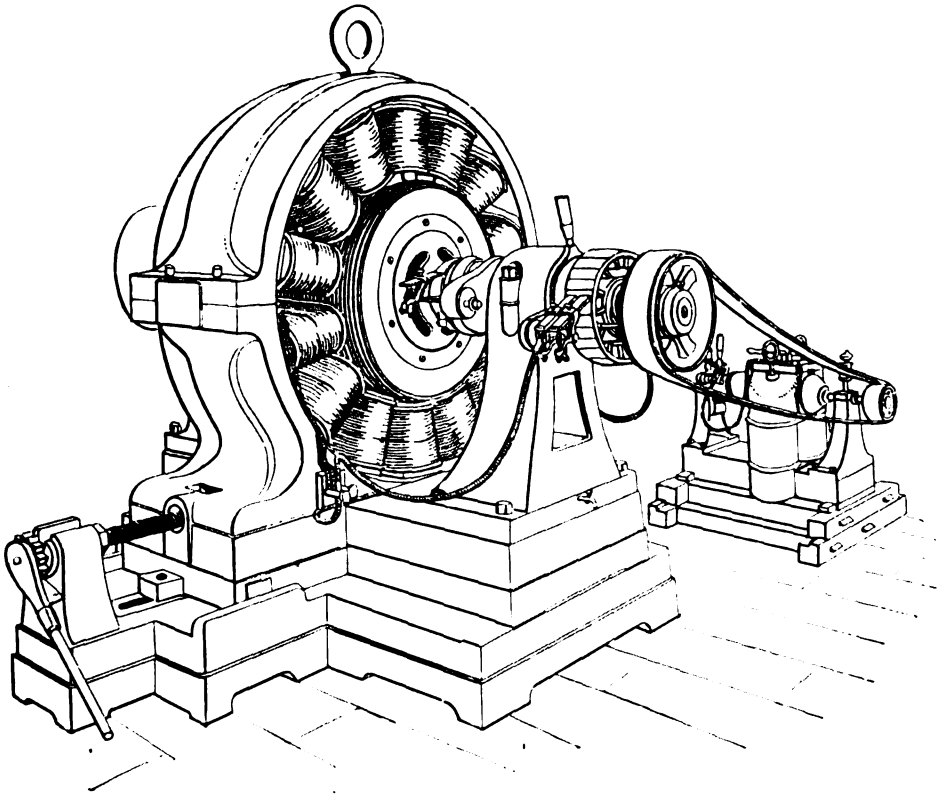


Fig. 1.—The Thomson-Houston Alternator.

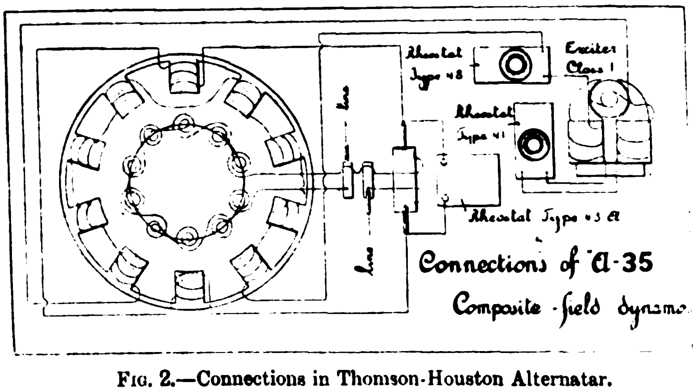



Fig. 2.—Connections in Thomson-Houston Alternatar.

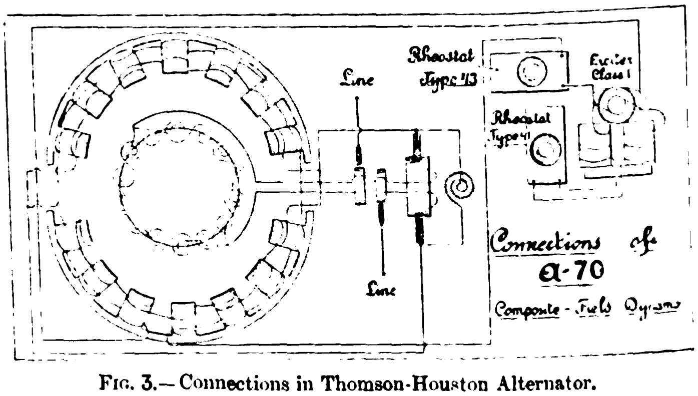



Fig. 3.—Connections in Thomson-Houston Alternator.

* All rights are reserved.

Digitized by Google

number of coils in series. By this means a 1,300 light armature is wound wire of the same size as a 650 lighter.

The armature core, in these machines, is built up as usual of thin iron sheets perforated with apertures through the centre, so as to allow a circulation of air.

These alternating current dynamos are made in three types, as follows:—

(i.) Self-excited.
(ii.) Separately-excited.
(iii.) Composite-wound.

(i.) *Self-excited Type.*—In this class of dynamo, which has been now more or less discarded in favour of the third mentioned, the field-exciting coils are coils wound about the armature in a manner like the ordinary Siemens' winding, and consist of but a very few turns of square copper wire. These coils are arranged as shown in Fig. 4, and they lie beneath the main armature coils and fill the spaces on the surface of the iron core between the wires of the flat or "pancake" coils as they are sometimes called. The upper sketch in Fig 4 shows the manner in which these coils are wound over the ends of the core, the two opposite coils being either connected in series or in multiple arc and their terminals brought out to a commutator on the shaft outside of the bearings at the collector end of the dynamo. This commutator has as many segments as there are poles on the dynamo, and the two terminals of the field exciting circuits on the armature are connected to alternate segments. The exciting current is controlled by a rheostat in its circuit mounted upon the switch-board, and in this circuit are included

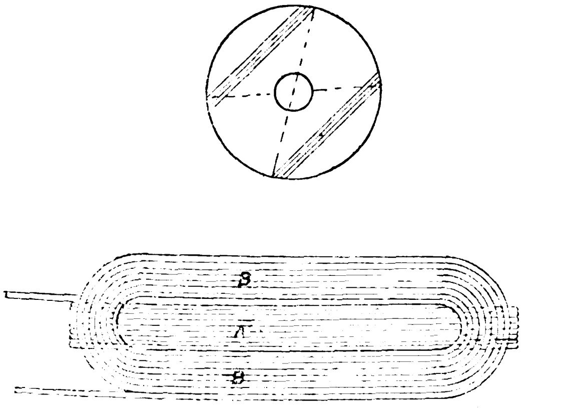



Fig. 4.

the coils on the field magnets. This design may, in fact, be described as an alternate-current armature winding on the top of a continuous current winding. This last supplies current for the field.

(ii.) *Separately-excited Type.*—The separately-excited dynamo is of the same form as the self excited, the only difference being that in it the commutator and armature exciting coils are absent. It is used with an exciting dynamo, such as shown in Fig. 1.

(iii.) *Composite-wound Type.*—The term "composite" as applied to the third type of the alternating current dynamo of the Thomson-Houston Electric Company was adopted to distinguish this arrangement of field excitation from that employed in direct current machines, which consists in the combination for producing the magnetic field of the main armature current with a derived current shunted around the external circuit. The arrangement of circuits which is used on the most improved type of Thomson-Houston alternator for maintaining a constant difference of potential at a defined point of distribution, regardless of load, is shown in Figs. 2 and 3.

A part of the magnetic field is maintained by means of current from a separate or exciting dynamo. If the load upon the outside circuit is increased it is necessary to increase the magnetism of the field, in order that the machine may in turn supply the increased demand in the circuit, and the lights remain steady.

This is accomplished in other machines by varying the current on the field magnets by a rheostat or variable resistance operated by hand. In the Thomson-Houston dynamo, however, the same result is obtained entirely automatically by passing the greater portion of the main current through two or more of the field magnets, thus energising the machine in exact accordance with the demands made upon it. As an alternating current is not suitable for magnetising the fields it is necessary to change the character of the current produced in the armature to a direct current before passing it through the special winding on the field, and this is done by a commutator at the end of the shaft. By this regulation the attention required at the dynamo is reduced to a minimum, while at the same time the efficiency of the machine is increased, and any number of lamps, from one to the full capacity, may be thrown on or off without in any way affecting the steadiness and brilliancy of those remaining.

To allow for a pre-determined percentage of loss in the wiring, it is necessary, as the load is increased, that there should be a definite amount of increase in potential, which is accomplished by placing around the field winding for the main current a resistance which shunts that portion of current not required for regulation.

It is precisely the same in principle as the compound winding in the case of a continuous current machine. In addition to the current derived from a small direct current separate exciter, a second current, which is a rectified portion of the main current, is used to energise the fields. This current, being proportional to that in the external primary circuit increases the field strength, and thus the potential with increasing load.

It will be seen from the diagrams of the connections that the armature current is "rectified" for a part of its course by means of a commutator having as many segments as there are field poles on the machine—alternate segments being connected together, and one set connected to one armature terminal, and the other to the external circuit.

This rectified current is either used to excite two of the polar projections, as in Fig. 3, or to partially excite all of them, as in Fig. 2, the latter method being the most approved.

Before each machine is sent out from the factory, the strength of the compounding current is regulated by means of a German silver shunt fastened to the frame of the machine. By changing this shunt the machines may be made self-regulating for any required line resistance or drop, being over-compounded to whatever degree is needed. The winding may be described as that of a "compounded" alternator for giving constant potential at the ends of a line.

The following table gives the sizes and capacities of the machines of this type thus far constructed, with the exciting and main current of each:—

| Alternator. | Watts. | Lamp load in 16-c.p. lamps. | Exciting circuit. | | Weight. | Speed. | Floor space (inches). | Output in amps. |
|---|---|---|---|---|---|---|---|---|
| | | | Volts. | Amp. | | | | |
| A 35 | 35,000 | 650 | 100 | 5·8 | 3,570 | 1,500 | 66 × 45 | 35 |
| A 70 | 70,000 | 1,300 | 100 | 11·2 | 8,270 | 1,070 | 84 × 56·5 | 70 |
| A 140 | 110,000 | 2,600 | ... | ... | ... | 680 | 80 × 105 | 140 |

Each machine yields current at 1,000 or 2,000 volts as required.

For the purpose of energising the field magnets the dynamos are furnished with small exciting dynamos of the direct-current type. It has been found desirable in some special cases to make the smaller sizes of alternating-current dynamos self-exciting, and to this end the armatures are wound with an extra or special coil for furnishing current to energise the fields. The exciter is usually placed, as shown in Fig. 1, behind the alternating dynamo, driven by a belt from a small pulley attached to the armature shaft. One exciter is usually employed with each alternating-current dynamo, but when several dynamos are operated in the same station, it is often found more convenient to employ exciters, any one of which is of sufficient capacity for all the machines. By this arrangement an accident to one exciter need not affect the general service.

Digitized by Google

Exciting dynamos are made in the following sizes :—

| lass | Volts. | Amperes. | Speed. | Weight. | Pulley Diam. | Pulley Face. | Floor Space. |
|---|---|---|---|---|---|---|---|
| 0 | 100 | 12 | 2,300 | 307 | 4 | 2 | 24 × 13½ |
| 1 | 100 | 24 | 2,200 | 480 | 5 | 3 | 29¼ × 16⅛ |
| 2 | 100 | 40 | 1,800 | 696 | 6 | 4 | 31¼ × 18¾ |
| 3 | 100 | 60 | 1,600 | 1,080 | 8 | 5 | 37¼ × 21¾ |
| 4 | 100 | 80 | 1,600 | 1,364 | 8 | 6 | 40 × 23⅜ |

The current required in the fields of the alternating-current dynamo is is follows :—

A-35 Composite Field, 5·8 amperes.

A-70 Composite Field, 11·2 amperes.

*(To be continued.)*

## DRUM ARMATURE WINDING.

BY F. M. WEYMOUTH.

*(Continued from page 101.)*

Further developments of this form of evolute end winding are to be found in the "Westminster" dynamos of Messrs. Latimer, Clark, Muirhead & Co. This firm, under the supervision of their electrical manager, Mr. F. V. Andersen, have employed conductor bars built up of either wire or tape, and sometimes both kinds on one armature. Fig. 18 shows a longtitudinal section through an armature of this latter description. The long bars *a a* are of copper strips laid edgeways, and each strip insulated with varnish. The short bars *b b* are of wire laid parallel, each wire insulated with shellac varnish, and the whole group cranked at both ends. An end thus cranked is given to a larger scale in Figs. 19 and 20.

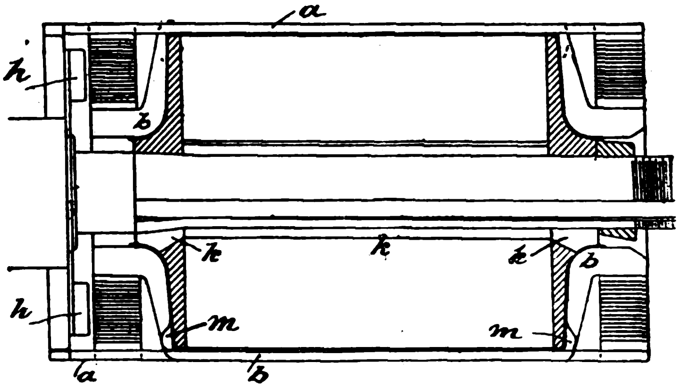
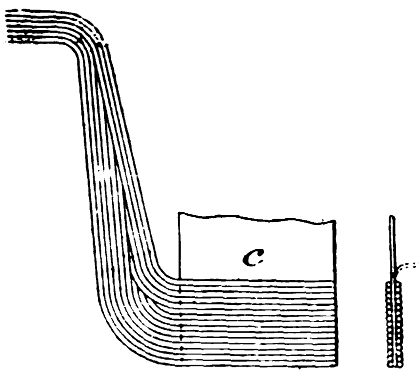



FIG. 18.—Andersen Winding. Longitudinal Section through Armature.

It will here be seen how the cranked end is splayed out, so that the wires embrace the inner end of an evolute strip *c*, and are soldered to it in a single layer on each side, as shown more clearly in the end view (Fig. 20). The wires are the more carefully spread over the end of the strip *c* that the soldered joint may be as large as possible, and so offer a minimum resistance. A transverse section through the conductor bars on the periphery of the drum is given (Fig. 21), showing their compound formation alternately of copper strip and wire. Each bar is insulated with varnished tape. The layers *a a* are of Willesden or Manilla paper, varnished, and *b* is the usual exterior band of steel wire. The evolutes, duly insulated from each other, run from the inner cranks outwards to the long copper strip bars opposite, as in the case of the Crompton-Swinburne winding, shown in Fig 12. The conductor bars are here jointed at both ends to other metal, the several wires or strips in each are consequently in metallic contact at each end. They need to have a half-twist given them in the middle, in the manner already referred to when discussing the subject of Foucault currents. In Fig. 18, *h h* are fan blades for drawing air through the core by airways *k k*, of which there are three. In subsequent machines, however, these blades have been omitted, the suction caused by the commutator lugs being considered sufficient. The winding is held from slipping by a crown of teeth *m m* on each end plate, between which the cranks lie. A burnt section, however, cannot be taken out without dismounting




FIGS. 19, 20.—Andersen Winding. Cranked Ends.

at least half of the winding. This firm has made machines with the conductors formed of copper tape only. As these are necessarily laid edgeways, and will not consequently easily bend, the cranks have to be formed of pieces soldered and rivetted together, in the manner shown in Figs. 22 and 23, the latter being a sectional plan on *a b* in the former to twice the scale. For the greater flexibility of the evolutes *c* these are here made of two thin strips of copper, instead of one, as is shown clearly in Fig. 23. Although this is of somewhat more simple construction than the wire-made cranked bars, inasmuch as these latter have to be carefully formed up in a mould, yet two extra joints are introduced.

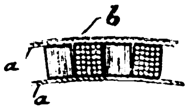



FIG. 21.—Andersen Winding. Transverse Section through the Conductor Bars on the Periphery of the Drum.

It will be observed that these evolute windings so far represented have one common advantage. They are made entirely of rolled copper in one form or another. Hence all desired lengths need but to be cut off, with a minimum of waste, both in material, labour, and use of machinery. On the other hand, comparatively speaking, the subsequent construction of the end winding is not exactly simple. In one method of pro-

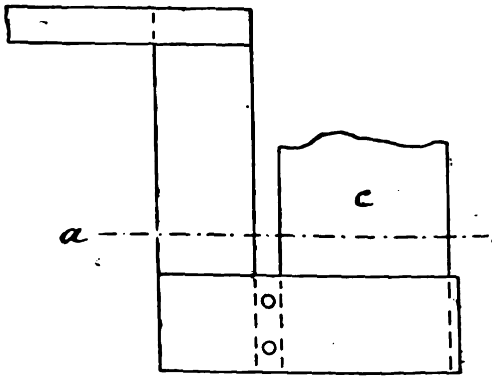



FIG. 22.—Andersen Winding. Cranks.

cedure, the short bars have first to be made up separately, with cranked ends, and with the connectors, as yet straight, duly attached to each crank, and lying in the same plane with it. These, thus far individually complete, are then laid in position on the core, and temporarily bound on, with the connectors projecting radially all round. By roping and so forth, all the connectors at one end are now forced round in a com-

Digitized by Google

bined mass, each one naturally assuming an evolute curve, until the outer end of each reaches the opposite side of the core end to that from whence it started, as shown in Fig. 11. Being held thus, and the connectors at the other end of the armature having been treated similarly, the long bars are finally added, and severally jointed up to their respective connectors. Hence, by the magnitude of the operation as a whole, it will be seen that the first-named advantage in the use of rolled copper is in some measure lost. One of the principal points, however, in this winding, as compared with Edison's discs, is, that there is a minimum electric pressure between the evolutes.

The evolute end windings we have thus far discussed, it may now be noted, have the peculiarity that each evolute from beginning to end is approximately half a circle. In another class of evolute winding, however, each evolute is approximately only a quarter circle, and the crank system is absent.

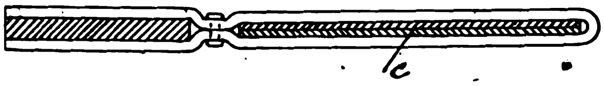


Fig. 23.—Andersen Winding. Sectional Plan on *ab* of Fig. 22.

This design was first brought out by Herr Hefner von Alteneck, and is that adopted by Drs. J. and E. Hopkinson in the manner represented in Figs. 24 to 27. Fig. 24 is a longitudinal section through an armature wound with one

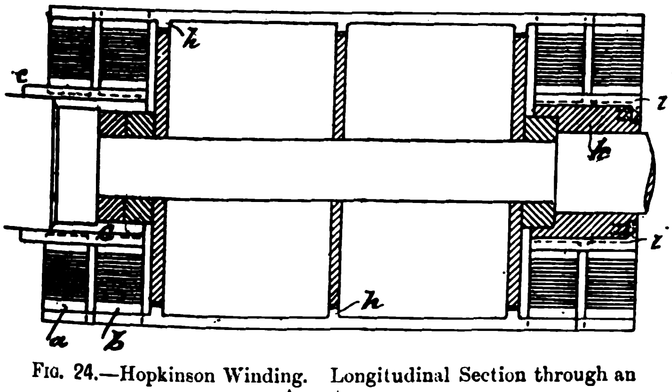


Fig. 24.—Hopkinson Winding. Longitudinal Section through an Armature.

turn per section. Fig. 25 is an end view, but showing only a portion of the winding for the sake of clearness. The bars, it will be noted, are solid, the heating being obviated in the manner already described, by enlarging the air space under the horns of the pole-pieces. The parallel conductors in this case also are short and long. But instead of the short ones being cranked at their ends, they are jointed to evolute strips as well as the long bars. There are thus two series of evolute strips side by side, as shown at *a* and *b* in the illustrations.

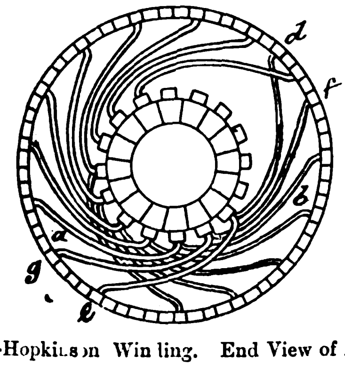


Fig. 25.—Hopkinson Winding. End View of Armature.

The evolutes in the one, however, run round in the opposite direction to those in the other, as shown in Fig. 25, and only cover an angle of approximately 90 degrees instead of 180 degrees. On each commutator segment a bar *c* is screwed, which projects within the end winding in a direction parallel with the shaft. To this the interior end of one connector in each series is screwed or otherwise jointed, thus connecting a long bar on the one side to a short one opposite, as, for instance, *d* and *e*, or *f* and *g*, as shown in Fig. 25. Figs. 26 and 27 show this arrangement duplicated for a winding of two turns per section, when there are four series of evolutes at each end. The driving of the winding is effected by means of snugs formed in some or all of the bars themselves, which fit into recesses in the peripheries of the end

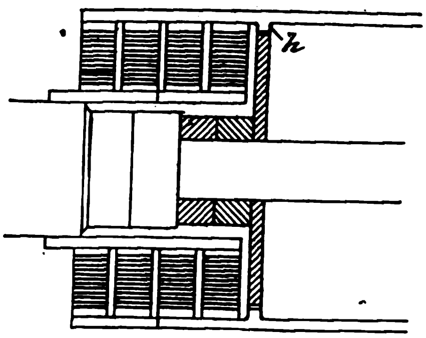


Fig. 26.—Hopkinson Winding. Two Turns per Section.

plates and a middle disc, as shown at *h h* in Figs. 24 and 26. At the pulley end of the armature, there being no commutator bar for the strips to be fastened to, an annular block of insulating material *k* (Fig. 24), is run on the shaft, and on this bars *i i*, parallel with the shaft, are screwed for the purpose, the screws being put in at the outer end turned inwards radially to receive them. It will be noted that with this method of two or four series of evolutes, all the parallel bars are straight, without bends, and their joints being all external and accessible, any can be removed separately. This latter advantage, however, does not appear to apply to the evolutes, should any of these require renewal. A minimum pressure exists between adjacent evolutes in any one series, as with the method of Messrs. Crompton and Swinburne. Likewise, also, the winding is symmetrical, tending to a good balance, and the separate sections are all the same length round, and consequently of the same resistance. This winding is also constructed of rolled coper.

We now come to another winding, the end connections of which are designed on the principle of a double series of evolutes, running in opposite directions, similarly to the last described. This is Eickemeyer's, of New York. Although like in principle to the Hefner von Alteneck method, it is in other respects altogether different. Each section of coil is composed of wires laid together, and contains no joint in it from one end at one commutator lug to the other end at the next lug. Each section, moreover, is entirely self-contained, and is formed to the right shape and curvature on a mould, or in part on a mould, before being put on to the armature. Thus the coils on any armature are exactly similar, and consequently interchangeable. Here, as with the Siemens' wire winding, a high-pressure small current can be obtained by making each

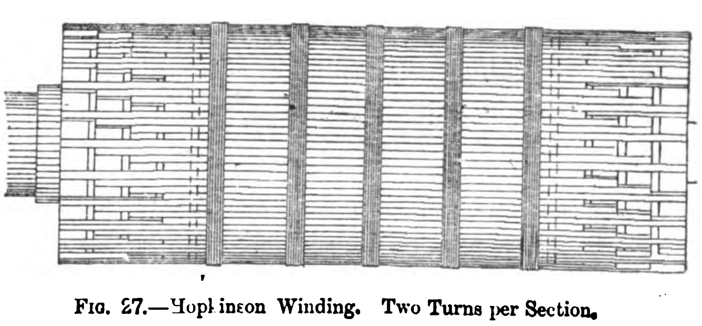


Fig. 27.—Hopkinson Winding. Two Turns per Section.

section, of one wire, carried round it several times, with the two wire ends united to the commutator. Or the wires can, however, be united in parallel, each section thus consisting of a group of wires carried round once, and all their ends united to the commutator—all the wire ends, that is, at one end of the group being jointed to one commutator lug, and all the other ends united to another lug. Or, again, a section composed in

Digitized by Google

the aggregate of many turns of wire may be made up of a group of a few wires in parallel carried a few times round in series.

Figs. 28 to 31 are views of an armature fitted with a simple winding of two turns per section. Fig. 28 is an elevation; Fig. 29 is an end view with the commutator removed, leaving a section on line, *p q*, in Fig. 28. Fig. 30 is a plan of one coil, and Fig. 31 an isometric perspective view of the same. The portions lettered *b b* in Figs. 30 and 31 correspond to the outer parallel bars that lie on the periphery of the core on opposite

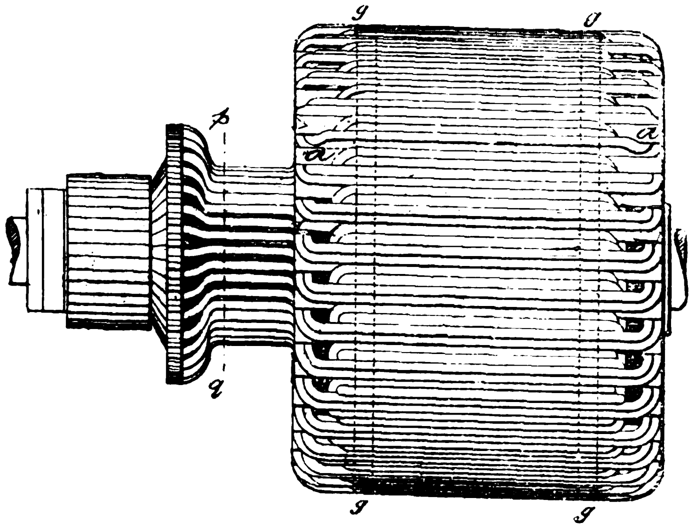



Fig. 28.—Eickemeyer Winding. Elevation of Armature.

sides of the armature. The parts, *c c* (Fig. 30) lie across the ends, and correspond to the connectors. It will be observed in Fig. 31 that the downward angles, *d d* (Fig. 31) are arranged to approach the shaft; while the swelling shoulders, *e e e e*, on either side will form the evolutes right and left as shown in Fig. 29. As the current here is small, and the sections not numerous, the commutator is also small as compared with the armature. Hence the connections *f* to the commutator are led off from one of the interior angles *d*. The pins, *a a*, in Figs. 28 and 29 are to drive the winding. The dotted lines,

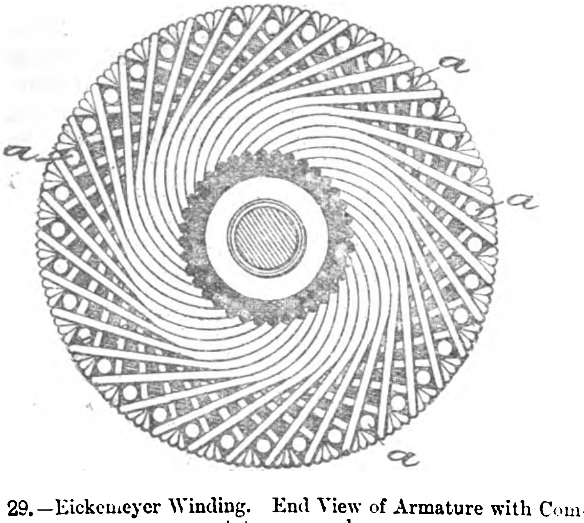



Fig. 29.—Eickemeyer Winding. End View of Armature with Commutator removed.

*g g*, in Fig. 28 represent the exterior binding wires. In Fig. 30 it will be observed that one side, *b*, is longer than the other, thus, in fact, forming our "long" and "short" bars. This allows room for the two series of evolutes at each end of the armature; also, when putting the coils on the core, the small side of one coil can easily be passed within the large sides of other coils, and so allow of their being got into position.

In Figs. 32 and 33 an arrangement is shown of many turns per section for a small current of high voltage. Two coils are here represented, one of them being dotted in Fig. 32, but both shown in full in Fig. 33. It will be seen here clearly how the small side of the one fits within the large side of the other, leaving the clearance space *a a* between. The wires in the parallel bars are laid 4 × 2, while in the convolutes portions they are all eight abreast, lying in curved planes parallel with the shaft. The "short" bars, it will be observed, are here intended to form a complete layer by themselves on the core *m m*, while the "long" bars are arranged outside. The two sides of a coil thus come exactly opposite instead of only nearly so. As the two layers will be exposed to a maximum difference of potential between them, they need to be well insulated from

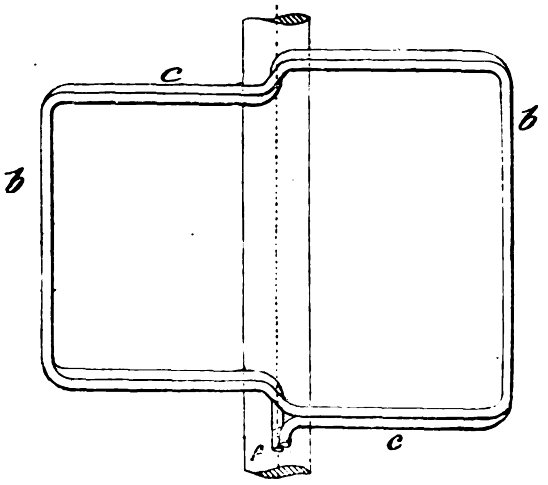



Fig. 30.—Eickemeyer Winding. Plan of a Single Coil.

each other. This insulation, and the taping round the bars, are omitted in the sketches for the sake of clearness. In Fig. 33 the section through the bars of one coil is shown in solid black, *b b*, while through the other coil the wire sections are left clear circles, as shown, *c c*. The connection to the commutator is led off from the middle at *f* (Fig. 32).

In Fig. 34 this same winding is shown, but with the wires in each coil all united in parallel for a large current. As the commutator will now need to be larger it will be more convenient to lead off the connections to it from the outside of the coils, as shown at *g*, rather than from the middle. This view, being a longitudinal section through the armature, also gives sections through the two series of evolutes at either end, showing clearly their mutual positions, and the air spaces *a a* between them effectually insulating one from the other. The semi-circular portions *d d* are the same as those similarly lettered in Figs. 32 and 33, where it will be seen that they lie in radial planes.

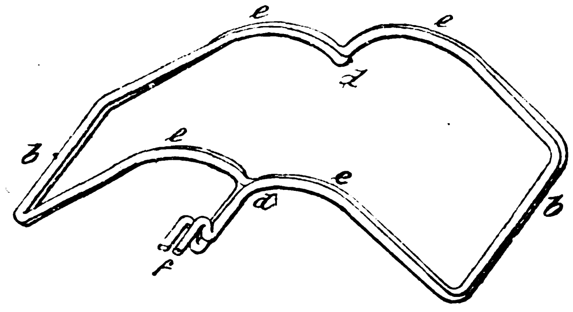



Fig. 31.—Eickemeyer Winding. Isometric Perspective View of a Single Coil.

A few words on this point of the air insulation. Our remarks will also apply to the Crompton and the Alteneck end-windings. This point, indeed, as has already been hinted at, constitutes one of the chief considerations of these special forms of end-winding. When adjacent coils are approximately in the plane of commutation, the "long" bar of one will be in connection with the commutator segment in contact with one brush, and the "long" bar of the other coil will similarly be connected to the other brush. Let the brushes be top and bottom, and the upper one positive. Using Fig. 34 for illus-

Digitized by Google

tration, we shall now find that the bar *b* is at its highest pressure delivering current to the brush; while the bar *c*, being a side of the coil connected to the negative brush, is at a minimum pressure. Hence the two bars *b* and *c* are lying close together, with a maximum difference of pressure between them. On the other hand, as the volts only gradually rise in one long bar after another as they approach in order from the bottom to the top on both sides of the armature, it comes about that there is only a minimum pressure ever between adjacent long bars or adjacent short bars. At the end of the armature, all the short bars are connected to the series of evolutes or radial cranks formed next the core ends; while all the long bars are united to the outer series. Hence there is only a minimum pressure between

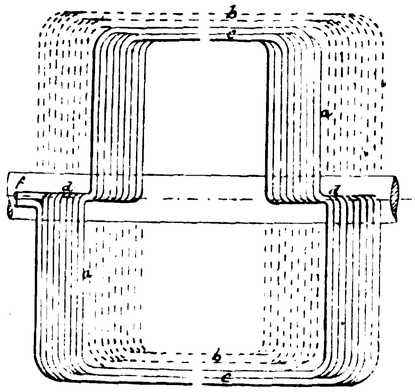


FIG. 32.—Eickemeyer Winding. Several Turns in Series per Section. Side View of Two Coils.

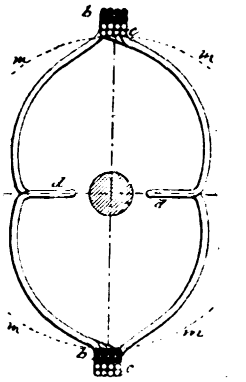


FIG. 33. — Eickemeyer Winding. Several Turns in Series per Section. End View of Two Coils.

adjacent connectors in the same series; and any connectors proceeding from the ends of two adjacent long and short bars, with maximum volts between them, pass each into different series of evolutes, where they are effectually insulated by the air spaces *a a* between them. Thus it will be seen, that while good insulation can well be put between the two layers of bars on the periphery, or the bars can each be well taped, without increasing the total size at all; among the connectors, where they are apt to be cramped for room, only slight insulation is needed between those in one series. Hence, of the total mass of a series of evolutes, a much larger proportion can be allowed for the copper than might otherwise be the case.

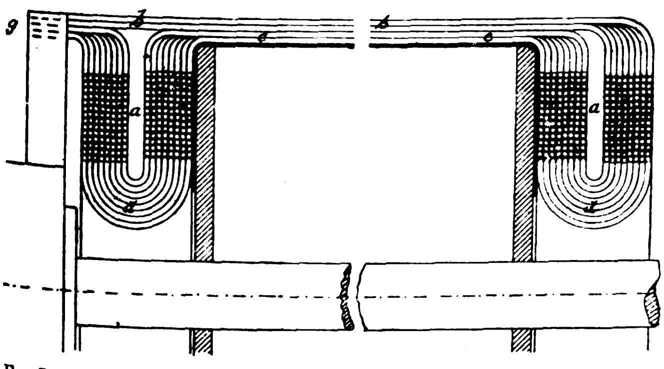


FIG. 34.—Eickemeyer Winding. Several Turns per Section, all in Parallel. Longitudinal Section through the Armature.

This Eickemeyer winding, in common with the Alteneck and Crompton arrangements, will be observed to be symmetrical, with the attendant advantages. One of the chief, however, among its many claims is the ease with which any damaged coil may be replaced, it being only necessary to undo the joints with the commutator, and remove the outside binding wires, to free the whole. It is economical also in total amount of copper used, and in labour of construction—after the coils are made, that is, as forming up the individual coils in the mould must doubtless take time. The absence of joints, however, especially in the case of large currents, remains one of its chief distinguishing characteristics.

As, both in connection with this latter and the previous windings we have described, we have alluded to the inside or outside union with the commutator, we may, perhaps, with advantage at this juncture also call attention incidentally to a result following on either of these two arrangements. In the Edison (Figs. 9 and 10) and the Hopkinson methods, as illustrated, and the Eickemeyer for low currents, this union is *interior*. In the Crompton and "Westminster" dynamos, and also the modified Eickemeyer for large currents, this union will be observed to be *exterior*. In the former case, and considering any one coupling of whatever form that unites two opposite bar ends, the connection with the commutator is taken off from the *middle* of such coupling, half-way between the bar ends. In the latter, the connection is made at the *end* of a coupling at its junction with a parallel bar. It will thus be seen that with the interior union, a plane through the axis of the commutator and one of its segments will be approximately at right angles to the planes of the coils to which such segment is connected. In the latter case, a plane through the commutator and such segments would be approximately coincident with the planes of its two coils, lying, in fact, between them. Now, in practice, and taking the case of a horizontal field, with pole pieces right and left, the polarity of the armature is brought by the much superior strength of the field to be nearly horizontal likewise: hence the plane of commutation comes about vertical. Thus, consequently, with exterior connections to the commutator, and assuming a horizontal field, the brushes will be top and bottom; while with interior connections, and a plane through the commutator axis and connected segment perpendicular to the plane of commutation, they will come at the sides of the commutator, right and left. When, however, the field is not so strong in proportion to that of the armature as above indicated, or when from any other cause the plane of commutation becomes oblique, the brushes will follow suit in both cases, and touch on the ends of an oblique diameter. It is to be noted, however, in the case of Edison's early end-winding (Fig. 8), that the connection, though *interior*, is yet taken off the *end* of a cross connector, the current running to or from the centre along a radial plate, hence here the brushes would be top and bottom.

*(To be continued.)*

## MEETINGS OF SCIENTIFIC SOCIETIES, &c.

**MONDAY, December 8th.**

SOCIETY OF ARTS.

*8 p.m.* Cantor Lecture I. 3. "Gaseous Illuminants," by Prof. VIVIAN B. LEWES.

THE ELECTRO HARMONIC SOCIETY.

*8 p.m.* Amateur Concert (Ladies' Night), at St. James' Hall Restaurant.

**TUESDAY, December 9th.**

INSTITUTION OF CIVIL ENGINEERS.

*8. p.m.* Ordinary Meeting. Paper to be read: "The New Chittravati Bridge, Madras Railway," by E. W. STONEY, M.E., M.I.C.E. To be followed by a discussion which will include the paper on "The Lansdowne Bridge over the Indus at Sukkur," by F. E. ROBERTSON, M.I.C.E., read at the last Meeting.

ROYAL VICTORIA HALL.

*8.30 p.m.* Lecture: "What we get from Coal Tar," by Dr. FOSTER MORLEY.

**WEDNESDAY, December 10th.**

SOCIETY OF ARTS.

*8 p.m.* Ordinary Meeting. Paper to be read: "Electric Lighting Progress in London." By F. BAILEY.

**THURSDAY, December 11th.**

INSTITUTION OF ELECTRICAL ENGINEERS.

*8 p m.* Annual General Meeting. Election of Council and Officers for 1891. Papers to be further discussed: "The Efficiency of Secondary Cells," "On the Chemistry of Secondary Cells," by Prof. W. E. AYRTON, F.R.S., C. G. LAMB, B.Sc., and E. W. SMITH.

**FRIDAY, December 12th.**

PHYSICAL SOCIETY.

*5 p.m.* Papers to be read: "Some Experiments with Selenium Cells," by SHELFORD BIDWELL, F.R.S.; "Note on Electrolysis," by JAMES SWINBURNE; and "Alternating Current Condensers," by JAMES SWINBURNE.

Digitized by Google

# The Electrician.

**Published every Friday, Price Fourpence; Post Free, Fourpence Halfpenny.**
**Editorial, Publishing, and Printing Offices:**
**SALISBURY COURT, FLEET ST., LONDON, E.C.**
*Telephone No.* 2714. *Telegrams:* "ELECTRICIAN NEWSPAPER, LONDON."

*All Letters relating to Subscriptions, Advertisements and other business matters should be addressed to the Publisher, "*THE ELECTRICIAN,*" Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to "*THE ELECTRICIAN*" Printing and Publishing Company, Limited, and be crossed "Coutts and Co." All other letters to be addressed to the Editor.*

*All letters intended for insertion in "*THE ELECTRICIAN,*" or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

"THE ELECTRICIAN" *is published every Friday morning, in time for the morning mails. Subscribers should receive their copies by the first post on Friday morning.*

"THE ELECTRICIAN" *is on sale at the railway bookstalls throughout the Kingdom on Friday morning, and can be obtained of all Booksellers and Newsvendors; or direct from the Publishing Offices as above.*

*New Volumes of* "THE ELECTRICIAN" *commence in May and November.*

## SUBSCRIPTION RATES

The rates for Subscriptions to "THE ELECTRICIAN" are as follows:—

| | 3 months. s. d. | 6 months. s. d. | 12 months. s. d. |
|---|---|---|---|
| For the United Kingdom | 5 0 | 10 0 | 19 6 |
| For Foreign Parts and Colonies:— Within Postal Union | 6 6 | 12 6 | 24 0 |
| Aden Borneo, Ceylon, China, India, Japan, Java, Labuan, Mozambique, New Caledonia, Persia, Philippine Islands, Siam, Transvaal, and Zanzibar | 7 6 | 14 6 | 28 0 |



## TO ADVERTISERS.

"THE ELECTRICIAN" *offers exceptional advantages to Advertisers.* **It has by far the largest circulation of any English Electrical paper, and circulates all over the World.**

*Particulars relating to Advertisements will be promptly forwarded on application to the Offices as above.*

TRADE ADVERTISEMENTS *intended for the current issue must reach the Offices not later than First Post on Thursday morning. Renewals of expiring advertisement orders and alterations to standing adv rtisements should be in the Publisher's hands by Wednesday at latest. No alteration can be made in Wrapper advertisements after Wednesday evening.*

SMALL PREPAID ADVERTISEMENTS *(for Rates see page xvii.) are accepted up to 4 p.m. on Thursday.*

## TECHNICAL PRINTING.

"THE ELECTRICIAN" PRINTING AND PUBLISHING COMPANY (LIMITED) *inform Electricians, Electric Light Engineers, &c., that they make a specialty of Technical Printing, and have a large Staff thoroughly acquainted with Electro-Technology. They can, therefore, promise Accuracy and Despatch in the Printing of Electro-Technical Literature, &c.*

## "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. (Royal 8vo.)

*Early in each year is issued* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. *The* DIRECTORY *was established in 1883, and the 1890 Edition consisted of about 850 pages of printed matter. The names and addresses of all persons engaged in the Electrical Industries at home and abroad may be relied upon as accurate. Useful Tables and Electrical Formulæ, and information specially compiled for this work are given, together with popularly-written Biographical Notices of the leading Electricians, Electrical Engineers, &c., accompanied in many cases by Portraits.*

*Orders for the 1890 issue should be forwarded* AT ONCE *to the Publishing Offices, Salisbury-court, Fleet-street, London, E.C.*

*The 1891 Edition is now preparing, and New Names, &c., can now be received.*

## ELECTRICAL BOOKS AND PUBLICATIONS.

*All Books, Newspapers, and other publications, dealing with Electrical and kindred subjects, can be ordered direct of* "THE ELECTRICIAN" *Printing and Publishing Company, who are proprietors of the well-known* "ELECTRICIAN" *Series of Standard Electrical Works, and are agents for all the leading publishing houses at home and abroad.*


## CONTENTS OF THE CURRENT NUMBER.


NOTES .......... 127
Electrical Distribution by Transformers from Central and Eccentric Stations. By Dr. J. A. Fleming, M.A. Illustrated. Continued .......... 132
Drum Armature Winding. By F. M. Weymouth. Illustrated Continued .......... 134
Meetings of Scientific Societies .......... 137
LLOYD'S RULES FOR ELECTRIC LIGHTING .......... 138
Notes on the Chemistry of Secondary Cells. By Prof. W. E. Ayrton and Messrs. C. G. Lamb, B.Sc., and E. W. Smith. Illustrated. Continued .......... 140
The Water-Power of the Falls of Niagara. Illustrated .......... 144
The Protection of the Electrical Industry in France .......... 144
The Electrical Treatment of Sewage. By W. Webster, F.C.S. .......... 146
The Artificial Light of the Future. By Prof. Edward L. Nichols. Illustrated .......... 147
The Electro-Magnet. By Prof. Silvanus P. Thompson, D.Sc., B.A., M.I.E.E. Illus. Continued .......... 151
Physical Society—
Additional Notes on Secondary Batteries .......... 154
American Notes .......... 155
Books Received .......... 155
LEGAL INTELLIGENCE—
The Queen v. Fareham Electric Light Company and Others .......... 155
Lane-Fox v. Drake and Gorham .......... 155
Re Henry Thompson .......... 155
Trade Notes and Notices .......... 155
PATENT RECORD .......... 156
New Companies Registered .......... 157
City Notes, &c. .......... 157
Companies' Share List .......... 158



## "THE ELECTRICAL WORLD" OF NEW YORK.

"THE ELECTRICAL WORLD" OF NEW YORK *can be obtained from* "THE ELECTRICIAN" *Office, Salisbury-court, Fleet-street, London, E.C. The Rate of Subscription (payable in advance), is* **£1 5s.** *per annum. Single Copies* **price 6d. each; post free, 8d.**


## LLOYD'S RULES FOR ELECTRIC LIGHTING.

The diversity and unsatisfactory state of the rules relating to electric lighting have recently been discussed both in the daily and in the technical journals. Some correspondents have raised objections to the inconvenience of having to follow a number of regulations imposed by several different authorities. Others, who advocated the general adoption of a certain set of rules, were met by the well-founded complaint that their interpretation was left too much to the whims of an inspector. It appears that yet another set of rules has been put forward, and these, when revised, will no doubt come into force before long. They will not, however, in any way interfere with those to which we have referred, as they apply only to electric light on board ship. It is natural that regulations for this purpose should emanate from Lloyd's, and the prestige of this institution, coupled with the fact that they have for many years successfully exercised their authority in matters of engineering construction, will no doubt give to their electric light rules such an influential character that any propositions from other insurance offices will be unlikely to arise.

We have received a report of the Chief Engineer-surveyor, and of his Assistant on electric lighting, and to this is appended the set of proposed regulations. The authors state that they have consulted the surveyors at the ports where vessels have been fitted, and the electricians who have been engaged on the work; they have also gathered from the large steamship companies their experiences, which, as the outcome of actual difficulties surmounted, are naturally of considerable importance. The dangers are of two kinds: the effect on the compasses and the danger of fire. The authors of the report state that "whatever type be adopted, the dynamo comprises, when working, a very powerful magnetic field, with one or more pairs of poles," which "not only exert a directive influence themselves on any compasses near them, but also induce magnetism in masses of iron near them, which in turn affects the compasses." They assume that "it is im-

Digitized by Google

possible to annul the magnetic effect, and all that can be done is to locate the dynamos and compasses as far apart as possible." The researches of these gentlemen have evidently failed to acqnaint them with the so-called ironclad dynamos, although we do not consider that the advantages offered by a complete absence of any external field are of any more importance in connection with the effect on compasses than with the efficiency of the dynamo as a generator. This question, together with the effect of the conductors carrying the current, was discussed somewhat briefly by Sir W. THOMSON, at a meeting of the Institution of Electrical Engineers in May last year, and he then pointed out that the stray field of a modern dynamo is much less than that of the earlier machines. The tendency to make long armatures with plenty of pole-face will materially reduce the leakage at a distance, but any attempts to make cheap or light dynamos by forcing the strength of their fields will have an opposite effect. The inverted arrangement which Mr. WILLANS advocates should be one of the best as regards the effect on a compass, not only because the poles are turned downwards, but because they are buried within the cast iron bedplate.

Although the builder of an inverted dynamo always inquires, if he be mindful of his interests, as to the distance at which his pole pieces will be placed from an iron deck, and the thickness of the deck, the leakage thus produced will only disturb the action of the dynamo if it be so near to the poles that some of the lines of force pass through it rather than through the armature. But a mass of iron at a reasonable distance from the machine will not sensibly lessen its output, though it will gather up all the stray field which might otherwise affect a compass.

We need not here discuss the relative merits of the one-wire and of the two-wire system. Mr. SIEMENS, who so strongly advocates the former, gave little or no reason for his choice in the discussion following the paper to which we have referred. The report alludes to the advantage offered by the double wire system in the reduced action upon the compass. The authors of the report to Lloyd's have grasped the general relations of current, resistance, and volts, and enter into a brief dissertation on them, but it would perhaps have been well if they had sought somewhat higher authority than the electricians who have been engaged on wiring ships. "It is found," they say, "that with wires of the same material, carrying the same current, the rise of temperature is inversely proportional to the square of their sectional areas." The heat generated is proportional to this, but the facilities for its escape, whether into the surrounding air, or into wooden casing, depends upon its surface, and therefore on its diameter; the temperature is then proportional to the square root of the cube of the diameter, as shown theoretically by Prof. FORBES and from experiment by Mr. KENNELLY. In describing compound dynamos and their engines, it is suggested that any variation of speed owing to want of sensitiveness in the governor will necessarily affect the volts, and the stipulation is recommended that the variation in speed should not exceed 5 per cent. With such a variation (and a governor cannot be expected to do more on board ship) the dynamo should be overcompounded; and if overcompounded there is no need to restrict the engine-maker to 5 per cent. if he can make a more efficient governor with a greater range. The report concludes with an allusion to Mr. ANDREWS' concentric system of wiring, and observes that this is practically a single wire system. Some such method is probably the best for ship work, if the return joints are really carefully made, and not screwed, or clamped, or soldered to the nearest piece of metal that happens to be in contact with the skin of the ship. One of the greatest evils of the single wire system is the temptation to make a cheap and easy contact for the return.

The report is followed by "suggested regulations," which are on the whole well drawn up. Some rules, however, seem to be copied from one set into another with little but their hackneyed habitude to excuse them. EDMUND SPENSER'S remarks on the Irish laws three hundred years ago may be applied to some of these wiring rules. "The statutes. . . are not manie. . . and yet of those fewe there are sondrie impertinent and unnecessarie: the which perhappes though at the tyme of the makinge of theme were very needeful, yet nowe through chainge of tyme are cleane antiquated and altogether idle." Such a statute is that which enacts that the copper must be of "a conductivity of at least 98 per cent. that of pure copper." The original framer of this rule presumably wished to avoid overheating, and, knowing that this depends on the resistance, thought he would make a rule which would keep this down as much as possible. The modern regulation of the Board of Trade which goes straight to the point is the proper one, and the rise of temperature should be specified, together with the maximum drop of volts; if a contractor likes to wire with brass under these conditions, there is no very apparent reason why he should not do so. The Board of Trade has very properly dropped the other ancient law which prohibited a greater current density than one thousand amperes per square inch. A little revision will be necessary before these regulations pass the present stage; and we would venture to suggest that a good many hints may be taken from the article on the electric lighting of a modern man-of-war in our issue of October 3. Cut-outs should be fitted to the circuit, says one of the proposed rules, as near as possible to each of the dynamo terminals, and also to each circuit as near as possible to the switches of these circuits. Since the "tree" system of wiring has generally to be adopted in ship work, with mains, branch mains, and lesser branches, instead of the much more desirable plan of mains and single wires for each lamp, the arrangement of cut-outs must be devised to suit it, and instead of a cut-out to each lamp, at the junction with the main, cut-outs must be placed at the branches, as near the larger conductor as possible, but the switch is not the point at which a cut-our is required, and it is by no means advisible to have one at *each* joint. Such a profusion of cut outs introduces a needless multiplication of contacts and resistances. They should be so arranged that no conductor shall be heated above the Board of Trade limit of 30° Fahr. by the current which is required to melt the fuse between that conductor and the dynamo.

The importance of having the very highest class of work on board ship cannot be over-estimated. Although the vessel be in mid-ocean, the conductors always have an "earth" near them. The ever present damp, aggravated by the hygroscopic nature of sea salt, searches out leaks, and corrodes metal fittings. A fire on board ship, even of a limited character, is fraught with the greatest danger, though a similar outbreak on land might cause but a little unpleasantness.

The difficulties of ship lighting are peculiar, and they are by no means fully apparent even to a contractor who has wired and fitted up half-a-dozen vessels. Nor can the sea-going officer, in whose hands the maintenance of the work is placed, be considered to have a complete knowledge of the whole work. An interchange of experience between these two individuals is greatly to be desired. The Admiralty lighting is neither remarkable for economy or for common sense, but the results are satisfactory; while the illumination of the ocean steamers is too often not only annoying, but dangerous, by reason of unsound and careless work.

Digitized by Google

## NOTES ON THE CHEMISTRY OF SECONDARY CELLS.*

By Professor W. E. AYRTON, Vice-President; C. G. LAMB, B.Sc., and E. W. SMITH, Associates.

*(Continued from page 105.)*

In order to see how far the resistance of the lead grid would tend to make the current-density in the upper part of the liquid less than in the lower, as well as for the purpose of seeing how large a fraction of the whole resistance of the accumulators was due to the lead lugs and to the connections between the successive pairs of lugs, the following tests were made by three of the students—Messrs. Hobson, Lee, and Montealegre:—

Parts of the lead lugs of some of the accumulators were scraped, and on these clean spots binding screws, which had been themselves filed bright, were tightly screwed (Figs. 7, 8 and 9). The accumulators were allowed to send measured currents, the values of which are given in the following tables, and the

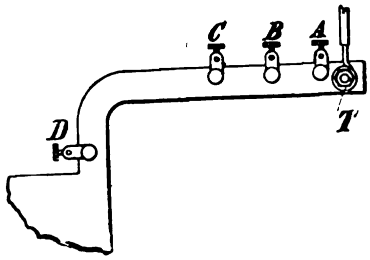



FIG. 7.

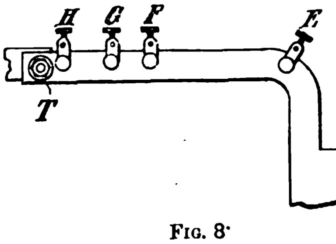



FIG. 8.

potential difference between the pairs of binding screws was carefully measured with a sensitive reflecting voltmeter. The resistance of the lugs between the pairs of binding screws is then at once obtained by dividing the potential difference by the current.

| Fig. | Position of binding screws. | State of nut and Screw T. | Length of lug in inches. | Current in amps. | P.D. in volts. | Resistance in ohms. |
|---|---|---|---|---|---|---|
| 7 | A and D | ... | ... | 8 | 0·00187 | 0·000230 |
| | A and C | ... | 3·25 | 8 | 0·00117 | 0·000150 |
| | A and B | ... | 1·5 | 8 | 0·00060 | 0·000070 |
| | T and A | Dirty ...... | Wire pressed on at T | 8 | 0·00038 | 0·000047 |
| | | Clean ...... | | 8 | 0·00028 | 0·000035 |
| | | Dirty ...... | Wire screwed on at T | 8 | 0·00028 | 0·000035 |
| | | Clean ...... | | 8 | 0·00025 | 0·000031 |
| 8 | E and H | ... | 6·5 | 8 | 0·00219 | 0·000270 |
| | F and H | ... | 4·0 | 8 | 0·00126 | 0·000160 |
| | G and H | ... | 1·5 | 8 | 0·00049 | 0·000060 |
| | T and H | Dirty ......... | ... | 8 | 0·00021 | 0·000030 |
| | | Clean ......... | ... | 8 | 0·00021 | 0·000030 |
| 9 | K and L | Dirty ......... | ... | 8 | 0·00522 | 0·000650 |
| | T and O | Dirty ......... | ... | 8 | 0·00063 | 0·000080 |
| | | Clean ......... | ... | 8 | 0·00057 | 0·000070 |
| | K and L | Very dirty ... | 13 | 5 | 0·00500 | 0·001000 |
| | T and O | Very dirty ... | ... | 3 | 0·00524 | 0·001750 |
| | | Clean ......... | ... | 10 | 0·00044 | 0·000044 |

From this it appears that the resistance per inch of the lug alone is about 0·000043 ohm; and that the resistance at the contact of two lugs which were tightly screwed together when quite clean, but which have become very dirty from the acid spray falling on them, may be as high as 0·001 ohm, or thirty times the resistance of an inch of the lug itself. The resistance between T and O (Fig. 9) being greater than between K and L, when T was very dirty, is probably explained by the fact that when the wire was screwed under T to test the resistance between T and O (Fig. 9), it was screwed against an exceptionally dirty bit of the lug.

As we have shown in the Edinburgh paper, the mean resistance from positive lug to negative lug of one of these accumulators *complete* is about 0·004 ohm when the contacts between the lugs and the testing wires are made quite clean. Hence it appears that about one-seventh of the whole mean resistance of such an accumulator is caused by the resistance of the lead lugs themselves; and that the resistance of such accumulators as we have been experimenting with can, when joined up in series, be increased by 25 per cent. if the contacts be allowed to become dirty by the acid spray falling on them, even although they remain all tightly screwed up.

Since these tests were made we have had all the accumulators disconnected, the contacts carefully cleaned and tightly screwed up, and the nuts and screws then coated with hot paraffin wax.

The coarsely divided paraffined cork which is sold by Messrs. Drake and Gorham for floating on the tops of accumulators to filter the hydrogen gas from sulphuric acid spray, was most successful in stopping the acid fumes from escaping into the room when we first obtained it. As, however, the cork became thoroughly wetted with the liquid, its filtering property was much diminished. It appears to us that there still remains the need for a really good spray-arrester.

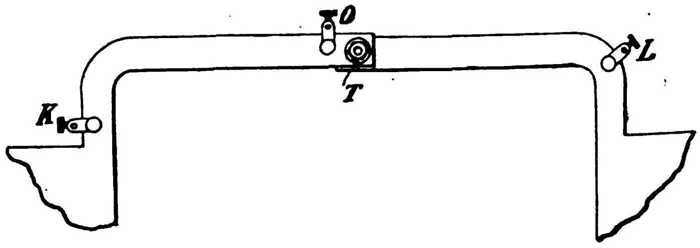



FIG. 9.

### IV.—ANALYSIS OF PLUGS.

The following is the report of the analyses of the plugs removed at different stages of the charging and discharging, which Mr. Robertson has been so kind as to prepare for us:—

*Report by G. H. Robertson on Analyses made in the Chemical Department of the Central Institution of Plugs from an E.P.S. Cell.*

*October 16th, 1890.*

Preparation of the samples for analysis:—

The positive samples were taken separately, washed on to filters, and thoroughly freed from acid. In every case the samples from the bottom were harder to wash than the others, and the residues were dried for some hours at about 120° C.

The samples were now ground up fine in an agate mortar, and the splinters of wood and glass removed as far as possible. The approximate weights for analysis were now taken and re-dried on watch glasses at about 140° C.

At first the substance for analysis was dissolved in a porcelain dish, and the insoluble residue of sulphate was filtered off, with the intention of determining the amount of sulphate by the ammonium acetate method; but owing to the small amount of material available, and the error introduced by the solubility of lead sulphate in the nitric acid used to dissolve the sample, the attempt to determine both the peroxide and the sulphate was abandoned, and the samples were used to determine the peroxide only as accurately as possible. This course was justified by the fact that very careful qualitative experiments showed that nothing but peroxide and sulphate was present in the plugs.

The method employed to determine the peroxide was the ammonium oxalate and permanganate method described in Sutton's "Volumetric Analysis," as in previous analyses it had been found very sensitive; and the solutions were checked about every two days against pure lead peroxide, and each day the solutions were run against each other, but they were not found to alter practically in the time they lasted. The first lot of ammonium oxalate was standardised against permanganate, which had been very accurately standardised against iron, and by the nitrometer method.

* Paper read before the Institution of Electrical Engineers on Thursday, November 13, 1890.

Digitized by Google

*Lead Peroxide Formed on the Positive Plates during Charge.*

| | Percentage of $PbO_2$. | Mean. | | Mean Increase in Percentage $PbO_2$, and Time Interval. | Total hours charge. | P.D. in volts just: Before breaking circuit. | P.D. in volts just: After closing circuit. | Specific gravity of Liquid. |
|---|---|---|---|---|---|---|---|---|
| | | | | | H. M. | | | |
| A* | Top ... 30·6, 31·0, 32·7 | 31·43 | 34·5* | ↑ | 0 37 | 2·134 | 2·122 | 1·178 |
| | Middle 35·23, 35·34 | 35·28 | | | | | | |
| | Bottom 36·5, 37·3, 36·6 | 36·80 | | | | | | |
| | | | | 41·0* 9 11 (H. M.) | | | | |
| B | Top ... 77·0 | 77·00 | 75·5 | ↓ ↑ | 9 48 | 2·2 | 2·186 | 1·198 |
| | Middle 76·1, 76·8 | 76·45 | | | | | | |
| | Bottom 73·2, 73·3 | 73·25 | | | | | | |
| | | | | 8·8 1 49 | | | | |
| C | Top ... 88·0 | 88·00 | 84·3 | ↓ ↑ | 11 37 | 2·234 | 2·186 | 1·201 |
| | Middle 85·15, 84·72 | 84·93 | | | | | | |
| | Bottom 79·8, 80·3 | 80·05 | | | | | | |
| | | | | 10·8 2 50 | | | | |
| D | Top ... 96·3, 96·8 | 96·5 | 95·1 | ↓ | 14 27 | 2·4 | ... | 1·206 |
| | Middle 94·1, 93·42 | 93·76 | | | | | | |
| | Bottom 95·00, 95·11 | 95·05 | | | | | | |

* Only the surface of the positive plugs was removed in the first attempt, A.

*Lead Peroxide Reduced on the Positive Plates during Discharge.*

| | Percentage of $PbO_2$. | Mean. | | Mean Increase in Percentage $PbO_2$, and Time Interval. | Total hours discharge. | P.D. in volts just: Before breaking circuit. | P.D. in volts just: After closing circuit. | Specific gravity of liquid. |
|---|---|---|---|---|---|---|---|---|
| | | | | | H. M. | | | |
| A′ | Top ... 96·7, 97·0 | 96·85 | 94·9 | ↑ | 0 25 | 1·998 | 2·002 | 1·205 |
| | Middle 94·88, 94·37 | 94·62 | | | | | | |
| | Bottom 93·4, 93·1 | 93·25 | | | | | | |
| | | | | 31·7 7 27 (H. M.) | | | | |
| B′ | Top ... 67·5, 67·06, 67·0 | 67·2 | 63·2 | ↓ ↑ | 7 52 | 1·956 | 1·958 | 1·189 |
| | Middle 64·82, 64·25 | 64·53 | | | | | | |
| | Bottom 57·9, 57·7 | 57·8 | | | | | | |
| | | | | 15·3 4 16 | | | | |
| C′ | Top ... 49·0, 48·8, 48·8, 48·3 | 48·7 | 47.9 | ↓ ↑ | 12 8 | 1·850 | 1·902 | 1·180 |
| | Middle 49·92, 50·5, 50·2 | 50·45 | | | | | | |
| | Bottom 44·07, 44·90 | 44·48 | | | | | | |
| | | | | 6·5 2 29 | | | | |
| D′ | Top ... 41·8, 44·01, 43·9 | 43·2 | 41·4 | ↓ ↑ | 14 37 | 0·6 | 1·9 | 1·175 |
| | Middle 42·70, 42·92 | 42·81 | | | | | | |
| | Bottom 37·9, 38·6 | 38·25 | | | | | | |
| | | | | 5·4 3 26 | | | | |
| E′ | Mixed 36·6, 36·7, 34·8 | 36·00 | | ↓ | 18 3 | Zero indefinite on re-making circuit. | E.M.F. | 1·172 |

Using this solution, "pure" lead peroxide, as purchased, and which afforded a slight white residue like silica, contained 97·3 per cent. as the mean of a large number of analyses made with different weights; and any subsequent solution which gave the percentage between 97 2 and 97·5, inclusive, was taken as correct. It will be noticed that D and A′ gave practically the same percentage as the sample of pure lead peroxide.

The residues from the samples containing the highest percentage of peroxide of lead were white, those from the samples containing the smaller percentage were brownish-white; and it was noticed that if the larger grains were crushed under the end of a glass rod they had a dark centre of peroxide, which at once dissolved, leaving a slight yellowish-white insoluble ring. By grinding the sample very fine in the mortar, so as to break up the capsules of sulphate more thoroughly, the residue was got lighter in colour; and using a flask to boil the substance in, the residue becomes perfectly white; but this yellowish-brown tinge to the sulphate does not seem to be due to any appreciable quantity of undissolved peroxide, as practically identical percentages were obtained with pure white and yellowish residues. Dark residues gave low results.

In the case of the very hard plugs, there was some error from the glass and wood, which could not be picked out altogether, though the samples were picked over very carefully (*cf.* D′, E′).

In the case of the negative plates, the sulphate was in such a loose and powdery condition that it fell off and adhered to the insides of the bottles used for receiving the plugs in, and it was quite impossible to obtain representative samples for quantitative analysis; so qualitative tests had to be made, which, in the case of charge, showed nothing but sulphate of lead and lead, the sulphate decreasing during charge until at D there was practically nothing but pure lead.

During discharge the sulphate increased; at C′ there was a doubtful indication of peroxide of lead, and at D′ and E′ there was decided evidence of peroxide. After a few days the plugs were white all over, and there was no difference in appearance between the front and back. The water had no acid reaction.

For the sake of comparison, the percentage of $PbO_2$ at A in the following table is taken as 47·9 as at C′.

The calculations refer to the mean values of $PbO_2$, and the values of potential difference before breaking circuit.

| | Interval. | Increase per Hour in Percentage $PbO_2$. | Percentage Increase in P.D. in Interval. | Percentage Increase in $PbO_2$ in Interval. |
|---|---|---|---|---|
| CHARGE. | A to B | 3·0 | 3·1 | 27·6 |
| | B to C | 4·8 | 1·6 | 8·8 |
| | C to D | 3·8 | 7·4 | 10·8 |
| | **Interval.** | **Decrease per Hour in Percentage $PbO_2$.** | **Percentage Decrease in P.D in Interval.** | **Percentage Decrease in $PbO_2$ in Interval.** |
| DISCHARGE. | A′ to B′ | 4·3 | 2·1 | 31·7 |
| | B′ to C′ | 3·6 | 5·4 | 15·3 |
| | C′ to D′ | 2·6 | 67·4 | 6·5 |
| | D′ to E′ | 1·6 | 100·0 | 5·4 |

The screening influence of lead sulphate is clearly brought out in this table. Between A and B the surface film and the coatings on the partially reduced granules of $PbO_2$ are got rid of; then between B and C the pure lead sulphate is attacked; and finally, between C and D, with the removal of the last traces we get a very rapid rise in volts potential difference.

It will be observed that:—

(*a.*) The particles of the peroxide very soon get coated in the discharge with a layer of lead sulphate which protects the peroxide from further action, as shown by the examination of the dark-coloured residues which contained peroxide, and which were rendered very hard to dissolve by the coating of sulphate.

(*b.*) The analysis also shows what a large proportion of active material is still remaining at the end of the discharge. This has been remarked on by many experimenters.

(*c.*) The loose powdery surface of the positive plate seems to be thoroughly converted into lead sulphate. C and B′ dissolve readily, leaving pure white residues.

(*d.*) When the peroxide in the surface of the plate falls to about 31 per cent. the cell loses its E.M.F. very rapidly, owing to the inactive layer of sulphate impeding the action of the sulphuric acid on the active material behind it, and also to the formation of peroxide on the negatives. The diffusivity of the acid is decreasing, and it has to penetrate further into the plate to find active material. When the whole of the paste approaches this composition of 31 per cent. peroxide, the cell loses its E.M.F. entirely.

(*e.*) The action seems to take place most rapidly where the current-density is greatest; the plate gets hard there from sulphate soonest on discharge, and oxidises quickest on charge.

Planté and Messrs. Gladstone and Tribe have both noticed the formation of peroxide of lead on the negative plate during discharge, and pointed out that once it is formed more rapidly than it is reduced, the two plates must rapidly approach electrical equilibrium; that when the circuit is broken local action alone can take place, and this will reduce the peroxide on the negative plate, and on making the circuit again the cell will again give a current; and in this way Messrs. Gladstone and Tribe account for the resuscitating power of the cell, as well as for the rise of E.M.F. on breaking the discharging circuit.

I have to acknowledge the facilities afforded me for seeing the plugs as they were removed, and the care taken to let me have the samples in good condition.

I am also indebted to Professor Armstrong for his invaluable advice and assistance in the execution of the work.

G. H. ROBERTSON.

Digitized by Google

From the mean results of the preceding analysis carried out by Mr. Robertson, we have drawn the curves seen in the lower part of Figs. 1 and 2, and which show the percentage of $Pb\,O_2$ found in the plugs of the positive plate at all stages of the charge and discharge. In the $Pb\,O_2$ curve for charge the first point is obtained from the analysis of the plugs at the end of the normal discharge—that is, when the terminal potential difference had fallen to 1·85 volts, indicated by the point C′ in Fig. 2. The percentage of $Pb\,O_2$ actually found in the positive plugs at the point indicated by A (Fig. 1) does not lie on the $Pb\,O_2$ curve as drawn, but, as already indicated, this arises from the specimens removed from the plugs at experiment A being only scrapings off the surface, and therefore not representing the average constitution of the plugs. On all subsequent occasions when specimens were removed from the plates, whole plugs as already stated were detached. The analysis at the point A (Fig. 1) was, therefore, abnormal, and the percentage of $Pb\,O_2$ obtained for this point, and which is given in the table, is not indicated on the curve.

If the energy given out by the cell be produced by the conversion of $Pb\,O_2$ in the positive plugs, and of Pb in the negative, into lead sulphate, a constant value of the potential difference at the terminals of the cell when a constant current is passing through it ought to correspond with a constant rate of variation of the percentage of $Pb\,O_2$ in the positive plugs; so that for a constant current

$$\text{the terminal potential difference should} \propto \frac{d(Pb\,O_2)}{dt},$$

$t$ representing time. This connection is seen to exist fairly well in the case of the discharge where the slope of the $Pb\,O_2$

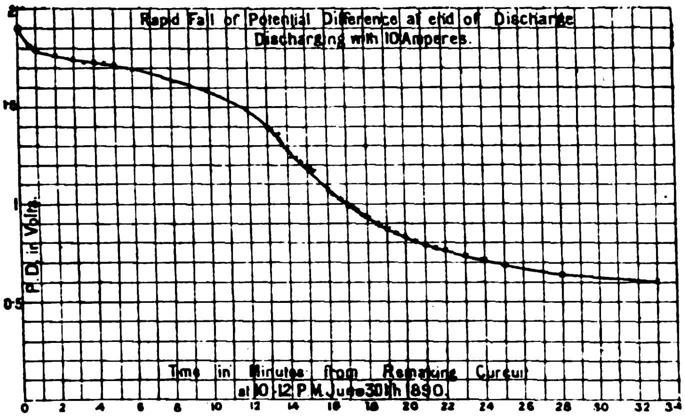



FIG. 10

The date on this curve should be June 10th.

curve is roughly constant as long as the potential difference is constant, and acquires a less inclination to the axis of time when the potential difference is rapidly falling. In the case of the charge, the connection between the value of the potential difference and the slope of the $Pb\,O_2$ curve is not so easily seen; but this arises from the fact that towards the end of the charging there is a rapid rise in the resistance of a cell, and therefore in the potential difference required to send a constant current through it; further, the back E.M.F. steadily increases during charging on account of the polarisation, which grows larger and larger from the continuous evolution of gas at the surface of the plates.

As already explained, the constant discharge-current of 10 amperes was, by the employment of some auxiliary cells, left flowing through the accumulator under test, even when its E.M.F. became very small. Towards the end of the discharge the fall of potential difference at the terminals of the cell under test became extremely rapid, so that, for example, on closing the circuit after the removal of the plugs at D′ (Fig. 2) the potential difference fell from 1·9 to 0·6 volts in 33 minutes, as seen from Fig. 10. This rapid fall is probably due to lead peroxide being formed on the negative plates more rapidly than it could be removed by local action, since the chemical analysis showed decided evidences of lead peroxide on the plugs removed at D′ from the negative plates. At E′ (Fig. 2) the E.M.F. of the accumulator under test became reversed, but rapidly recovered its original direction on stopping the discharge currents, as seen from Fig. 11.

It is a very striking example of the recuperative action of a secondary cell that you can completely discharge it as you think, and then even charge it in the wrong direction, but it will, on being insulated, rapidly recover an E.M.F. in the original direction. Indeed, we were told of a curious case some time back: after the removal of the laboratory, employed for testing ammeters, from one part of a well known London factory to another, it was found that the E.P.S. accumulators always ran down very rapidly whenever an attempt was made to use them, in spite of their having been charged in the intervals. As the E.M.F. was always in the right direction it was supposed that the cells had become partially short-circuited in the removal, and it was not for some time that the true explanation of the refusal of the cells to do their work was discovered. The real fact was that in fitting up the new laboratory the leads from the dynamo to the switch had been reversed, so that the unfortunate cells were charged in the wrong direction every time the dynamo was turned on.

The preceding incident also forcibly illustrates the sort of attention that secondary cells may receive in practice, and shows the necessity for the potential difference and specific gravity being occasionally measured, even in places where the

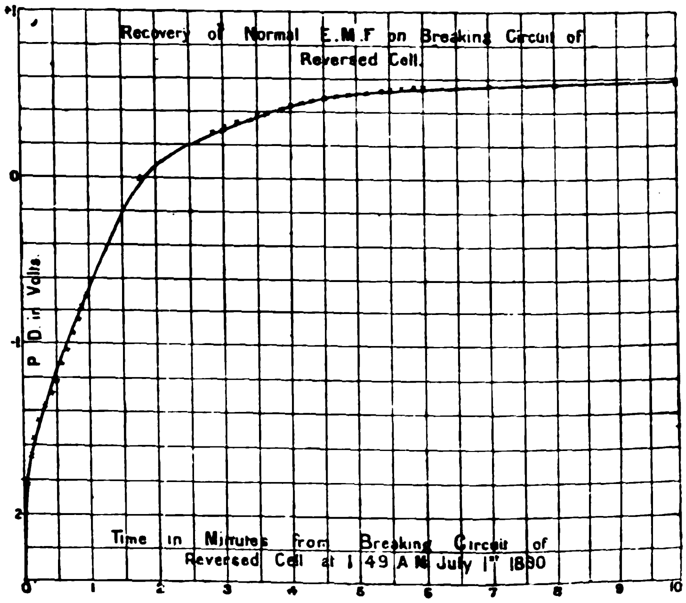



FIG. 11.

study of the behaviour of cells is not the main business of the factory.

One of the great defects of the earlier specimens of the E.P.S. cells lay in the buckling of the plates. Mr. Capito tells us that it was Mr. Collet who noticed that all the plates generally curved in one direction, and who suspected that this arose from the unequal chemical action on the two sides of the last positive plate of the cell. Mr. Collet therefore proposed putting a negative plate at each end of this cell, and this plan—which has been always followed since—of using one more negative than positive plate, has had much to do with removal of the buckling difficulty.

### V.—Effect of Rest on Charged Accumulators.

As the result of a number of tests described in our Edinburgh paper, we found that if E.P.S. accumulators be charged with 9 amperes and discharged with 10 a number of times without intermission, between the potential difference limits of 1·8 and 2·4 volts per cell, until the cells are brought to a perfectly steady "working state," the quantity efficiency is about 97 per cent., and the energy efficiency 87; further, that if the cells be fully charged until the potential difference per cell is 2·4 volts, and then be left perfectly insulated for 16 days, the next discharge between the fixed potential difference limits only gives out about 65 per cent. of the ampere-

hours, and about 57 per cent. of the energy put in before the rest. Further, not merely is energy lost during the rest of an insulated accumulator, but for several subsequent charges and discharges between the same potential difference limits after the rest the storage capacity and the quantity and energy efficiencies are all lower than before the rest.

For the purpose of examining into what took place in an accumulator which was left charged, a small E.P.S. cell was charged until the potential difference was 2·4 volts, and then the positive plates were withdrawn and put into another vessel containing dilute acid of specific gravity 1·2, the negatives being left in the vessel in which they were charged. Both sets of plates were covered up with gutta-percha hoods, the edges of which dipped under the liquid, and to the top of each hood was fitted, gas-tight, a vertical graduated glass tube, closed at the top. The hoods and the glass tubes were first filled with liquid, and the amount of gas that came off from the two sets of plates was measured from day to day by watching the descent of the liquid in the tubes.

No gas was seen to come off from the positive plates, but in the case of the negatives gas came off very slowly at first, then more rapidly, and finally more slowly again. The following table gives a record of the amount of gas that came off from the negative plates, the gas on analysis being found to be hydrogen* :—

*Hydrogen Gas Collected from Charged Negative Plates after Removal of Positive Plates.*

| Date. | Time. H. M. | Cubic centimetres of gas collected. | Time of collecting gas, in hours. |
|---|---|---|---|
| November 15th | 11 45 | 0 | 0 |
| „ 17th | 10 0 | 2 | 46 |
| „ 20th | 12 0 | 52 | 120 |
| „ 21st | 10 0 | 72 | 142 |
| „ 22nd | 10 0 | 87 | 166 |

If the lead of the positive plate be turned into lead sulphate by local action, 87 cubic centimetre of hydrogen liberated corresponds with about 0·81 gramme of lead turned into sulphate. It is clear, then, that the lead of the negative plate is steadily being turned into some oxide or salt, and probably the loss of energy which we observed in the charged cell left insulated for many days was due to this local action at the negative plate. And further, as this action takes place apparently only at the negative plate, it is clear that in the subsequent discharge the cell will appear to be discharged before the positive plate is discharged, and charged up again without reducing all the lead sulphate on the negative plate. The local action at the negative plate while a cell is standing charged has, therefore, for the first few discharges and charges after a long rest, exactly the same effect as if a portion of the negative plate had been bodily removed out of the cell. Hence we see that the peculiarities observed by us in curves 8 to 23 in our Edinburgh paper may be explained by this defective behaviour of the negative plates.

### VI.—Construction and Formation of E.P.S. Plates.

The question arises why the E.P.S. accumulators are so constructed that the plugs in the positive plates contain some 48 per cent. more peroxide of lead than is required to be converted into sulphate in the normal discharge. Two explanations suggest themselves. One is, that since the granules of lead peroxide begin, as we find, to be coated with a protecting coating of sulphate early in the discharge, it is impossible, with the present form of plate, for the interior of each granule of lead peroxide to be converted into sulphate, and therefore it is necessary to employ nearly twice as much lead peroxide as is actually needed for the chemical action. Another reason is the fear of the positive plate crumbling to pieces if it be completely formed; and this reason Mr. Capito, who was formerly in the employ of the Electrical Power Storage Company, thinks, on the whole, is the more important.

* Since the preparation of this paper we have noticed that Dr. Gladstone and Mr. Hibbert, in their paper communicated this summer to the Physical Society, have also observed that hydrogen comes off from a charged negative plate of a secondary cell when left idle.

In the construction of the original Faure accumulators, as well as of the early E.P.S. cells, both the positive and the negative plates were pasted with red lead ($Pb_3O_4$), and formed together for a period of some 50 hours. Later on litharge ($PbO$) was used to coat the negative plate, red lead being used only for the positive one, and the plates were formed separately, the negative being much more formed at the works than the positive. Some time ago I was informed by a very competent authority that the following is the modern process of *forming* employed by the Electrical Power Storage Company:—

*Positive plates.*—8⅞in. by 7⅞in. by ¼in. Two amperes per plate, or 0·028 ampere per square inch, sent for 18 hours.

*Negative Plates.*—9in. by 9⅝in. by $\frac{3}{16}$in. One and a-half to two amperes per plate, *i.e.*, 0·017 to 0.023 amperes per square inch, for 120 hours.

The actual time of forming either set of plates depends greatly on the length of stoppages during the formation. This is especially the case with the negative plates, therefore they endeavour to form the negatives for the 120 hours without any stoppage of the current. On the receipt of a cell from the Electrical Construction Corporation, the purchaser is requested to form it for 40 hours more with the ordinary charging current used in working, which is at the rate of 0·026 ampere per square inch.

Mr. Capito tells us that, when he was at Millwall, such periods of formation as 120 hours were not used; and he thinks that this may be due to the fact that formerly the plates were not dried after pasting and before formation, as they are at present. This drying hardens the plates and produces a better cell; but he thinks that, as the paste is itself mixed with sulphuric acid, there is probably some sulphating of the negative plates during drying, and that several hours in the subsequent formation are probably spent in reducing this sulphate.

The reason, we understand, for the manufacturers only forming the positive plates for 18 hours, and leaving the purchaser to form them for the remaining 40 hours, is that if positive plates be *well formed* and then dried for carriage, the plugs become loose, which is not the case if the positive plates be only slightly formed before drying.

We were interested in learning from Mr. Capito whether, while superintending the manufacture of many thousands of accumulator plates, he had ever tried pasting the positive with lead peroxide ($PbO_2$) in order to avoid the necessity of having to form this salt electrically out of the red lead with which the positive plates are usually pasted. This idea of applying a paste of lead peroxide directly to the positive plate, he told us, he had tried, but that the method turned out a failure, from the impossibility of getting the lead peroxide paste to stick on to the grid even when some red lead was mixed with the lead peroxide. He also mentioned a very interesting fact—that whereas a paste of red lead mixed with dilute sulphuric acid of density 1·1 gives an adherent deposit on formation, on the contrary, a powdery deposit is produced if the density of the liquid used in making the red lead paste be 1·2. We understand the process that has shown itself the best is to use dilute sulphuric acid of density 1·1 for mixing the red lead paste, and dilute acid of 1·2 for mixing the litharge paste for the negative plates.

**Royal Society.**—At the anniversary meeting of the Royal Society, held on Monday last, the Rumford Medal was presented to Professor Heinrich Hertz, for his work in electro-magnetic radiation, and a Royal Medal to Dr. J. Hopkinson, for his researches in magnetism and electricity. The Society elected the officers and council for the ensuing year, and Sir William Thomson was chosen president in succession to Sir G. Stokes. In the evening Sir W. Thomson took the chair, as president, at the dinner of the Society at the Hôtel Métropole.

Digitized by Google

## THE WATER-POWER OF THE FALLS OF NIAGARA.*

For many years it has been a matter of frequent comment, that at Niagara there existed an enormous water-power not utilised, and the feasibility of usefully applying a portion of the power of the cataract has been discussed for many years by the scientists and manufacturers of America. The illustration (Fig. 1) will give an idea of the inexhaustible source of the power, unaffected by floods or droughts.

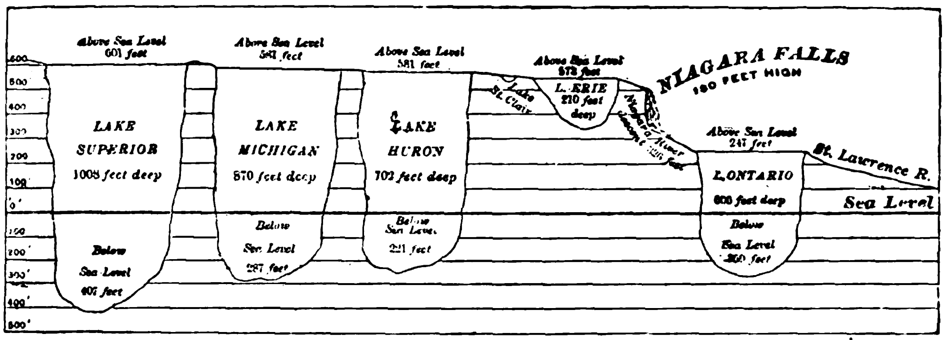



Fig. 1.—Depths and Levels of the Great Lakes supplying the Niagara Falls.

In March, 1886, the Niagara Falls Power Company was incorporated by a special act of the Legislature of the State of New York, for the purpose of constructing, maintaining, and operating the hydraulic tunnel, and for furnishing power for manufacturing purposes. The company has purchased lands extending two miles along the shore of the Niagara river adjacent to the hydraulic tunnel, which have been laid out for lots, streets, mill races, wharves and railway sidings for the purpose of forming a town composed wholly of mills, factories, and workshops. The company has also purchased an adjoining tract of one thousand acres, which has been laid out in streets and lots for homes for workmen employed. This association of prominent business men at Niagara Falls was organised for the further development of the water-power at Niagara. For this purpose, from the water level below the Falls, a subterranean tunnel will be constructed of horse-shoe shape, having capacity equal to a circle 25ft. in diameter, extending through the solid rock, to the upper river at a point about one mile above the Falls. From this point the tunnel continues parallel with the shore of the river one and one-half miles, at an average depth of 160ft. below ground, and about 400ft. distant from the navigable waters of the river, with which it is connected by means of surface conduits or canals, through which the water from the river enters, and is drawn through the shafts and wheel-pits into the great tunnel below, which forms an immense tail race for all of the mills, factories, and workshops. The plans adopted will develop 120,000 horse-power.

For convenience of construction, the work will be divided into three sections. The plan of the first section, upon which work is now begun, is shown in Fig. 2. The water falls upon turbine wheels, which will be put in by the company in a number of the pits, and the power developed thereby will be brought to the surface, from which point it will be delivered to the numerous mills and factories, or transmitted by cable, pneumatic tube, or electricity to adjacent lands, as the customers may desire. The company will also lease power to customers wishing to excavate their own wheel-pits, and put in their own water-wheels and connections.

For the construction of this great work a contract has been made, and under it operations have been commenced by the Cataract Construction Company upon the building of the tunnel and the shafts, raceways, and works to complete the undertaking.

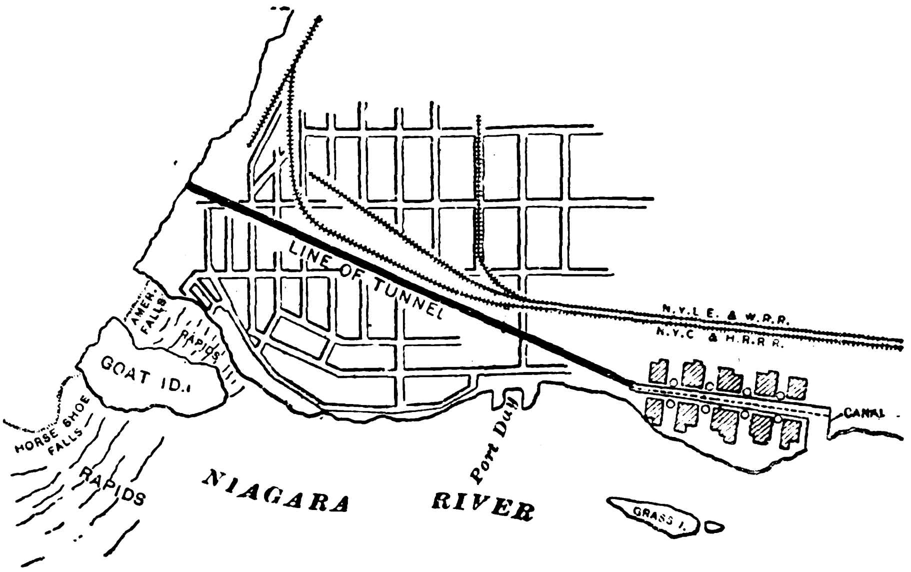



Fig. 2.—Plan of the First Portion of the Hydraulic Tunnel.

* From an illustrated Pamphlet issued by the Niagara Falls Power Co.

## THE PROTECTION OF THE ELECTRICAL INDUSTRY IN FRANCE.

A Committee of the Chambre Syndicale des Industries Électriques, appointed to investigate the question of the degree of protection required by the electrical industry in France, has just published an instructive report containing recommendations which are of considerable importance in view of the probability of their adoption by the Legislature when the treaties of commerce expire in February, 1892.

The report commences by pointing out that on the occasion of the last renewal of commercial treaties in 1881, the electrical industry was practically non-existent. Electric bells and fire alarms were the only apparatus specifically referred to, and these were subject to a duty of 15fr. per 100 kilogrammes, all other electrical apparatus being ranged under the head of

Digitized by Google

"Optical, observational, calculating, and mathematical instruments." In 1886, however, this "fantastic classification" was reformed, and the words dynamos, arc lamps, incandescent lamps, and accumulators were introduced into the customs' list and appropriate duties were levied.

"Such is the situation," the report goes on to say, "in which our industry has been placed since 1886. It corresponds neither to that of our competitors in the adjacent countries, nor to the exigencies of French labour. It leaves us completely disarmed in the face of foreign competition, and the Chambre Syndicale owes it to itself, and to the important interests which it represents, to agitate in the proper quarters, so that this state of affairs may be modified in 1892, when the commercial treaties which at present tie us will expire. Our industry is no longer a negligible quantity. It employs nearly 4,000 hands, and produces annually goods to the value of more than 30,000,000fr. For the past three or four years the electrical industry has been obliged to maintain against foreign firms a struggle which daily becomes more severe. These competitors, thanks to their protective tariffs and favourable economic conditions, have obtained a footing in our country which must be regarded with anxiety, unless the future is to be assured to us by a recasting in 1892 of the existing duties."

The report then proceeds to argue that a "compensatory," not a "protective" tariff is what is wanted, and figures are quoted showing the comparative cheapness of labour and materials in adjacent countries, and the necessity, therefore, for the imposition of import duties to maintain the equilibrium. "There is an universally held prejudice that to protect a new industry by import duties is equivalent to condemning it to stagnation, and, by reason of the suppression of foreign competition, to destroy the inevitable necessity for progress. Nothing is more specious, yet nothing can be more fatal. On the contrary, the manufacturer protected by a reasonable duty and consequently assured of a fair profit, is stimulated to improve his products in order to compete with native firms, and to impose his goods on the foreigner. The profits on home sales then suffice to cover general expenses, and he is therefore in a position to compete abroad, since any price that he obtains over and above the mere cost of labour and material is clear profit. This, in fact, is the policy of our German, Swiss, and Belgian neighbours." Figures are then brought forward to show that labour is from 40 to 100 per cent. cheaper across the French frontier, and that the cost of materials is about 10 per cent. less. The exact amount of the duties levied by adjacent countries on electrical goods is, it seems, difficult to determine exactly. The conclusion drawn from the result of all these investigations is, that the imposition of *ad valorem* duties are necessary to "defend our imperilled industry against invasion."

The committee then go *seriatim* through the different electrical articles manufactured in France, assigning to each the protective duty which they deem to be necessary.

*Telegraphic Apparatus.*—The existing duties, it seems, require no amendment, telegraphic apparatus being only purchased by Government and by the great railway companies. In the case of the former, the law prohibits the purchase of foreign apparatus, and the railway companies have always made it a point of honour to follow suit.

*Telephonic Apparatus.*—No alteration required, the State being now the only purchaser, and "French apparatus being far better than foreign."

*Measuring Instruments.*—No alteration required, since accuracy is of more importance than cheapness in this class of apparatus. Moreover, from time immemorial all States have allowed physical instruments to go duty free in the interest of scientific progress, and "France could not be the first country to give up a custom conceived in such a liberal spirit." The Committee, however, cast longing eyes on voltmeters and ammeters, but relinquish the idea of imposing a tax, owing to the difficulty of definition,

*Voltaic Batteries.*—The present duty is vague, but owing mainly to the fact that the parts of a voltaic battery are generally imported separately, no alteration is proposed.

*Electric Bells and Domestic Accessories.*—For various good and sufficient reasons, this branch of the French electrical industry can, so it appears, hold its own in spite of the fact that the present duty of 2 per cent. is "absolutely derisory."

*Electric Light Apparatus.*—This branch of the industry is, according to the report, in a very parlous state. Belgium, Switzerland, and even the United States, compete in respect of dynamos. Germany inundates the country with cheap arc and incandescent lamps, while Belgium begins to rival England and Germany in its electric light cable imports.

*Dynamos.*—Analysing the cost of production of a 45 horse-power Gramme machine, the committee find that material costs 1,600fr. and labour 600fr. in France, while across the frontier the figures are respectively about 1,440fr. and 330fr.; that is to say, a 45 horse-power Gramme machine, which can be turned out for about 1,770fr. across the French frontier, cannot be turned out for less than 2,200fr. in Paris, or sold at a fair profit for less than 3,500fr. Similar analyses lead to similar results, and the committee consequently recommend a "compensatory" *ad valorem* duty of 10 per cent. Dynamos weighing less than 10 kilogrammes are, however, to be allowed in duty free, being physical apparatus.

*Arc Lamps.*—The present duty amounts to 1·33 per cent. The average cost of an arc lamp made in France may be taken at 95fr., viz., 35fr. for material and 60fr. for labour, and the cost of production of a similar article abroad is worked out at 76fr. 50c., or 18fr. 50c. less. Since, therefore, an arc lamp is sold at about 150fr., the difference in cost of production amounts to 12 per cent. of its selling value. The French arc-lamp makers are, however, magnanimous; they only want a 10 per cent. duty.

*Incandescent Lamps.*—These lamps, which used to be sold in France at 6fr., can now be bought, the report states, for from 1·8fr. to 2·25fr. Such prices, we are assured, render profit impossible to French manufacturers. In Germany, where the manufacturers are protected by a 12 per cent. duty, and where the consumption is considerable, they are able to export lamps at a profit, so long as they fetch more than 1fr. In Paris the cost of production of an incandescent lamp is 1·4fr., and, taking other items into consideration it cannot be sold at a profit for less than 1·85fr. Taking, however, the present average selling price as 2fr., and allowing ·4fr. for the difference between the cost of German and French labour, a "compensatory" duty of 20 per cent. is deduced, the present duty being at the rate of ·15 per cent. The French Edison Company thought a 25 per cent. duty desirable, but the committee feel unable to recommend anything higher than 20 per cent.

*Arc Light Carbons.*—"The lamentations of the arc light carbon-makers are," the report states, "more sharp even than those of the lamp-makers. It is incontrovertible that German competition has rendered the fight impossible." The cost of production of a 10mm. carbon in France is placed by the committee at 35 centimes, while German carbons can be *bought* in Paris for 28 centimes. Logically applying the "compensatory" principle would mean the imposition of 30 per cent. duty, a duty, indeed, which is "energetically called for" by the carbon manufacturers. Again, however, the Committee are unable to recommend such a prohibitory tax, and propose a 20 per cent. *ad valorem* duty. Carbons from Germany, being classed as lampblack, are admitted into France practically duty free, paying only a tax of 1·25frs. per 100 kilogrammes. The German tax, on the other hand, is 37·5frs. per 100 kilogrammes, or about 15 per cent. *ad valorem.*

*Accumulators.*—Accumulators, being classed as sheet lead, pay a duty of 3frs. per 100 kilogrammes, *i.e.*, about 1·5 per cent. *ad valorem.* "In spite of the insignificance of this tax, foreign competitors have not, so far, succeeded, except by virtue of the superiority of their products . . . It would seem, therefore, as if our manufacturers are able largely to hold their own. . . . Nevertheless, the arguments which have been brought forward elsewhere with regard to the difference in the cost of labour and material in France and Belgium (the important manufacturing centre) prove the equity of imposing a tax of ·24 per kilogramme, or 10 per cent. *ad valorem*, in order to maintain

Digitized by Google

an equal balance between this apparatus and the other electric lighting appliances which we desire to protect."

*Electric Cables.*—The cost of the insulating material being so greatly in excess of any other item, and its cost being much the same in all European countries, the cost of labour becomes comparatively unimportant; as, however, this latter item amounts in France to between 8 and 10 per cent. of the selling price, and only to between 4 and 5 per cent. in Germany, a 5 per cent. *ad valorem* duty is proposed. Belgium imposes at present a 10 per cent. duty on French cables, and France a 2 or 3 per cent. duty on Belgian cables.

*Detached Pieces.*—Coming finally to the consideration of possible fraud on the part of the heavily taxed foreign competitor, the Committee propose to prevent the "tariff being turned" by the imposition of a double duty on sundry detached articles.

*Conclusion.*—This remarkable document concludes as follows:—"To resume, gentlemen, your Committee propose, after an exhaustive investigation of the electrical industrial situation, that the following *projet de taxation* should be adopted, and inserted in the general Customs list which will be promulgated on February 1, 1892, and ask you to empower your Committee to urge with energetic perseverance its acceptance by the authorities."

List of Proposed Duties.

| | Per cent. |
|---|---|
| Dynamos | 10 |
| Arc Lamps | 10 |
| Incandescent lamps | 20 |
| Arc light carbons | 20 |
| Accumulators | 10 |
| Cables | 5 |
| Dynamo Armatures | 20 |
| Hollow or solid metal bobbins covered with insulated copper wire | 20 |
| Pieces worked in copper, weighing less than 1kg., numbered or marked, together or separate, intended for electrical apparatus | 150fr. per 100kg. |

The authors of this report are MM. Carpentier, De Branville, Radiguet, Lévy, Benard, Picou, and Sciama.

## THE ELECTRICAL TREATMENT OF SEWAGE.*

BY W. WEBSTER, F.C.S.

In the early days of the process experiments were made with electrodes of carbon and platinum, but the high cost of the latter and the disintegration of the former in the presence of the nascent elements compelled their abandonment in favour of iron. This alteration brought other chemical reactions into play, and though the precise mechanism of the change was still somewhat obscure, a hypochlorite of iron appeared to be formed at the expense of the anode and the chlorides naturally present in sewage. The progress of the purification was attended with the production of ferrous hydrate and ferrous carbonate, the former of which acted as a precipitant. On the passage of the current the sludge began to separate as a flocculent precipitate. When this was done on a laboratory scale, the flocculent matter rose, being full of hydrogen bubbles, but in practice it went to the bottom. The method now adopted consisted essentially in passing the sewage through a brick channel contained a large number of cast-iron electrodes connected in parallel, The cast-iron plates were from ½in. to 1in. thick, and 6ft. long, and 25 pairs were connected in series, the pressure between each pair being about 1·8 volts. The plates were placed in a shoot 18in. deep, 2ft. wide, and 200ft. long. Favourable reports had been received from various well-known experts, one of whom—Sir Henry Roscoe—had had entire control of the experimental work for about a month. He found from 70 to 80 per cent. of the organic matter precipitated, as the following figures, taken at hazard from his analysis, indicate:

| | Oxygen absorbed. | Albumenoid ammonia. |
|---|---|---|
| | (Parts per 100,000.) | |
| Raw sewage | 5·64 | 0·87 |
| Unfiltered effluent | 1·92 | 0·45 |
| Raw sewage | 5·49 | 1·12 |
| Effluent | 1·48 | 0·14 |

About 20,000 gallons were treated, samples being taken every five minutes. The nature of the effluent was most satisfactory; no tendency to subsequent putrefaction was detected even under severe conditions of testing. There was a small quantity of red hydrate of iron in suspension, giving a reddish colour to the effluent; this would be an advantage when turned into a stream rather than otherwise, but it might very easily be removed by filtering through 6in. of sand if required. Besides this experimental work which had been on London sewage, the process was being tried at Salford, the sewage from that town and Pendleton being treated. Efficient purification was of particular importance here, as the effluent would pass into the Manchester Ship Canal, and must be of reasonable purity.

The quantity to be dealt with was 10,000,000 gallons per 24 hours, and for this it was calculated about 400 indicated horse-power would be requisite. The plant would consist of three boilers of 200 indicated horse-power, any two of which would suffice to do the work, and four engines, any three of which would be similarly adequate.

In the estimate of working expenses no commercial value was credited to the sludge, though after being dried and ignited it might serve as a filtering material in the event of a clear effluent being required. The current required per gallon was ·37 ampere hour, which was equivalent to 37 horse-power per million gallons. The annual cost of running the process was reckoned at £2,500, with an additional sum of £2,500 for the deterioration of 5,000 tons of iron electrodes. If a clear effluent were necessary, a further charge of £1,200 to £1,500 would have to be met.

* Abstract of a Paper read before the London Section of the Society of Cemical Industry, on Monday, December 1st. In the absence of Mr. W bster the Paper was read by Mr. Worth.

### DISCUSSION.

Mr. BISCHOFF spoke of the work of earlier experimenters on the resistance of the living organisms commonly present in sewage to the effects of electrolysis. The outcome of their investigations was that a considerable voltage and a comparatively high temperature were necessary for complete sterilisation. He doubted whether the Webster process would succeed in this particular respect.

Mr. SILLER regretted the apparent indifference of those interested in this process to the possible value of sludge obtained by various methods of purification, and instanced the success of the A. B. C. process at Kingston, where some 10,000 tons of sludge had been sold in the course of twenty-five years for £34,000, the harmlessness of the effluent to fish life must also be considered.

Mr. BIRCH joined issue with the last speaker on the question of the value of the sludge, holding that that derived from the Webster process should be at least as valuable as the A. B. C. product, there being no addition of clay, &c., and inquired the cost per head for the complete treatment of ordinary town sewage, both as proposed, and also for a higher degree of purification than had been hitherto attained.

Mr. CROSS dealt particularly with the scientific aspect of the process, asking for further information as to the reactions that took place during electrolysis. In the *precis* of the experts' reports that had been submitted to the meeting, nothing was said as to the degree of aëration of the effluent. He was of opinion that most, if not all, the dissolved oxygen —so potent a factor in water purification—was consumed to convert ferrous salts into the ferric state.

Mr. NEWLANDS remarked that electrical processes were apt to be viewed with a little suspicion if applied to products and materials having apparently little connection therewith. He could remember the commotion created by the application of an electrical process to the purification of a substance with which he had had a good deal to do, viz., sugar, and the unkind things that had been said of its promoters. A patent had been taken out about 10 years ago by Messrs. Hodge and Eastwicke for purifying sugar solution by electrolytical means, and it was worded so widely that it seemed almost to cover the case of a substance somewhat less sweet—sewage, to wit. He commended its perusal to those interested in the latter commodity.

Mr. FLETCHER endorsed the statements contained in his report, which had been referred to in the Paper.

Mr. C. E. CASSAL, having elicited that the results of the analyses given above were stated in parts per 100,000, proceeded to criticise the process on the ground that the purification was less complete than could be wished, and regretted that the meeting had been unable to listen to the whole of the reports by various eminent chemists, as much information might sometimes be gathered by reading between the lines. He welcomed any process less monstrous than the recent proposal to convey the whole of London sewage bodily to the sea—a scheme the useful effect of which appeared to be confined to the pecuniary advantage of its promoters.

Colonel JONES recalled the *furore* that the advent of the Webster process had caused at the Institution of Civil Engineers, and supposed it might be explained on the *omne ignotum pro magnifico* principle. It was remarkable that the very considerable effect of mere agitation, aëration, and subsidence upon sewage had been overlooked by most of those engaged in its purification. The result due to these simple agencies was invariably credited to each several process as it was devised. The first time attention had been directed to it appeared to be in the Blue Book of the proceedings of the Royal Commission appointed at the instance of Lord Bramwell.

Mr. DAVID HOWARD asked particularly what *time* was requisite for purification, as rapid subsidence was essential to the success of a process of this kind.

Dr. MESSEL feared that electrolytic oxygen would prove a costly oxidant, and doubted whether cast-iron plates could be used on account of their slow rate of solution.

Digitized by Google

Mr. A. P. TROTTER asked for further information as to the time required. Accepting Mr. Webster's figures, he had roughly calculated that the duration of treatment amounted to about 12 min., but should be glad of a definite statement on this point. The time necessary for subsidence of the sludge was an important factor, concerning which he should be glad to have accurate data.

Mr. C. C. HUTCHINSON attacked the figures that had been given as to the cost of treatment at Salford. According to his calculations and reckoning, the cost of one indicated horse-power at one penny an hour, and allowing for the cost of oil, labour, and maintenance, the necessary yearly expenditure for the treatment of 10,000,000 gallons per 24 hours, as at Salford, would amount to £21,000 to £24,000, which was about four times as much as the estimate Mr. Worth had given. The whole value of the process turned on this question of cost, and according to its decision it must stand or fall.

Mr. WORTH, in reply, regretted that he had to act as a substitute for Mr. Webster, owing to his less perfect familiarity with all the details of the process. Any questions which he was unable to answer would be replied to by Mr. Webster from the shorthand notes of the querist's remarks. He did not think the complete diminution of organisms referred to by Mr. Bischoff necessary or even desirable; a sterilised effluent, even if practicable, would be speedily swarming with life again. He could not, like Mr. Siller, point to a town where the process was in actual operation; but it must be remembered that the process was a young one, and had not been at work, as the A. B. C. process had, for 25 years. Still they hoped to emulate Mr. Siller's perseverance, and have a town of their own, possibly as important as Kingston, before the elapse of another quarter of a century. Though considering the sludge from the Webster process at least equal to that produced by the A. B. C. process, he did not expect to get £3. 10s. a ton for it, and congratulated Mr. Siller on his greater good fortune. It had been proved that fish would live in the effluent, though that was scarcely a criterion of its purity. The questions put by Messrs Birch and Cross would be referred to Mr. Webster, who would doubtless answer to them as stated above. He could assure Mr. Cassal that the elimination of the whole of the organic matter was unnecessary for the production of a safe effluent, and heartily endorsed his criticism of the proposed treatment of London sewage. He fearlessly challenged Col. Jones (who had unfortunately left) to shake a sample of London sewage, such as had been treated by the Webster process before the section for 20 minutes, or even longer, being convinced that such simple treatment would not suffice to effect its clarification. In reply to Mr. Howard, he stated that the Webster process undoubtedly caused more rapid subsidence, and that its inventor was alive to the necessity thereof. In reply to Mr. Trotter he could say that the maximum time of subsidence was about three hours. The figures to which Mr. Hutchinson objected were calculated on the assumption that coal at 10s. per ton could be used and give one indicated horse-power for a consumption of 2lb. per hour. It would be, perhaps, better to suspend judgment on some of the points under dispute until the report of the engineers and chemists having charge of the Salford experiment was issued, as it was to be published very shortly.

## THE ARTIFICIAL LIGHT OF THE FUTURE.*

BY PROF. EDWARD L. NICHOLS.

When we come to consider the quality of the light produced and the efficiency of the apparatus as a light-making machine, we find that the incandescent lamp of to-day produces the same quality of light which the earliest examples of its type were capable of giving. We find, however, that its light differs but little from that obtained by burning oil and gas.

It is true that the efficiency of the incandescent lamp has gradually risen from five to three watts per candle, but those who have had occasion to trace the discouraging life-curves of such lamps know how little real progress the change implies. We start a well-manufactured lamp at any temperature we please, provided that we do not pass a certain limit, beyond which the life of the lamp would be too seriously curtailed. The initial efficiency may be made as large as we please, within that limit; but it is only a question of a few days or hours when the lamp will have dropped to the dead level of mediocrity the five-watt level which seems to mark the confines of permanency in the case of incandescent carbon.

When we take a lamp and raise its electromotive force step by step, measuring the current, voltage, and candle-power at each stage of the experiment, and plot the curve which expresses the relation between the energy required and the light produced, we are gratified at the marked rise in efficiency which follows each slight increase in the temperature of the filament (Fig. 1). That rise of temperature, however, means shortening of the life of the carbon, is well known. Unfortunately, rise of temperature means much more than that. I will venture to show you a few life curves recently obtained in the laboratory of Cornell University. These curves enable us to see at a glance what happens during the curtailed existence of a lamp which is forced to undue brilliancy. I introduce them because they indicate very definitely the nature of the difficulties which confront us when we endeavour to increase the efficiency of an incandescent lamp by raising its temperature.

In the first instance a lamp was started at the candle-power indicated by the maker, and was held at constant voltage by means of the current from a storage battery. The initial candle-power was 16, which was obtained at the expenditure of 3·015 watts per candle. Measurements of electromotive force and current were made at intervals of about 10 hours during the 800 hours that the lamp lasted. The candle-power was redetermined at intervals of about 100 hours. The voltage never rose more than 0·65 volts above its initial value, and then only for a short time. The average electromotive force of the entire run was 0·40 volts below the initial

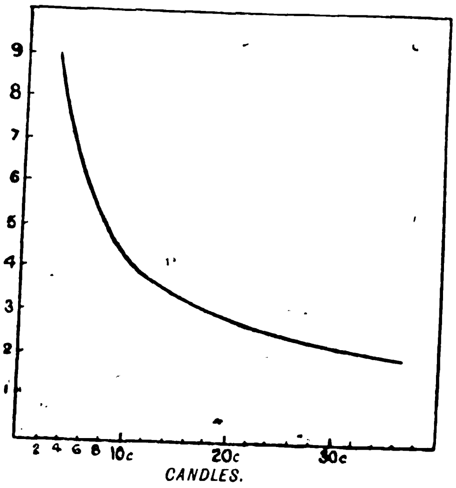



FIG. 1.—Efficiency Curves of an Incandescent Lamp.

value. The record of this lamp is contained in Fig. 2. It represents an individual case and not the average obtained from many lamps, but it is typical of the results which have been obtained with many. The characteristic features are rapid, followed by slower falling off in candle-power, the decrement amounting finally to more than 50 per cent., and rapid, followed by slower falling of efficiency, to a final value of 5·75 watts per candle. These changes were accompanied by continuous and marked increase in the resistance of the filament.

If it be asked whether this individual case represents a state of affairs common to all incandescent lamps, I can only say that in my

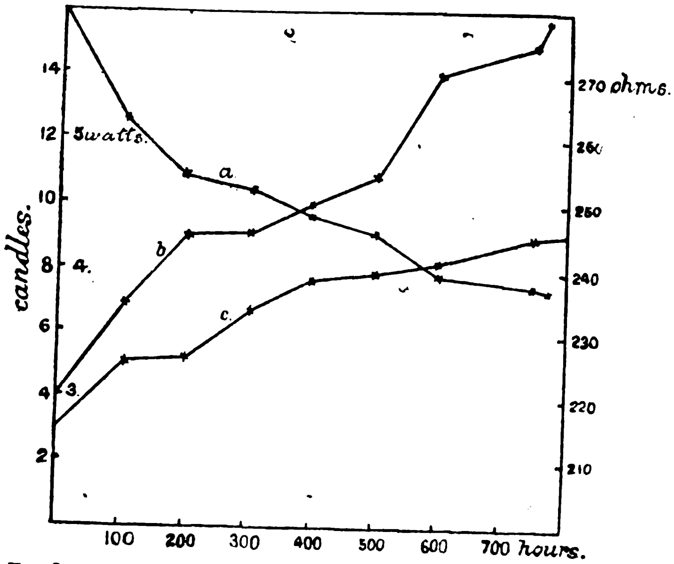



FIG. 2.—Curves showing the Changes which take place during the Life of a Lamp at Normal Voltage. *a* Candle Power, *b* Watts per Candle, *c* Resistance.

experience, which is certainly much less extensive than that of some others, I have known of no class of lamps the performance of which did not agree approximately with that indicated by these curves. Mr. W. H. Pierce, who described extended tests of the initial and average efficiency of incandescent lamps in a Paper read before the Institute of Electrical Engineers some time ago, recorded no exceptions to this rule of decreasing candle-power and efficiency with time.

The falling off in candle-power exhibited by lamps maintained at constant voltage can be met by a procedure not easily applicable, perhaps, in commercial work, but readily carried out where the

* Abstract of a Lecture before the New York Electric Club, Nov. 20, 1890.

Digitized by Google

object in view is simply to study the behaviour of the lamp under unusual conditions. The method consists in raising the electromotive force at short intervals of time by amounts sufficient to restore the candle-power to its normal value.

The results of such an experiment performed upon a lamp precisely similar to that from which the curves in Fig. 2 had been obtained are depicted graphically in Fig. 3. Under this treatment the life of the lamp in question was not quite 100 hours. The total rise in electromotive force during the test amounted to about nine volts; the efficiency decreased from 3·118 watts per candle to 3·468 watts per candle. The resistance of the filament rose from 221·6 to 234·8 ohms. During the first 50 hours the changes were slight, then occurred a sudden increase of resistance, accompanied by marked rise in electromotive force and in amount of energy consumed. The life history of the incandescent lamp at still higher temperatures does not differ essentially from that which we have just been considering, but the changes in question go on much more rapidly.

The performances were recorded of two lamps which were similar to those from which the curves in Figs. 2 and 3 had been obtained. The first of these was started at 57 candles. It was maintained at constant voltage for 11 hours and 30 minutes, when it went out. During its brief life the candle-power fell to 24·6, and the watts per candle increased from 1·58 to 3·09. The loss of candle-power during the experiment was 55 per cent., an amount which corresponds very closely with the loss suffered by the first lamp tested during the 800 hours that it lasted. In the case of the other lamp, the initial candle-power (64 candles) was maintained throughout. Its life under these circumstances was 140 minutes, during which short period it had been found necessary to raise the electromotive

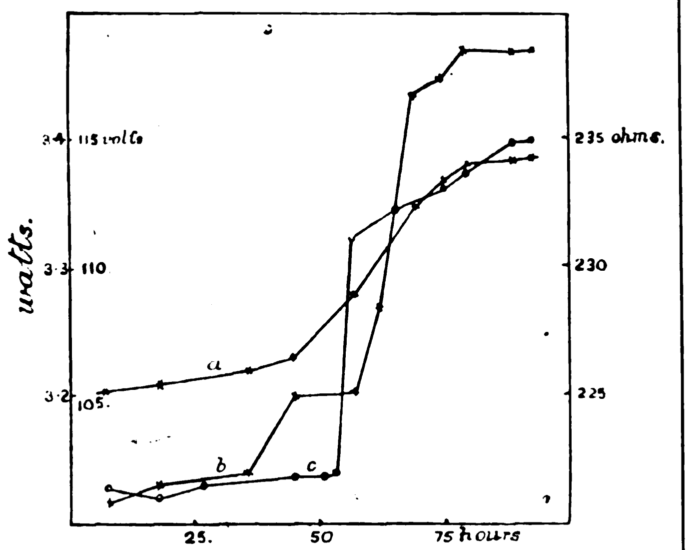


FIG. 3.—Life Curves of Incandescent Lamp at Normal Candle-power (Candle-power Constant), the Volts being Raised. *a* Volts, *b* Watts per Candle, *c* Resistance.

force from 114·08 volts to 129·53 volts. The efficiency of the lamp fell meantime from an initial value of 1·33 watts to 1·677 watts at the end of the first hour; then more and more rapidly to 1·945 watts at the end of the test.

The conclusion to be reached from these data, and from the great mass of experimental results which has accumulated since the incandescent lamp has become an object of investigation, is only too evident. The efficiency of an illuminant in which carbon is the glowing material, is a function of the temperature. It appears that the incandescent lamp is fairly stable only at temperatures, for which its efficiency does not exceed about five watts per candle. We have just seen what occurs when one attempts to maintain lamps at degrees of incandescence corresponding to a much higher temperature. It is, perhaps, not possible to point out with perfect definiteness all the causes that are at work to reduce the candle-power. The black coating which gradually forms on the interior of the lamp-bulb intercepts more and more of the light from the filament as the age of the lamp increases.

The life curves were made as a necessary part of the investigation of the loss of light due to the opaque film, and I will venture to take from the work, as yet unpublished, the results which have been obtained in the case of the lamp to which the curves in Fig. 2 refer. These results are given graphically in Fig. 4. They show the amount of light of each wave length of the visible spectrum which the coating on the interior of the bulb absorbed. The measurements were made after the lamp had been in operation 100 hours, 200 hours, 400 hours, and 800 hours. In the diagram, abscissæ are wave lengths, and ordinates show the amount of light transmittted by the lamp-bulb at the above mentioned times, in terms of the amount which the bulb allowed to pass before the coating began to form. You will see by a glance at these curves that the absorbing power of the film was very nearly uniform throughout the spectrum, so that the blackening of the lamp had no appreciable effect upon the light which it emitted; also that the absorption at the end of 200 hours was considerably more than half as great as that at the end of 800 hours, and that the total loss of candle-power due to blackening was about 22 per cent.

These measurements enable us to account for rather more than one-third of the loss of candle-power suffered by the lamp. We are not with our present knowledge in position to speak so definitely concerning the other two-thirds, but the increase in the resistance in the carbon indicates another source of diminution. That gradual failure of the vacuum, which the use of the spark-coil would unquestionably have enabled the observers to detect, may well be answerable for the rest. Now, the temperature of an incandescent lamp filament at five watts per candle is very nearly the same as that of the carbon in the light-giving flames produced by the combustion of oils and gas, and it appears that the attempt to pass this temperature introduces difficulties of such a nature as to lead to the serious question whether we have not reached a definite limit, beyond which incandescent carbon ceases to be permanent. At that limit the efficiency of the lamp is very small indeed, 95 per cent. or more of the radiant energy emitted being of wave lengths too long to afford light.

As to the arc light, no more encouraging report can be made. On the contrary, it is perfectly well established that the quality of the light, instead of increasing, has fallen off in the course of the

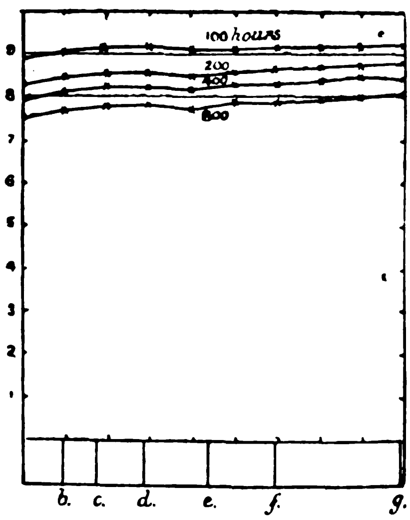


FIG. 4.—Curves of the Light at Different Parts of the Visible Spectrum. Given by a Lamp at Various Stages in its Life; Showing the Absorption by the Blackening of the Glass.

development of the lamp from the clock-work regulators of Dubosc and Foucault, with their slender carbons, to the commercial lamps of to-day.

The researches of Nakano, Marks, and others show that the efficiency of the arc is a definite function of the current density at the terminals of the carbons, increasing nearly in inverse ratio to the cross-section of the pencil. When the maximum current capacity of the latter has been reached, the efficiency is in the neighbourhood of 10 per cent., a value which is not likely to be greatly exceeded by any of the methods in vogue at the present day.

As Mr. Edward Weston says, in his discussion of Nakano's Paper on "The Efficiency of the Arc Lamp":—"The small amount of luminous energy, compared to the total energy employed, is a sad thing always." It seems only too probable that the limiting temperature at which carbon can be used for the production of light has been reached, and with it the maximum efficiency of artificial illumination.

The phenomena observed whenever we attempt to raise carbon above what may be termed its normal temperature of incandescence are significant, and they all point in one direction. We have just seen that when we raise the voltage of an incandescent lamp, we gain splendour of performance at the cost of permanence and stability. I might remind you, in this connection, that when the heat of gas flames is increased by forced draft, they become non-luminous; that the magnificent illuminating power of the arc lamp is not due to the intensely hot electric arc itself, filled, though it be, with carbon in process of transfer from the positive to the

Digitized by Google

negative pencil, but to the cooler carbon terminals. Such are the facts with which we have to deal when we consider the problem of increasing the efficiency of illumination by carbon; whether by direct combustion, by incandescence in vacuo, or by the use of the electric arc. In the face of the many unexpected things that have been accomplished through the agency of electricity, he would be rash who asserted that the possibilities of carbon had been exhausted. In view of the achievements of the time one is not permitted to declare the case hopeless; nevertheless, the outlook is not an encouraging one.

If, in what I have said thus far, I have drawn what seems to be a gloomy picture, it is not because I fail to recognise the importance of the electric light of to-day as a factor in our civilisation. Its superiority over other methods of artificial illumination is so well understood that it need not be enlarged upon here. Of its advantages we hear on every hand; of its limitations we hear less, and yet a knowledge of the latter is quite as important to those who are interested in its further development. The waste of 90 or 95 per cent. of non-luminous energy in the production of light is a matter to which we are apt to give little thought, and when the economic importance of the fact has been forced upon us by the study of the recent investigations which have been made to establish it, we find consolation in the thought that, after all, these percentages are somewhat larger than the corresponding values for candles, oil, and gas.

I have thought it not without interest, therefore, to discuss the behaviour of incandescent carbon under conditions, some of which are not "commercial," and to attempt to point out the significance of that behaviour. Now, if you will permit me, I will turn toward the future and consider the properties of some other sources of light,

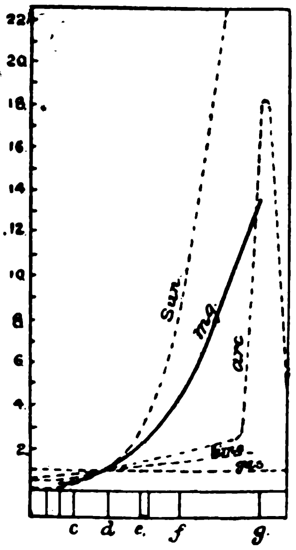



FIG. 5.—Light of the Sun, Magnesium, Arc, Lime and Gas, at Different Parts of the Spectrum.

with the view of inquiring whether they may not have a part to play in the artificial lighting of days to come.

What is to be the light of the future? From the standpoint of the engineer I will frankly say that I cannot answer that question, but abandoning the directly practical point of view, there is something to be said. I need offer no apology here for presenting facts, the application of which is at best remote, and the present importance of which is, therefore, rather scientific than utilitarian.

The number of elements and of compounds capable of sustaining a high temperature without dissociation or change of state is very large. Carbon is the only one of these, the capabilities of which as a source of light can be said to have been fully tested; and yet all the others, when heated to a proper point, emit light-giving radiation. Take for example the metallic oxides. We heat the oxide of calcium in our magic lanterns, and it gives us a light of great intensity, and but little inferior to the arc light in whiteness. The exceeding clumsiness of our method of rendering it incandescent, however, has prevented its adoption excepting for certain special purposes. We burn magnesium in fireworks and for photographic flash lights, and occasionally we indulge in the luxury of igniting a bit of the ribbon, and admiring, for an instant, the intense brilliancy of its flame. Now, magnesium is one of the most abundant elements on the face of our planet. It is a rather costly metal at present, being quoted at 50 cents an ounce in this country and at about half that price on the continent of Europe. Even under the limited demand for it which exists at present, it has fallen to about one-tenth of its price of a few years ago, and I feel sure that it lies within the power of the electrician to greatly further reduce the cost of production. Among artificial illuminants, magnesium has in one respect no equal. W. H. Pickering, who studied its spectrum in 1880, found it to approach sunlight in quality even more closely than the electric arc light does.

The precise character of the magnesium light is shown in Fig. 5. The abscissæ of the curves are wave lengths, and ordinates indicate the brightness of each portion of the spectrum of the magnesium flame in terms of that of the corresponding regions in the spectrum of gas light. The accompanying curves for the arc light and the limelight, introduced for convenience of comparison, are from measurements by Mr. W. S. Franklin and myself. These curves all refer to lights of the same candle-power. It will be seen that the magnesium flame is about 10 times brighter in the violet than a gas flame of the same power, and but little more than half as strong in the red. It will be seen, also, that it surpasses the electric arc everywhere beyond the yellow, save in a very limited region of the extreme violet. In order to appreciate fully the significance of these curves, one must have had occasion to compare the various lights to which they refer, placing them side by side and noting the effects. You are all aware that the magnesium light is very white and very powerful, but unless you have happened to see it in direct competition with our ordinary illuminants, you will be but dimly conscious of the difference between them.

A screen which is well lighted by incandescent lamps gives you the impression of a nearly uniform white surface. Its whiteness now, however, is a very different thing from that which it takes under the rays of the magnesium light. It sinks by comparison into a rather weak chocolate brown.

The proper way to compare sources of illumination is to determine their net and gross efficiencies; by which I mean, respectively, the ratio of total radiation to light giving radiation, and the ratio of the total amount of heat set free in the process of producing a candle-power of light, to the heat energy represented by the light itself. Now, the heat equivalent of a candle-power of gas, or of the light of an incandescent lamp at five watts per candle, is about 3·6 gramme-calories per minute. The total heat of combustion set free in generating a candle-power of gas light has been variously estimated at amounts ranging from 971 gramme-calories per minute (Preece) to 4,100 gramme-calories (Thomsen). Calculations based upon the theoretical heats of combination of illumiting gases give values nearer the latter than the former amount.

The amount of heat set free when a gramme of magnesium is converted into the oxide is very much less than that resulting from the combustion of a gramme of coal gas, and the light obtained is, as we have just seen, more than 32 times as great. The gross efficiency of the magnesium light must, therefore, be many times higher than that of gaslight. To be exact, we find, if we adopt the value given by Thomsen* for the heat of combination of magnesium (6,077), that the magnesium flame of one candle power should generate only 25 52 gramme-calories per minute. Taking the very low estimate of 1,000 gramme-calories per minute for gas, we find the gross efficiency of the magnesium flame to be about forty times that of gas light. The total luminosity of the arc light, for instance, may be considered fully 25 per cent. greater than that of gas.

We have seen that, weight for weight, magnesium affords more than 30 times the light obtained from gas, with the development of much less heat.

The character of the light corresponds to a temperature much above that of the electric arc, but the flame does not seem to be very hot. I have not as yet succeeded in obtaining a satisfactory measurement of the flame temperature, but the preliminary test, made at my request, gave approximately 1,400°C.

The large candle-power of the magnesium flame is due to its peculiar structure. A gas flame consists of a column of heated gases, the particles of which are rising rapidly from the jet of the burner. These carry off with them, by convection, 80 per cent. or more of the heat of combustion. The flame owes its luminosity entirely to the fact that near the base of the column a few particles of carbon, as yet unoxidised, are heated to incandescence. The total radiating surface of these particles is very insignificant, compared with the apparent superficial area of the flame; it is, indeed, not very different in extent from the radiating surface of the filament of an ordinary incandescent lamp of the same candle-power. The constitution of the magnesium flame is very different. The product of combustion is the oxide of magnesium, a white, amorphous solid of considerable density; it is, indeed, fully twice as heavy as the metal itself. The oxide remains, for the most part, in the place where it was first formed. It becomes intensely incandescent, and, having large radiating surface, it affords a large amount of light. Under such conditions, convection plays a minor part, and that which is the chief source of loss in the production of light by direct combustion of gaseous fuels is avoided. The gross efficiency is, therefore, very large.

The question of the *character* of the radiation from the magnesium flame offers greater difficulties. It is certain that neither platinum nor carbon at any temperature to which they can be sub-

* J. Thomsen: *Journal fur Praktische Chemie*, N. F., 16, p. 97.

Digitized by Google

jected in practice will give anything approximating to the quality of the magnesium light. I am convinced that we have to do here with a very different law of radiation from that which governs ordinary cases of incandescence. Taking carbon to represent the normal state of affairs, we may say that the radiation of magnesium oxides is out of all proportion to the temperature of incandescence; also that the percentage of those shorter wave lengths, which furnish green, blue, and violet light, is abnormally large.

That the radiation of the magnesium flame comes in part under the head of what Prof. E. Wiedemann has termed "Luminescence," I have little doubt. This word covers all those interesting phenomena known as phosphorescence, fluorescence, &c.

Luminescence is supposed to be due to a different class of molecular vibrations from those which cause ordinary incandescence. One of the characteristics of this class of vibrations is that it tends to produce selective radiation—that is to say, radiation in which a single wave length, or set of wave lengths, predominates. Another characteristic of luminescence is, that it is frequently, perhaps always, the result of previous treatment to which the glowing body has been subjected. This previous process may have been nothing more than the shining of the sun's rays upon the luminescent surface, as in those cases of phosphorescence, concerning which Becquerel has taught us so much.* It may have been in the course of some chemical reaction or process of crystallisation that the body received its preparation. In such cases the power lies latent until it is disengaged by the action of some external force. The immediate exciting cause may be mechanical, electrical, or thermal. In the last case, which most directly concerns us here, a certain rise of temperature is necessary to start the body into luminescence. When this critical temperature is below the red heat the phosphorescent glow attracts attention, and investigation follows. When, however, the temperature of luminescence is high, the effect, however marked it may be, is masked by the ordinary incandescence to be expected at that temperature, and it is overlooked. Luminescence by heat is perforce transient. It is due to the expenditure of energy which has been stored by previous action. If we wish to see the effect repeated, we must restore to the material the potential energy which it has lost.

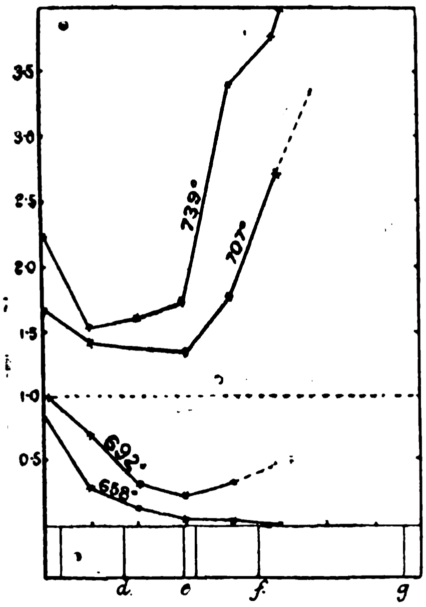


FIG. 6.—Radiation of Zinc Oxide at 658° and 692°C (First Stage), and at 707° and 739°C. (Second Stage) at Different Parts of the Visible Spectrum. Relative to Platinum.

I am not in a position to state positively that the glow of magnesium oxide is due to luminescent vibrations, but I am of the opinion that such will be found to be the case. Other metallic oxides also show peculiarities of radiation, which find their explanation most readily under that theory. While studying the distribution of energy in the visible spectrum of the lime light three years ago, Mr. Franklin and I found that a freshly ignited cylinder, under the oxy-hydrogen flame, glowed with a brilliancy equal to that of the magnesium light itself. This state of affairs lasted but a moment, however, and no amount of heating would bring out an old cylinder again into its initial splendour. It was plain that we were taking advantage of vibratory power stored in the lime at some stage in its preparation. These vibrations, disengaged by the blowpipe, gave out in a very short time, after which the performance of the lime degenerated rapidly to the level which corresponds to ordinary radiation at the temperature in question.

* Becquerel: *Annales de Chimie et de Physique* (3), 55.

You are all acquainted with the beautiful greenish-yellow light which the oxide of zinc emits under the flame of the blowpipe. It is entirely different from the light of the incandescent charcoal on which it lies, although the two cannot differ widely in temperature. The zinc oxide is luminescent; the carbon is simply incandescent, in the usual sense of the word. This is a case which lends itself readily to study, since the temperature at which the abnormal glow appears is a comparatively moderate one. Last summer I took the matter up, with the efficient co-operation of Mr. B. W. Snow, instructor in physics in Cornell University. We made a systematic comparison of the radiation from zinc oxide and from platinum, at temperatures between the red heat and 1,000°C., measuring temperatures and studying spectra by methods which I cannot dwell upon here. Since the results which we obtained are of a character to illustrate the points which seem to me most significant in this question of the radiation of the metallic oxides, I will indicate them graphically.

Zinc oxide is a rather brilliant white pigment. Its radiating power, therefore, according to the theory of exchanges, should be very small. At temperatures below 700°C. we found it to be very much lower than that from platinum throughout the spectrum, and the light from the oxide to be a duller red. Fig. 6 shows the results of the comparison. In this and the subsequent curves, platinum is taken as the standard. The curves show how the oxide of zinc compares with platinum in strength of radiation. The law according to which the visible radiation of platinum rises from zero at the extreme red heat, as the temperature rises, varies with the wave length. It had to be especially determined, for the purposes of our investigation, in each region of the spectrum to which our measurements were extended.

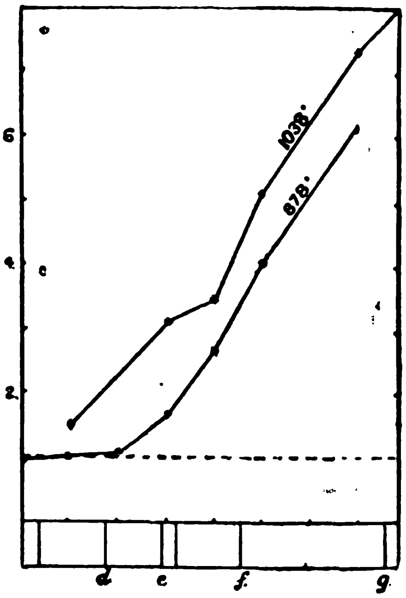


FIG. 7.—Radiation from Zinc Oxide at 878° and 1,038°C. at Different Parts of the Visible Spectrum. Relative to Platinum.

At about 700deg. a sudden change occurs in the character of the light from the oxide. It becomes brighter than the platinum of the same temperature, the increase showing itself principally at the ends of the spectrum. In Fig. 6 (707deg. and 739deg.) we have curves which represent this second phase. The emanations are selective to a marked degree, the yellow being relatively very weak. Measurements of fresh films of the oxide at still higher temperatures revealed the further development of the abnormal radiation of this substance. Fig. 7, which gives curves for 878deg. and 1,038deg., shows the transition into a third, and, apparently, a final stage. The red end of the spectrum loses its prominence, and the curve seems to be developing into a straight line, the trend of which is such as to indicate that zinc oxide, as we pass from the longer to the shorter wave lengths of its spectrum, increases in superiority over platinum at the same temperature. It soon became evident from the character of our results that the radiation at temperatures above about 800deg. was of a very evanescent sort, falling off in intensity and changing in quality from the first instant in which the oxide was heated. To follow these rapid changes proved a trying task. By taking a great many fresh films of the oxide and watching the time changes of one portion of the spectrum after another, however, we were able to obtain data from which the curves in Fig. 8 were drawn. These show the intensity of radiation and its character, relative again to that of platinum, after the oxide had been maintained 1,013deg. for a period of 30secs., of 60sec., of

Digitized by Google

300secs. and of 600secs. At the end of the 10min. the changes, although not entirely completed, were very slow.

The evidence of the existence of luminescence afforded by these measurements seems to us to be nearly conclusive. Extension of the investigation to other of the metallic oxides and to wider ranges of temperature, would, doubtless, lead to results more striking.

The application of all this to the problem of the light of the future is as follows: The fundamental question is that of efficiency. High efficiency at low temperatures means selected radiation, which appears to be a characteristic of luminescence and not of ordinary incandescence. The study of the radiation of the metallic oxides above the red heat reveals the existence of properties which lead us to regard them as being luminescent "by heat." It is from such bodies that radiation of high efficiency is to be looked for. We have in magnesium oxide a member of this particular class, and we have seen that when it is heated in the process of formation it gives us a light, the efficiency of which is unapproached by that of other artificial illuminants.

The problem is easily stated. (1) We need a body which is rendered vividly luminescent by heat. The metallic oxides would seem to offer us many such. (2) The material is to be brought to the temperature at which its luminescence is most marked. Does it not seem probable that the best method, as in the case of carbon, will not be that of direct combustion, but of heating through the agency of the electric current? (3) The material must be restored from time to time. Whether rejuvenation is to be secured through electrical, chemical, actinic, or mechanical means remains to be determined.

Luminescence "by heat" offers, however, only a partial solution of the problem of the highest efficiency. However great the efficiency of the luminescent itself, it is accompanied by incandescence of the ordinary kind. The ultimate solution is to be sought for along other lines. Incandescence is too expensive a means of exciting luminescence. There are many other ways in which it may be generated; friction, chemical action, the impact of light waves, electrical excitation, certain vital processes, are known to result in the production of light. The physics of these phenomena is, for the most part, undeveloped. I know of but two attempts to determine the efficiency of this "light without heat," as it has sometimes been called. The intensity is, as a rule, very small, and the heat has doubtless been regarded as quite below the range of even our most sensitive apparatus. One of these two cases is of especial interest to the electrician. It is that of the spark discharge in vacuo. Prof. S. P. Langley and Mr. F. W. Very, in a recent remarkable Paper, entitled, "The Cheapest Form of Light," speak of the heat generated in the Geissler tube as so minute as to seem to defy direct investigation. It has, however, been successfully measured by Dr. Staub, of the University of Zurich, by means of one of the most delicate instruments for the measurement of heat—the Bunsen ice calorimeter.*

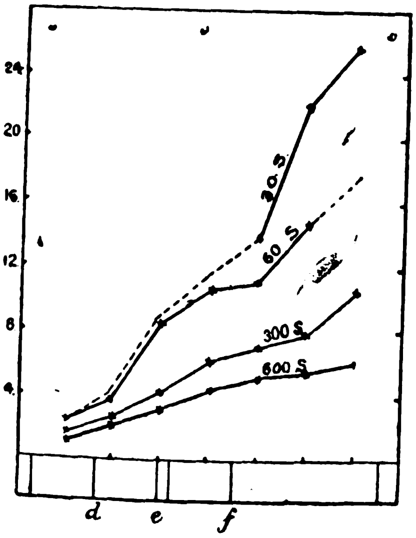



FIG. 8.—Radiation from Zinc Oxide at 1,013°C. for a period of 30, 60, 300, and 600 seconds.

In Staub's experiments the vacuum tube was smoked with lamp-black and inserted in the ice calorimeter. The ice melted in a given time afforded a measure of the total heat generated by the electric discharge through the tube. A repetition of the determination with the unsmoked tube, under which conditions the light-giving rays could escape, gave the energy of the non-luminous radiation. The efficiency was found to be 3·268 per cent. The extremely small candle-power of the light derived from the electric discharge in vacuo may seem to preclude all questions of its utilisation in practical illumination. The result is one, however, which should not be lost sight of. It suggests a field of investigation which may prove unexpectedly fruitful.

The Geissler tube effect was not the source to which Langley and Very applied the term "the cheapest form of light." The subject of their research was the light of a Cuban fire-fly. Their work cannot fail to excite the highest admiration of everyone who is able to appreciate the difficulties of such an investigation. The exploration of the heat spectrum of so insignificant a source of light is a task which very few physicists would, I think, have considered practicable, but it has been carried through by these investigators to complete success.

When we study the curve of distribution of energy in the spectrum of the fire-fly thus obtained, and compare it with the corresponding curves for gas light, the arc light and sun light, we find the expression, "the cheapest form of light," which is applied to the light of the fire-fly by Langley and Very, to be fully justified. All the energy of its spectrum is massed within the narrow limits of the visible spectrum, and what is more, by far the greatest part of it is in the form of rays which are especially important for the purposes of radiation, the particular rays which give us yellow and green light. The non-luminous radiation which accompanies the light of the fire-fly seems to be so insignificant that it was with difficulty that it could be estimated, even with the almost inconceivably delicate apparatus used by Langley and Very. They give the efficiency as about 400 times as great as that of a gas flame. It cannot fall appreciably below 100 per cent.

In what I have said I fear that I have fallen far short of what might have been expected of a lecturer on the artificial light of the future. I have endeavoured to show that the efficiency of our present methods is too low to meet the demands of the future for economical illumination, and that whether we ever succeed in approaching the perfect economy of nature's light-making processes, as exemplified in the fire-fly, or not, there are many sources of light which promise high efficiency.

* G. Staub: Inaugural Dissertation, Zurich, 1890. (See the *Beiblätter zu den Annalen der Physik*, 14; p. 538.)

## THE ELECTRO-MAGNET.*

BY PROFESSOR SILVANUS P. THOMPSON.

*(Continued from page 111.)*

The rule for calculating the intensity of the magnetic force at any point on the axis of the long tubular coil within this region where the force is uniform is:—

$$H = \frac{4}{10}\pi \times \text{the ampere-turns per cm. of length.}$$

And, as the total magnetising power of a tubular coil is proportional not only to the intensity of the magnetic force at any point, but also to the length, the integral magnetising effect on a piece of iron that is inserted into the coil may be taken as practically equal to $\frac{4}{10}\pi\times$ the total number of ampere-turns in that portion of the tubular coil which surrounds the iron. If the iron protrudes as much as three diameters at both ends, the total magnetising force is simply $\frac{4}{10}\pi\times$ the whole number of ampere-turns.

Now that case is, of course, not the one we are usually dealing with. We cannot procure steel magnets with unalterable poles of fixed strength. Even the hardest steel magnet, magnetised so as to give us a permanent pole near or at the end of it—quite close up to the end of it when you put it into a magnetising coil—becomes by that fact further magnetised. Its pole becomes strengthened as it is drawn in, so that the case of an unalterable pole is not one which can actually be realised. One does not usually work with steel; one works with soft-iron plungers which are not magnetised at all when at a distance away, but become magnetised in the act of being placed at the mouth of the coil, and which become more highly magnetised the further they go in. They tend, indeed, to settle down, with the ends protruding equally, for that is the position where they most nearly complete the magnetic circuit; where, therefore, they are most completely and highly magnetised. Accordingly, we have this fact to deal with, that whatever may be the magnetising forces all along a tube, the magnetism of the entering core will increase as it goes on. We must therefore have recourse to the following procedure. We will construct a curve in which we will plot not simply the magnetising forces of the spiral at different point, but the product of the magnetising forces into the magnetism of the core which

* A series of four Cantor Lectures delivered before the Society of Arts, January—February, 1890.

Digitized by Google

itself increases as the core moves in. The curve with a flat top to it corresponds to an ideal case of a single pole of constant strength. We wish to pass from this to a curve which shall represent a real case, with an iron core. Let us still suppose that we are using a very long core, one so long that when the front pole has entered the coil the other end is still a long way off. With an iron core of course it depends on the size and quality of the iron as to how much magnetism you get for a given amount of magnetising power. When the core has entered up to a certain point, you have all the magnetising forces up to that point acting on it; it acquires a certain amount of magnetism, so that the pull will necessarily go on increasing, and increasing although the intensity of the magnetic force from point to point along the axis of the coil remains the same, until within about two diameters from the far end. Although the magnetic force inside the long spiral remains the same, because the magnetism of the core is increasing, the pull goes on increasing and increasing (if the iron does not get saturated) at an almost uniform rate all the way up until the piece of iron has been poked pretty nearly through to the distant end. In Fig. 61, a tubular coil, B A, is represented. Suppose a long iron core is placed on the axis to the right, and that its end is gradually brought up toward B. When it arrives at X the pull becomes sensible, and increases at first rapidly, as the core enters the mouth of the tube, then gently, as the core travels along, attaining a maximum, C, about at the further end, A, of the tube. When it approaches to the other end, A, it comes to the region where the magnetising force falls off, but the magnetism is still going on increasing, because something is still being added to the total magnetising power, and these two effects nearly balance one another, so that the pull arrives at the maximum. This is the highest point, C, on the curve; the greatest pull occurring just as the end of the iron core arrives at the bottom or far end of the tubular coil; from which point there is a very rapid

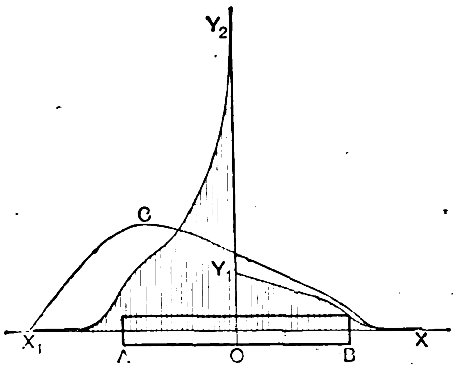



Fig. 61.—Diagram of Force and Work of Coil-and-Plunger.

falling off. The question of rapidity of descent from that point depends only on how long the core is. If the core is a very long one, so that its other pole is still very far away, you have a long, slow descent going on over some three diameters, and gradually vanishing. If, however, the other pole is coming up within measureable distance of B, then the curve will come down more rapidly to a definite point, $X_1$. To take a simple case where the iron core is twice as long as the coil, its curve will descend in pretty nearly a straight line down to a point such that the ends of the iron rod stand out equally from the ends of the tube.

Precisely similar effects will occur in all other cases where the plunger is considerably longer than (at least twice as long as) the coil surrounding it. If you take a different case, however, you will get another effect. Take the case of a plunger of the same length as the coil, then this is what necessarily happens. At first the effects are much the same, but as soon as the core has entered about half, or a little more than half its length, you begin to have the action of the other pole that is left protruding outside tending to pull the plunger back; and although the magnetising force goes on increasing the further the plunger enters, the repulsion exerted by the coil on the other pole of the plunger keeps increasing still faster as this end nears the mouth of the coil. In that case the maximum will occur at a point a little further than half-way along the coil, and from that point the curve will descend and go to zero at A; that is to say, there will be no pull when both ends of the plunger coincide with the two ends of the coil. If you take a plunger that is a little shorter than the coil, then you find that the attraction comes down to zero at an earlier period still. The maximum pull occurs earlier, and so does the reduction of the pull to zero; there being no action at all upon the short core when it lies wholly within that region of the tube within which the intensity of the magnetic force is uniform. That is to say, for any portion of this tube corresponding to the flat top of the curve of Fig. 60, if the plunger of iron is so short as to lie wholly within that region, then there is no action upon it; it is not pulled either way. Now these things can be not only predicted by the help of such a law as that, but verified by experiment. Here is a set of tubular coils which we use at the Finsbury Technical College for the purpose of verifying these laws. There is one here about 9in. long, one about half that length, another just a quarter. They are all made alike in this way, that they have exactly the same weight of copper wire, cut from the same hank, upon them. There are, of course, more turns on the long one than on the shorter, because with the shorter ones each turn requires on the average a larger amount of wire, and therefore the same weight of wire will not make the same number of windings. We use that very simple apparatus, a Salter's balance, to measure the pull exerted down to different distances on cores of various lengths. You find in every case the pull increases and becomes a maximum, then diminishes. We will now make the experiment, taking first a long plunger, roughly about twice as long as the coil. The pull increases as the plunger goes down, and the maximum pull occurs when the lower end gets to the bottom; beyond that the pull is less. Using the same plunger, with these shorter coils, one finds the same thing; in fact, more marked, for we have now a core which is more than twice the length of the coil. So we find, taking in all these cases, that the maximum pull occurs, not when the plunger is half way in, as the books say, but when the bottom end of it is just beginning to come out through the bottom of the coil that we are using. If, however, we take a shorter plunger, the result is different. Here is one just the same length as the coil. With this one the maximum pull does occur when the core is about half way in; the maximum pull is just about at the middle. Again, with a very short core—here is one about one-sixth of the length of the coil—the maximum pull occurs as it is going into the mouth of the coil; and, when both ends have gone in so far that it gets into the region of equable magnetic field, there is no more pull on one end than on the other; one end is trying to move with a certain force down the tube, and the other end is trying to move with exactly equal force up the tube, and the two balance one another. If we carry that to a still more extreme case, and employ a little round ball of iron to explore down the tube, you will find this curious result, that the only place where any pull occurs on the ball is just as it is going in at the mouth. For about half an inch in the neck of the coil there is a pull; but there is no pull down the interior of the tube at all, and there is no measurable pull outside.

Now these actions of the coil on the core are capable of being viewed from another standpoint. Every engineer knows that the work done by a force has to be measured by multiplying together the force and the distance through which its point of application moves forward. Here we have a varying force acting over a certain range. We ought, therefore, to take the amount of the force at each point, and multiply that by the adjacent little bit of range, averaging the force over that range, and then take the next value of force with the next little bit of range, and so consider in small portions the work done along the whole length of travel. If we call the length of travel $x$, the element of length must be called $dx$. Multiply that by $f$, the force. The force multiplied by the element of length gives us the work, $dw$, done in that short range. Now the whole work over the whole travel is made up of the sum of such elements all added together; that is to say, we have to take all the various values of $f$, multiply each by its own short range $dx$, and the sum of all those, writing $\int$ for the sum, would be equal to the sum of all the work; that is to say, the whole work done in putting the thing together will be written:—

$$w = \int f\,dx.$$

Now what I want you to think about is this:—Here, say, is a coil, and there is a distant core. Though there is a current in the coil it is so far away from the core that practically there is no action; bring them nearer and nearer together; presently they begin to act on one another, there is a pull, which increases as the core enters, then comes to a maximum, then dies away as the end of the core begins to protrude at the other side. There is no further pull at all when the two ends stand out equally. Now there has been a certain total amount of work done by this apparatus. Every engineer knows that if we can ascertain the force at every point along the line of travel the work done in that travel is readily expressed by the area of the force-curve. Think of the curve X C X, in Fig. 61, the ordinates of which represent the forces. The whole area underneath this curve represents the work done by the system, and therefore represents equally the work you would have to do upon it in pulling the system apart. The area under the curve represents the total work done in attracting in the iron plunger, with a pull distributed over the range X $X_1$.

Now I want you to compare that with the case of an electromagnet where, instead of having this distributed pull, you have a much stronger pull over a much shorter range. I have endeavoured to contrast the two in the other curves drawn in Fig 61. Suppose

Digitized by Google

we have our coil, and suppose the core, instead of being made of one rod such as this, were made in two parts, so that they could be put together with a screw in the middle, or fastened together in any other mechanical way. Now first treat this rod as a single plunger, screw the two parts together, and begin with the operation of allowing it to enter into the coil, the work done will be the area under the curve which we have already considered. Let us divide the iron core into two. First of all put in one end of it; it will be attracted up in a precisely similar fashion, only being a shorter bar, the maximum would be a little displaced. Let it be drawn in up to half way only: we have now a tube half filled with iron, and in doing so we shall have had a certain amount of work done by the apparatus. As the piece of iron is shorter, the force-curve, which ascends from X to $Y_1$, will lie little lower than the

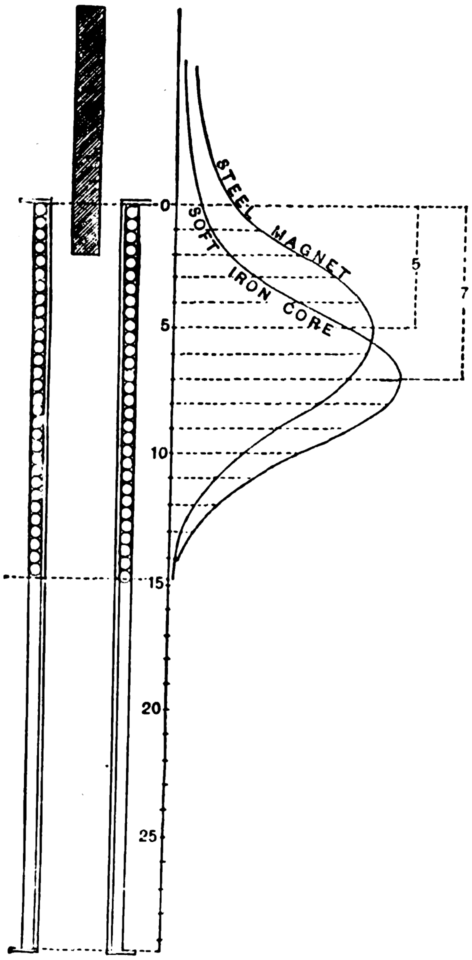



Fig. 62.—Von Feilitsch's Experiment on Plungers of Iron and Steel.

curve, $X C X_1$; but the area under that lower curve, which stops halfway, will be the work done by the attraction of this half core. Now go to the other end and put in the other half of the iron. You now have not only the attraction of the tube, but that of the piece which is already in place, acting like an electro-magnet. Beginning with a gentle attraction, it soon runs up, and draws the force-curve to a tremendously steep peak, becoming a very great force when the distance asunder is very small. We have, therefore, in this case a totally different curve made up of two parts, a part for the putting in of the first half of the core, and a steeper part for the second; but the net result is, we have the same quantity of iron magnetised in exactly the same manner by the same quantity of electric current running round the same amount of copper wire—that is to say, the total amount of work done in these two cases is necessarily equal. Whether you allow the entire plunger to come in by a gentle pull over a long range, or whether you put the core in in two pieces—one part with a gentle pull, and the other with a sudden spring up at the end—the total work must be the same; that is to say, the total area under our two new curves must be the same as the area under the old curve. The advantage, then, of this coil-and-plunger method of employing iron and copper is, not that it gets any more work out of the same expenditure of energy, but that it distributes the pull over a considerable range. It does not, however, equalise it altogether over the range of travel.

A number of experimental researches have been made from time to time to elucidate the working of the coil-and-plunger. Hankel, in 1850, examined the relation between the pull in a given portion of the plunger and the exciting power. He found that, so long as the iron core was so thick and the exciting power so small that magnetisation of the iron never approached saturation, the pull was proportional to the square of the current, and was also proportional to the square of the number of turns of wire. Putting these two facts together we get the rule—which is true only for an unsaturated core in a given position—that the pull is proportional to the square of the ampere-turns. This might have been expected, for the magnetism of the iron core will, under the assumptions made above, be proportional to the ampere-turns, and the intensity of the magnetic field in which it is placed being also proportional to the ampere-turns, the pull, which is the product of the magnetism and of the intensity of the field, ought to be proportional to the square of the ampere-turns.

Dub, who examined cores of different thicknesses, found the attraction to vary as the square root of the diameter of the core. His own experiments show that this is inexact, and that the force is quite as nearly proportional to the diameter as to its square root. There is, again, reason for this. The magnetic circuit consists largely of air-paths by which the magnetic lines flow from one end to the other. As the main part of the magnetic reluctance of the circuit is that of the air, anything which reduces the air reluctance increases the magnetisation, and, consequently, the pull. Now, in this case, the reluctance of the air-paths is mainly governed by the surface exposed by the end portions of the iron core. Increasing these diminishes the reluctance, and increases the magnetisation by a corresponding amount. Von Waltenhofen, in 1870, compared the attraction exerted by two

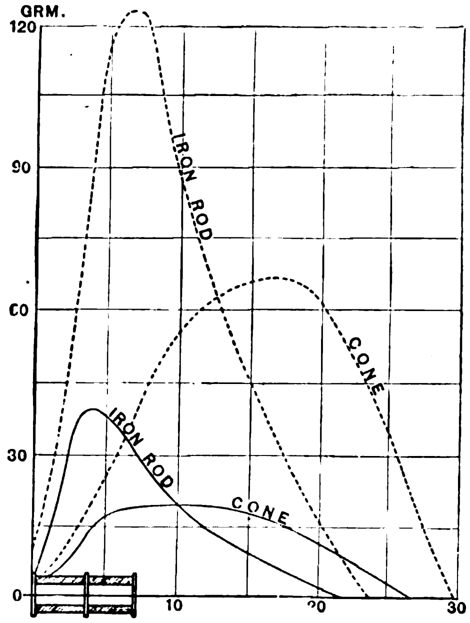



Fig. 63.—Bruger's Experiments on Coils and Plungers.

equal (short) tubular coils on two iron cores, one of which was a solid cylindrical rod, and the other a tube of equal length and weight, and found the tube to be more powerfully attracted. Doubtless the effect of the increased surface in diminishing the reluctance of the magnetic circuit explains the cause of the observation.

Von Feilitzsch compared the action of a tubular coil upon a plunger of soft iron with that exerted by the same coil upon a core of hard magnetised steel of equal dimensions. The plungers (Fig. 62) were each 10·1 centimetres long, the coil being 29·5 centimetres in length, and 4·2 in diameter. The steel magnet showed a maximum attraction when it had plunged to a depth of 5 centimetres, whilst the iron core had its maximum at a depth of 7 centimetres, doubtless because its own magnetisation went on increasing more than did that of the steel core. As the uniform field region began at a depth of about 8 centimetres, and the cores were 10·1 centimetres in length, one would expect the attracting force to come to zero when the cores had plunged into a depth of about 18 centimetres. As a matter of fact, the zero point was reached a little earlier. It will be noticed that the pull at the maximum was a little greater in the case of the iron plunger.

The most careful researches of late years are those made by Dr. Theodore Bruger, in 1886. One of his researches, in which a cylindrical iron plunger was used, is represented by two of the curves in Fig. 63. He used two coils, one 3½ centimetres long, the other 7 centimetres long. These are indicated in the bottom left-hand corner. The exciting current was a little over 8 amperes. The cylindrical plunger was 39 centimetres long. The plunger is sup-

Digitized by Google

posed in the diagram to enter on the left, and the number of grammes of pull is plotted out opposite the position of the entering end of the plunger. As the two curves show by their steep peaks, the maximum pull occurs just when the end of the plunger begins to emerge through the coil; and the pull comes down to zero when the ends of the core protrude equally. In this Figure the dotted curves relate to the use of the longer of the two coils. The height of the peak, with the coil of double length, is nearly four times as great, there being double ampere-turns of excitation. In some other experiments, which are plotted in Fig. 64, the same core was used with a tubular coil 13 centimetres long. Using currents of various strengths, 1·5 ampere, 3, 4·8, 6, or 8 amperes, the

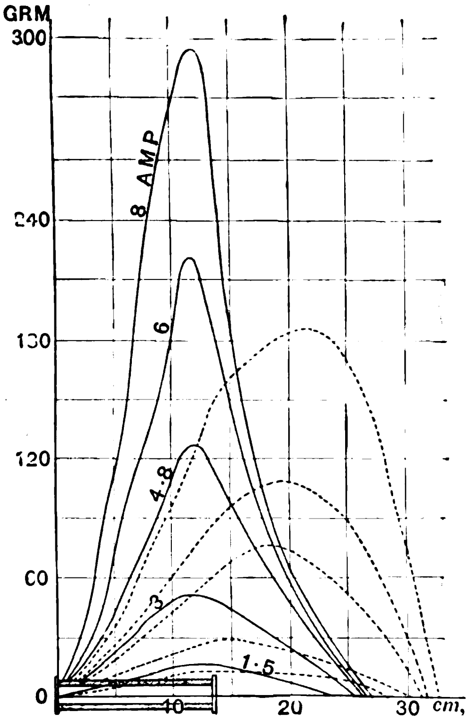



Fig. 64.—Bruger's Experiments, using Currents of Various Strength.

pull is, of course, different, but, broadly, you get the same effect, that the maximum pull occurs just where the pole begins to come out at the far end of the tubular coil. There are slight differences; with the smallest amount of current the maximum is exactly over the end of the tube, but with currents rather larger, the maximum point comes a little farther back. When the core gets well saturated the force curve does not go on rising so far; it begins to turn over at an earlier stage, and the maximum place is necessarily displaced a little way back from the end of the tube. That was also observed by Von Waltenhofen when using the steel magnet.

*(To be continued.)*

## THE PHYSICAL SOCIETY.

At the meeting of this Society, held on the 28th of November, the following communications were made:—

### "Additional Notes on Secondary Batteries."

By Dr. J. H. Gladstone, F.R.S., and W. Hibbert, F.I.C.

The authors observed that during the publication of a series of Papers by Dr. Gladstone and Mr. Tribe, in *Nature*, 1887, on "The Chemistry of the Secondary Battery," a discussion had arisen as to whether the sulphates of lead to which they ascribed so important a part in the reaction could be reduced by electrolysis. Experimental proof of the possibility of this was given at the time, even supposing the sulphate of lead to be pure, and the authors of the Papers maintained that when, as was the case in practice, the sulphate was intimately mixed with peroxide there was no difficulty whatever about the matter. ("The Chemistry of the Secondary Battery," *Nature* Series.) It was believed, however, by some, that a sub-sulphate of lead was produced on the plate, and that this was the explanation of the difficulty experienced in reducing those masses of salt which were sometimes formed in practice. Last year, however, Professor Frankland (*Royal Soc. Proceedings*, Vol. XLVI., page 304) (*Electrician*, Vol. XXIII., p. 470) published a Paper in which he described what he considered to be two definite sub-sulphates. The sub-sulphate produced from litharge has been already considered in a Paper communicated by the present authors to the Society last June (*Phil. Mag.*, Vol. XXX., p. 162). With regard to the compound formed by the action of sulphuric acid upon minium, Prof. Frankland has found its formula to be $S_2Pb_3O_{10}$, the same percentage composition as that found by Gladstone and Tribe in their Paper already quoted. They, however, considered it to be a mixture of $PbO_2$ with $2PbSO_4$. To decide as far as possible between these two views, some of the red substance was prepared by treating minium with a 10 per cent. solution of sulphuric acid in water, and treating the resulting compound with acetate of ammonium, which is known to dissolve sulphate of lead, but which would not be likely to decompose such a compound as $S_2Pb_3O_{10}$. The result of this was a residue much darker than the original in colour, and containing 82 per cent. of lead; that is to say, approximating in composition to $PbO_2$, which contains 86·6 per cent. of lead, and a colourless solution of pure $PbSO_4$. This result confirmed the view of the present authors; but, as they point out, it is, of course, impossible to affirm that a sub-sulphate is ever formed in the reaction of secondary cells; but what they have proved is, that all that we know is perfectly consistent with the old and simpler supposition that $PbSO_4$ is alternately formed and decomposed.

The other point considered was the action of sulphuric acid on lead. The authors pointed out that in their former Paper to the Society they had described a comparative experiment in which dilute sulphuric acid either alone or mixed with a small quantity of sodium sulphate was allowed to act on spongy lead. The experiment continuing for about five months. The evolution of hydrogen gas continued for such a length of time that they thought it would be of interest to analyse the resulting substance. When the lead was treated with pure sulphuric acid the residue consisted of 82 per cent. of sulphate of lead and 18 per cent. of metallic lead, while if the acid was mixed with sodium sulphate it consisted of 89 per cent. of lead sulphate and 11 per cent. of metallic lead. The authors point out that although the action of the acid on the lead was diminished in its initial stages by the presence of sodium sulphate, the final result was in the other direction. They consider that the whole of the spongy lead would have been converted into sulphate if it had not been for the large amount of insoluble salt which protected the remaining particles. They suggest that this result throws light upon the reason why a lead plate deteriorates during a long rest.

#### DISCUSSION.

Mr. G. H. ROBERTSON, who had used ammonium acetate to analyse plugs from storage cells, said he had arrived at results much the same as those stated by the authors.

Mr. SWINBURNE said Dr. Frankland was absent, but, without agreeing with him, he would suggest that Dr. Frankland might say that ammonium acetate decomposed the subsalt $Pb_3S_2O_{10}$, and then dissolved the sulphate $PbSO_4$. The question might be attacked by acting on equal quantities of the substance and the mixture $PbO_2$, $2PbSO_4$ in a calorimeter with ammonium acetate, to see if the same heat is produced. This would show whether the substance is a mixture or a compound.

Dr. S. P. THOMPSON was glad that the authors allowed a possibility of basic sulphate being formed, for it was well known that an almost irreducible sulphate resulted from leaving a cell nearly discharged. This, he thought, would point to a possible formation of a basic sulphate from $PbO$ and $PbSO_4$.

Mr. SWINBURNE did not see where the PbO came from, except in newly pasted negatives, and he knew of no evidence of an intermediate stage of oxide on the plates. They appear to change directly to sulphate.

Dr. THOMPSON said that a rapid discharge was known to produce basic salts.

This Mr. SWINBURNE thought due to deficiency of acid near the plates. Peroxide, he said, could not be formed on the negative, without the acid was heterogeneous, and gave rise to local currents.

Mr. W. HIBBERT, referring to Mr. Swinburne's statement, said he had put one plate of spongy lead into strong acid and another into weak, and from this arrangement obtained a fairly large current. As regards the basic sulphate spoken of by Dr. Thompson, he did not think there was much probability of its being formed. Time, he said, had an important influence on a partially discharged cell, and he would not expect to easily reduce the $PbSO_4$ formed by the long continued action of lead on sulphuric acid.

The PRESIDENT inquired whether Mr. Hibbert's argument would apply to a fully-charged cell.

Mr. HIBBERT, in reply, said that in this case the time required to produce sufficient sulphate to be irreducible would be very much longer, for in a partially-discharged cell much sulphate was already formed.

Dr. GLADSTONE said he had anticipated that Dr. Frankland would raise the objection referred to by Mr. Swinburne. As far as he was aware, there was no direct evidence either way; but he thought the suggested decomposition was improbable. If he acted on a mixture of $PbO_2$ and $PbSO_4$, he would expect to get the results actually obtained. Mixtures, however, were difficult to deal with, and the results not conclusive, for the physical condition of the mixture was not the same as that of the actual products. Referring to Dr. Thompson's remarks, he understood that it was the basic sulphate which he (Dr. Thompson) considered irreducible.

Digitized by Google

Dr. Frankland, however, believed this sulphate more easily reduced than $PbSO_4$.

The PRESIDENT remarked that he thought Dr. Frankland had two reasons for his belief in the existence of the basic sulphates. One of these was the difficulty in reducing normal sulphate, whilst the other was based on the rapid fall of E.M.F. at a certain part of the discharge. It was at this point that Dr. Frankland thought the new sulphate formed, and to meet this argument it was necessary to find some other explanation of the rapid fall. In this connection, he (the President) inquired whether there was sufficient peroxide formed on the negative plate to account for the drop. On this point Dr. Gladstone could not speak decisively.

## AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *November* 21, 1890.

**Compound Winding.**—At the regular monthly meeting of the American Institute of Electrical Engineers on Tuesday evening of this week a Paper was read by Dr. Louis Bell, editor of the *Electrical World*, on "The Theory of Compound Winding for Constant Potential." The Paper gave a brief *resumé* of the somewhat incomplete formulæ used by different designers in a calculation of compound winding for constant potential, and then developed a slightly different and more complete formula, which was thought to be better suited for this purpose. Starting with the plain shunt machine, the various losses which must be compensated for by the use of series turns on the field coils, were considered separately. These were, first, the fall of potential due to the resistance of the armature; second, the loss due to the decreased effect of the shunt when the series turns are added; and, third, the loss due to the demagnetising effect of the armature. In the discussion of the Paper, the interesting point was brought out by Mr. Entz that the resistance of the air space between the armature and pole pieces cannot be considered a constant, since the angle at which the lines of force cross the air gap, and consequently the length of the path which they take is variable. It was thought that in some cases the variation in the angle which the lines of force make with a line joining the centre of the pole pieces might be as much as 45 degrees.

**The Artificial Light of the Future.**—On Tuesday evening of this week Prof. Edward L. Nichols, of Cornell University, gave a very interesting lecture before the New York Electric Club. After reviewing very carefully the various results which have been obtained in efficiency tests of arc and incandescent lamps, gas flames, and other ordinary sources of artificial illumination, Prof. Nichols briefly pointed out what must be considered as the limiting efficiences which could be obtained from these sources of illumination. The lecturer then considered several other and, at present, uncommon sources of artificial light, to which he and his colleagues in the Cornell University have recently given considerable attention. The most important of these he considered to be magnesium, and he briefly reviewed some very promising results as to its efficiency which he has recently obtained. In the discussion of the Paper, Mr. Tesla called attention to some interesting experiments which he had made by the mixture of a solution of chloride of magnesia with finely powdered carbon. The resulting paste was pressed into a pencil suitable for an arc light, and gave some interesting results when burned. He had also experimented with incandescent carbon filaments, in the structure of which the same material had been intimately incorporated.

## BOOKS, &c., RECEIVED.

"Kalender für Elektrotechniker, 1891." Edited by F. Uppenborn. (Munich and Leipszig: R. Oldenburg.)

"The Electric Light Popularly Explained." By A. Bromley Holmes. (London: Bemrose and Sons.) Price 1s.

"Spinning Tops" (Romance of Science Series). By Prof. J. Perry, F.R.S. (London: Society for Promoting Christian Knowledge.) Price 2s. 6d.

"Soap Bubbles" (Romance of Science Series). By Prof. C. V. Boys, F.R.S. (London: Society for Promoting Christian Knowledge.) Price 2s. 6d.

## LEGAL INTELLIGENCE.

### Queen v. Fareham Electric Light Company and Others.

In the Queen's Bench Division on Monday last, before Mr. Justice Stephen and Mr. Justice Charles, sitting as a Divisional Court,

Mr. B. SMITH moved on behalf of the Defendants in the case of the Queen v. The Fareham Electric Light Company and Others, for a rule absolute, removing the trial of an indictment found against them at the last Winchester Summer Assizes into the Queen's Bench Division.

The learned Counsel said that as two sets of the Defendants were corporate bodies, he was entitled to a rule absolute.

Their Lordships granted the application.

### Lane Fox v. Drake and Gorham.

This was an action in the Westminster County Court by the plaintiff, Mr. Lane Fox, to recover ten shares in the Lane Fox Electrical Company, which shares, he alleged, were being wrongfully withheld by the defendants, Messrs. Drake and Gorham, electrical engineers, of Victoria-street, Westminster.

It appeared from the opening of counsel for the plaintiff, that Mr. Lane Fox gave the defendants ten shares in the Electrical Company in consideration of certain services rendered. It subsequently came to the knowledge of the plaintiff that both the defendants were, in common with other firms, infringing the very patents for the sale of which the company was formed. That being so, the plaintiff thought they were undesirable people to be directors of his company, and offered them £30 if they would transfer the shares back to him. They agreed to do so, but ultimately a disagreement arose, and they refused to part with their shares. The action was now brought for specific performance of the agreement.

At this stage of the case the learned counsel on both sides held a consultation, which resulted in the case being withdrawn from his Honour's list by consent, each party agreeing to pay their own costs.

**Re Henry Thompson.**—A receiving order was made in October against this debtor, he being described as of Gresham-street, Gray's-inn-road, and St. Peter-street, Islington, electrical case and cabinet maker. The summary of accounts has just been issued by Mr. Wildy, Official Receiver, showing unsecured debts £3,679, and assets £860. 14s. 4d. The debtor, an accountant and general business agent, in 1886, became manager of his present business, which he eventually purchased, with the assistance of a partner, who brought in about £2,800, and carried it on as the "Eclipse Cabinet Works" and the "Eclipse Electrical Case Works." The partner afterwards retired, upon terms which were not carried out. The Official Receiver reports that the debtor admits having been insolvent for the last ten years, and that he attributes his deficiency to loss on trading, owing to bad debts and falling off in business, to his household and personal expenses, to interest on borrowed moneys, and to other causes. Mr. Percy Ravencroft, accountant, 10, Cheapside, is the trustee of the estate.

## TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

TENDERS WANTED.—As will be seen by our advertisement columns, persons willing to purchase india-rubber and gutta-percha core may obtain conditions of the contract from Mr. A. Abercrombie Jopp, Director-General of Stores, India Office, Whitehall, S.W., to whom tenders must be sent not later than 2 p.m., on Tuesday, the 16th inst.

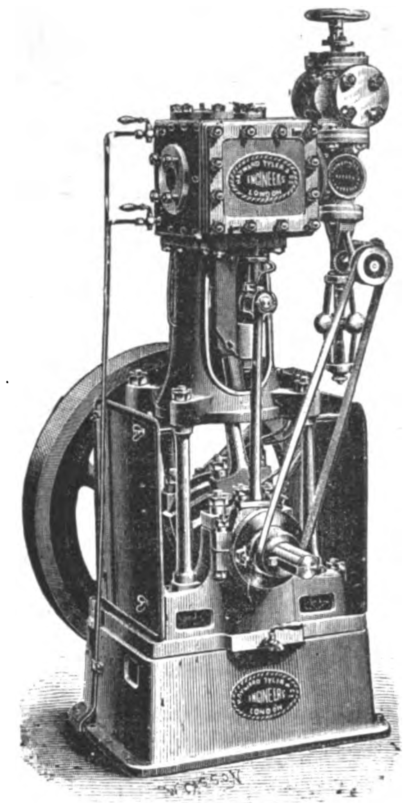
———The Corporation of Nottingham, having obtained a Provisional Order for supplying electricity in the Borough of Nottingham, and having power with the approval of the Board of Trade to transfer their powers, duties, and liabilities to any company or person, request such companies or persons as would be prepared to contract and find the necessary capital for working the order under a transfer of the powers and liabilities of the Corporation to send their names and addresses to Mr. S. G. Johnson, town clerk, Guildhall, Nottingham, on or before December 15, 1890. Further particulars will be found in our advertisement columns.

———Tenders are required by the North-Eastern Railway Company for the supply of telegraph apparatus and telegraph wire and line stores during the six months ending June 30, 1891. Forms of tender may be obtained of Mr. Graves, Telegraph Department, York, and Tenders must reach the Secretary of the Company by noon on the 9th instant.

PLANT FOR SALE.—Our advertisement columns contain particulars of an electric lighting plant for sale, comprising a 50-volt dynamo, large switch-board, 75 switches, voltmeters, Wheatstone bridge, about 100lb. of 5·2mm. platinoid wire, pulleys, leather and camel-hair driving belts, and four marine countershafts.

Digitized by Google

VERTICAL HIGH-SPEED ENGINE.—Messrs. Hayward, Tyler and Co., of London and Luton, have constructed a single-cylinder double-acting high pressure non-condensing engine, which is illustrated herewith. The cylinder is carried on a casting forming the guides, and this is supported on four mild steel columns. The cylinder is 7½in. diameter, and has a stroke of 7in. It is made of the hardest workable cast iron, and is tested to 250lb. per square inch. The piston is of cast iron, very deep, and fitted with Ramsbottom rings. The governor is of the high-speed type, acting directly on a double-beat perfect equilibrium throttle-valve, and is so constructed as to have no joints. It is adjustable whilst running. Two lubricating boxes are fitted in suitable positions, so that by means of copper pipes the oil is carried to every bearing. Special means of carrying the oil from the lower ends of the pipes to the bearings are adopted, so that the whole can be oiled while in motion, and thus



obtain constant running if necessary. Splash-plates are provided for the back and front of the engine, provided with wing nuts for easy removal, and arranged so that the whole of the oil drips into the oil channel. The crank pin in the bed-plate drains through a pipe into the general oil channel, and a gun-metal cock is provided for drawing off the oil from the channel as need be. A speed of 350 revolutions per minute is considered to be the best, but the engine will run without trouble at 450 if desired.

MESSRS. DICKINSON & CO.—This firm have just secured from Mr. Norman Forbes a contract to install the electric light throughout the Globe Theatre.

FIRE.—Shortly before three o'clock on Saturday afternoon last a fire occurred on the premises of Messrs. Gent and Co., electricians, Bede-street, Leicester. Very little damage was done, and no hindrance to business was occasioned.

REMOVALS.—Messrs. Lacombe & Co. announce that, in consequence of increase in business, they have removed to 7, Carteret-street, Queen Anne's-gate, Westminster, where a stock of carbons, &c., will be kept.——Mr. Joseph Coles, electrical engineer, announces that he has removed from 1, Barlborough-street, New Cross, London, S.E., to larger premises at 840, Old Kent-road, S.E.

KELWAY'S ELECTRIC LOG SYNDICATE (LIMITED).—The liquidator (Mr. R. Alabaster) announces that a meeting of the shareholders of this syndicate will be held at his office, Leadenhall-buildings, 1, Leadenhall-street, E.C., on December 19th, at 3 p.m., to receive his report as to the liquidation.

## PATENT RECORD.

### APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

November 21, 1890.

18,896. A. S. ELMORE. London. Improvements in the process and apparatus for manufacturing copper tubes, sheets, strips, and wires by electrolysis.

18,904. H. J. O. FRASER. London. Improvements in magneto-electric telephonic apparatus.

18,910. C. F. JOSZ. London. Improved apparatus for stopping machinery by electricity.

18,913. E. L. JOSEPH. London. An improved electrical switch.

18,916. H. ARON. Liverpool. Improvements in, or appertaining to apparatus for measuring electric currents.

18,926. F. SUISSE. London. Improvements in electric arc lamps.

November 22, 1890.

18,969. W. A. PRICE and W. E. GRAY. London. An improved apparatus for measuring the resistance and insulation of electric conductors

18,993. N. PROKHOROFF and N. FAHLBERG. London. Improvements in and relating to electric clocks.

November 24, 1890.

19,033. WOODHOUSE and RAWSON. London. Improvements applicable to switches used for electrical purposes (A. W. J. Hinde, Australia)

19,034. R. J. JONES and WOODHOUSE and RAWSON. London. Improvements in automatical electrical apparatus.

PATENT

SILICIUM BRONZE AND SILICIUM COPPER WIRE.

The best for overhead Telephone and Telegraph Lines,

AND ALL ELECTRICAL PURPOSES.

Hard Drawn High Conductivity Copper Wire.

ROLLED AND DRAWN PHOSPHOR BRONZE.

PHOSPHOR BRONZE VULCAN PHOSPHOR DURO METAL

PHOSPHOR BRONZE BEARINGS, BUSHES, AND OTHER PARTS OF ELECTRICAL MACHINERY.

*SOLE PROPRIETORS of the British, Indian and Colonial Patents,*

THE PHOSPHOR BRONZE COMPANY (Limited),

*87, Sumner Street, Southwark, London, S.E.*

WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

Digitized by Google

19,035. F. W. Dodd. London. Improvements in dynamos for firing explosive charges, or for medical purposes

19,037. J. S. Gisborne. London. Means of neutralising or controlling the polarity of iron or steel for the protection of magnetic needles from local attraction.

19,049. F. L. Muirhead. London. Improvements in electric lighting appliances for photographic and other purposes.

19,052. M. N. Mallison. London. Improved combination of ingredients constituting a compound as an illuminating medium for electric incandescent lamps.

19,057. W. P. Thompson. Liverpool. Improvements in electric arc lamps (R. H. Beach, United States).

19,068. J. E. Kingsbury. London. Improvements in telephone spring-jack switches (The Western Electric Company, United States).

19,076. W. M. Mordey. London. Improvements in electric safety fuses.

November 25, 1890.

19,079. J. Armstrong. Bilston. Electric cables.

19,097. A. M. Clark. London. Improvements in, and in the method of, manufacturing incandescent electric lamps and other exhausted receivers (A. Bornholdt and J. Glatz, United States).

19,108. C. Adams-Randall. London. Improvements in, or connected with combinations of hydraulic, pneumatic, and electric means for obtaining, transmitting, and applying motive power.

19,155. H. H. Lake. London. Improvements in electrical storage batteries or accumulators (G. E. Hatch, United States).

19,162. M. W. Dewey. London. Improvements in methods of electric welding and metal working.

19,191. M. Whelass and J. E. Wheatley. London. Improvements in and relating to underground electric tramways.

19,203. L. Hausmann. London. Improvements in the manufacture of thin metal tubes by electrolysis.

November 26, 1890.

19,234. H. C. Swindell. Birmingham. A method of and apparatus for controlling gas-lighting in cases of failure of electric light installations.

19,239. H. Barton. London. Improvements in electric switches.

19,272. C. E. Carpenter. London. Electric soldering irons. (Date applied for under Patents Act, 1883, Sec. 103, 10th May, 1890, being date of application in United States).

## SPECIFICATIONS PUBLISHED.

1890.

58. Gardner. Incandescent electric lamps. (Price 6d.)

761. Dahl. Generating electricity. (Price 8d.)

2,255. Macaulay. Cruikshank (Schwabacher). Electric switches, etc. (Price 8d.)

5,062. Depoele. Electric Railways. (Price 8d.)

14,269. Radcliffe. Electrical signalling. (Price 8d.)

15,006. Kennedy. Converting electrical energy. (Price 6d.)

15,469. Imray. (The Bethel Electric Medical Baths Company, Limited). Administering electricity to the human body. (Price 6d.)

## NEW COMPANIES REGISTERED.

**HORSHAM IRONWORKS (LIMITED).**—Registered by Waterlow Brothers and Layton (Limited), 24 and 25, Birchin-lane, E.C., with a capital of £5,000 in £5 shares. Object: To acquire the business of Steele and Dodson, of Horsham, engineers and machinery agents, &c.

**THE SOUTH INDIAN RAILWAY COMPANY (LIMITED).**—Registered by Freshfields and Williams, 5, Bank-buildings, E.C., with a capital of £1,000,000 in £10 shares. Objects: (1) to enter into and carry into effect, either with or without modification, an agreement, the form of which is set forth in the schedule to the articles of association of the Company; (2) from time to time to divide among the members of the Company any interest received from the Secretary of State for India in Council under the provisions of the said agreement; (3) to purchase, take on lease, or otherwise acquire or accept permission to use any railway, tramway, roadway, lines of telegraph and telephone, or other mode of general communication, or any interest in any of the same.

**SLEEMAN CONTROLLED TORPEDO SYNDICATE (LIMITED).**—Registered by H. Y. Dickinson, 56, Gray's Inn-road, W.C., with a capital of £12,000 in £1 shares. Object: to carry on the business of manufacturers and dealers in torpedoes.

**WEYMERSCH ELECTRIC BATTERY SYNDICATE, LIMITED.**—Registered by Harwood and Stephenson, 31, Lombard-street, E.C., with a capital of £20,000 in £5 shares. Object, to carry on in the United Kingdom and elsewhere the business of an electric light company in all its branches. The first subscribers of one share each are:—A. M. Cardwell, 29, St. James-street, Piccadilly; H. Weymersch, 17, Glengarry-road, Dulwich; W. S. T. Martin, 17, Melbourne-grove, Dulwich; E. C. de Segundo, 7, Victoria-street, S.W.; F. Fanta, 10, Moorgate-street; C. F. Jones, Inglewood, Upper Norwood; Mrs. McKenzie, 21, Talbot-road, Bayswater. There shall not be less than three nor more than five directors. The first are the first two signatures and T. H. and W. A. Cardwell. Qualification, £500. Remuneration to be determined in general meeting.

## CITY NOTES, &c.

**BRAZILIAN SUBMARINE TELEGRAPH COMPANY.**—The Directors of this Company have declared an interim dividend of 3s. per share, or at the rate of six per cent. per annum, free of income-tax, for the quarter ended September 30th last, and payable on the 23rd inst. The books of this Company will be closed from the 16th to 22nd inst., both days inclusive. The receipts of this Company for the past week amounted to £6,368.

**COMMERCIAL CABLE COMPANY.**—At a meeting of this Company, held on Wednesday, it was decided to increase the quarterly dividend, payable on January 1st, to 1¾ per cent. The Company also decided to pay £120,000 in distribution to the bondholders.

**CUBA SUBMARINE TELEGRAPH COMPANY.**—The estimated traffic receipts of this Company for the month of November were £3,100, as compared with £3,112 in the corresponding month of last year. The receipts for the month of August, estimated at £2,900, realised £2,913.

**EASTERN TELEGRAPH COMPANY, LIMITED.**—The traffic receipts of this Company for the month of November, 1890, amounted to £58,975 as against £60,578 for the corresponding period of 1889, or a decrease of £1,603.

**EASTERN EXTENSION TELEGRAPH COMPANY.**—The receipts of this Company for November amounted to £44,742, as against £44,147 in the corresponding period, showing an increase of £595.

**FOWLER-WARING CABLES COMPANY (LIMITED).**—The second ordinary general meeting of this Company will be held at Winchester House, Old Broad-street, E.C., this day (Friday) at 12 noon.

**GREAT NORTHERN TELEGRAPH COMPANY.**—The traffic returns of this Company are as follows:—Receipts in November, 1890, £23,600; 1st January to 30th November, 1890, £256,400; corresponding months, 1889, £252,400; corresponding months, 1888, £250,200.

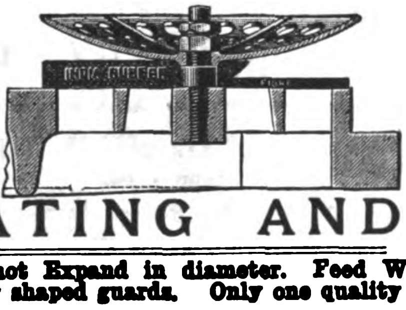
**WESTERN AND BRAZILIAN TELEGRAPH COMPANY.**—The traffic receipts of this Company for the week ending November 28, 1890, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £5,016.

**WEST COAST OF AMERICA TELEGRAPH COMPANY.**—The traffic receipts of this Company for the month ending November 30, 1890, amounted to £4,350.

**WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).**—The estimated traffic receipts for the half-month ended Nov. 30th were £2,807, against £3,111 in the corresponding period of 1889, or a decrease of £304.


NEW VALVE

No Rubber, Percha, or Leather.



One-half the price of Rubber or Metal.

FOR CIRCULATING AND AIR PUMPS.

Unaffected by any Lubricating Oils. Does not Expand in diameter. Feed Water may be worked at any temperature Suitable for any shaped guards. Only one quality manufactured.

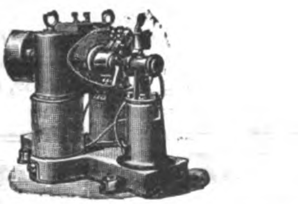
"12, John-street, Sunderland, 26th Sept. 1886.

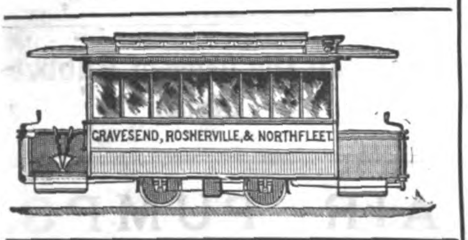
"DEAR SIRS,—In reply to your letter of the 25th inst., the Valves I got from you have done their work well, and ARE AN UNQUALIFIED SUCCESS. I will continue to get them from you as required.—Yours faithfully, JAMES WESTOLL."

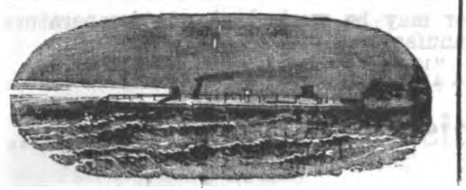
For further Testimony and Prices, apply to MOSSES & MITCHELL, 68-71, Chiswell Street, London.

# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name. | Previous Week's Price, Nov. 26. | | Price Wednesday, Dec. 3. | | Rate per Cent. Yielded. | Dividend Due. | Business Done During Week Ending Dec. 3. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **TELEGRAPHS.** | | | | | £ s. d. | | Highest. | Lowest. |
| £1,381,380 | Stock | 15/0 | Anglo-American | 48¾ | 49¼ | 48½ | 49½ | 5 16 2 | Jan., Apr., July, Oct. | 49¾ | 49½ |
| £2,809,310 | Stock | 30/0 | Do. Preferred | 84½ | 85½ | 85 | 86 | 6 13 9 | " " | 86 | 85½ |
| £2,809,310 | Stock | .. | Do. Deferred | 13 | 13½ | 13½ | 14 | .. | " .. " | 14½ | 13 |
| £250,000 | £100 | 4% | African Direct, 4 per Cent. Debentures | 98 | 101 | 98 | 101 | 3 19 3 | January and July .. | 100½ | 99½ |
| £130,000 | 10 | 6/0 | Brazilian Submarine | 11 | 11 | 11¼ | 11¾ | 6 7 8 | Mar., June, Oct., Dec. | 11⅝ | 11½ |
| £84,500 | 100 | 5% | Do. 5 per Cent. Bonds | 101 | 103 | 101 | 103 | 4 17 1 | January and July .. | .. | .. |
| £75,000 | 100 | 5% | Do. 5 per Cent. Bonds (2nd Series, 1906) | 104 | 108 | 104 | 108 | 4 12 7 | June and December | .. | .. |
| $7,216,000 | $100 | 8½ | Commercial Cables | 102 | 104 | 102 | 104 | 5 15 5 | April and October .. | .. | .. |
| £16,000 | £10 | 8/0 | Cuba Submarine | 11½ | 12 | 11½ | 12 | 7 1 8 | February and August | 11⅞ | 11½ |
| £6,000 | 10 | 10% | Do. Preference 10% | 17 | 18 | 17 | 18 | 5 11 1 | " " | .. | .. |
| £12,931 | 5 | 2/4½ | Direct Spanish (£4 paid) | 3¾ | 4½ | 3¾ | 4½ | 5 12 11 | April and October.. | .. | .. |
| £6,000 | 5 | 10% | Do. Preference 10% | 8½ | 9½ | 9 | 10 | 5 0 0 | " " | 9½ | .. |
| £60,710 | 20 | 3/6 | Direct United States | 10 | 10½ | 10½ | 10¾ | 6 15 0 | Jan., Apr., July, Oct. | 10½ | .. |
| £100,000 | 10 | 2/6 | Eastern | 13⅝ | 13⅞ | 13¾ | 14 | 4 5 9 | " " | 14 | 13¾ |
| £70,000 | 10 | 6% | Do. 6 per Cent. Preference | 14½ | 15 | 14½ | 15 | 4 0 0 | " " | 14¾ | 14⅝ |
| £1,200,000 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock | 103 | 106 | 103 | 106 | 3 15 6 | May and November | 105½ | 104½ |
| £200,000 | £100 | 5% | Do. 5 per Cent Debentures, 1899 | 106 | 109 | 106 | 109 | 4 11 9 | February & August | .. | .. |
| £250,000 | 10 | 2/6 | Eastern Extension | 13¾ | 14 | 13¾ | 14 | 5 0 0 | Jan., Apr., July, Oct. | 14 | 13¾ |
| £320,000 | 100 | 6% | Do. 6 per Cent. Debentures, 1891 | 100 | 102 | 101 | 103 | 5 16 6 | February & August | .. | .. |
| £91,800 | 100 | 5% | Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900 | 102 | 105 | 102 | 105 | 4 15 3 | January and July .. | .. | .. |
| £145,300 | 100 | 5% | Eastern & S. African 5 per Cent. Mor. Deb., 1900 | 101 | 104 | 101 | 104 | 4 16 2 | " " | 102¾ | 102 |
| £180,227 | 10 | 1/9 | Globe Telegraph and Trust | 8⅝ | 8⅞ | 8¾ | 9 | 5 8 4 | Jan., Apr., July, Oct. | 9 | 8¾ |
| £180,042 | 10 | 6% | Do. 6 per Cent. Preference | 14¼ | 14½ | 14½ | 14¾ | 4 1 4 | " " | 14⅝ | 14⅜ |
| £150,000 | 10 | 5/0 | Great Northern | 15¾ | 16¼ | 15¾ | 16¼ | 4 12 4 | Jan., April, and July | 16¼ | 15⅞ |
| £15,000 | 100 | 5% | Do. 5 per Cent Debentures, 1881 | 101 | 104 | 101 | 104 | 4 16 2 | January and July .. | .. | .. |
| £180,000 | 100 | 5% | Do. 5 per Cent. Debentures, 1883 | 104 | 107 | 104 | 107 | 4 13 6 | March & September | 106½ | 104½ |
| £17,000 | 25 | 12/6 | Indo-European | 35 | 37 | 35 | 37 | 6 15 2 | May and November | .. | .. |
| £38,348 | 10 | 4/0 | London Platino-Brazilian | 6 | 7 | 6 | 7 | 5 14 4 | " " | .. | .. |
| £100,000 | 100 | 6% | Do. 6 per Cent. Debentures | 105 | 108 | 106 | 109 | 5 10 1 | March & September | 108 | .. |
| £9,000 | 8 | 4/0 | Reuter's | 8½ | 9 | 8½ | 9 | 5 11 1 | April and October.. | 8⅝ | 8½ |
| £3,381 | £100 Cert. | 6% | Submarine Cables Trust | 110 | 114 | 108 | 112 | 5 7 2 | " " | .. | .. |
| £15,609 | £10 | 6/6 | West African | 8½ | 9½ | 8½ | 9½ | 5 5 3 | January and July .. | 9 | .. |
| £290,000 | 100 | 5% | Do. 5 per Cent. Debentures | 98 | 101 | 98 | 101 | 4 19 0 | March & September | .. | .. |
| £30,000 | 10 | 3/0 | West Coast of America | 4 | 5 | 3½ | 4½ | .. | January and July .. | .. | .. |
| £150,000 | 100 | 8% | Do. Debentures 8% | 102 | 107 | 102 | 107 | 7 9 7 | June and December | .. | .. |
| £38,321 | 10 | Nil. | West India and Panama | 2⅞ | 3⅛ | 2⅞ | 3 | .. | .. | 3⅛ | 2⅞ |
| £34,563 | 10 | 6/0 | Do. 1st Preference 6% | 11½ | 11¾ | 11¼ | 11¾ | 5 2 2 | May and November | 11⅝ | 11½ |
| £4,669 | 10 | £3 | Do. 6 p. c. 2nd Pref. | 11 | 12 | 11 | 12 | 5 0 0 | " " | .. | .. |
| £34,174 | 15 | 6/0 | Western and Brazilian ...xd | 10¾ | 11¼ | 10¾ | 11¼ | 5 6 8 | " " | 11 | 10¾ |
| £27,873 | 7½ | 6/0 | Do. 5 per Cent. Cumulative Preferred ...xd | 6½ | 7 | 6½ | 6¾ | .. | – | 6⅝ | 6½ |
| £27,873 | 7½ | 4/6 | Do. 5 per Cent. Deferred | 4½ | 5 | 4½ | 5 | .. | .. | .. | .. |
| £300,000 | 100 | 6% | Do. 6 per Cent. Debs., Series "A" | 103 | 106 | 103 | 106 | 5 13 2 | February & August | 105 | 103 |
| £250,000 | 100 | 6% | Do. 6 per Cent. Mort. Debs., Series "B" | 103 | 106 | 103 | 106 | 5 13 2 | " " | .. | .. |
| $1,336,000 | $1,000 | 7% | Western Union 7 per Cent. 1st Mortgage | 120 | 125 | 120 | 125 | 5 12 0 | May and November | .. | .. |
| £175,100 | £100 | 6% | Do. 6 per Cent. Sterling Bonds | 99 | 103 | 99 | 103 | 5 16 6 | March & September | 100½ | .. |
| | | | **TELEPHONES.** | | | | | | | | |
| £324,850 | 14/0 | 0/4½ | Consolidated Telephone Const. & Maintenance. | 7/16 | 9/16 | 7/16 | 9/16 | .. | May and November | .. | .. |
| £320,000 | £1 | 8% | Oriental (11s. paid) | [illegible] | [illegible] | [illegible] | [illegible] | 4 8 8 | Yearly | .. | .. |
| £133,984 | 5 | 3/0 | National | 4½ | 4¾ | 4½ | 4¾ | 6 6 4 | June and December | 4⅝ | 4½ |
| £15,000 | 10 | 6/0 | Do. 6 per Cent. Cumulative 1st Pref. | 12½ | 12¾ | 12½ | 12¾ | .. | " " | .. | .. |
| £15,000 | 10 | 4/9¾ | Do. 6 per Cent. Cumulative 2nd Pref. | 9½ | 10¼ | 9¾ | 10¼ | 5 17 1 | " " | .. | .. |
| £209,750 | 1 | ½% | South of England, Ordinary | [illegible] | [illegible] | [illegible] | [illegible] | .. | .. | .. | .. |
| £20,000 | 5 | 2/1 | Do. 6 per Cent. Cumulative Pf. (£3 10s. pd) | 2½ | 3 | 2½ | 3 | .. | .. | .. | .. |
| £58,000 | 5 | 1/0 | United River Plate | 3 | 4 | 3 | 4 | .. | January and July .. | .. | .. |
| £146,128 | Stock | 5% | Do. 5 per Cent. Debenture Stock | 90 | 91 | 90 | 99 | 5 11 0 | .. | .. | .. |
| £3,200 | 100 | 7% | Do. 7 per Cent. Debentures | .. | | .. | | .. | – | .. | – |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | | | |
| £200,000 | £5 | .. | London Electric Supply | 2 | 2½ | 2 | ½ | .. | – | .. | – |
| £13,900 | 10 | .. | Metropolitan Electric Supply (£8 paid) | 6¾ | 7¼ | 6¾ | 7¼ | .. | – | 7 | – |
| £12,853 | 5 | .. | Westminster Electric Supply (£3 paid) | 2¼ | 2¾ | 2¼ | 2¾ | .. | – | .. | – |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | | | |
| £33,416 | 3 | .. | Brush Electrical Engineering | 1 | 1½ | 1½ | 1¾ | .. | .. | 1½ | 1⅜ |
| £33,416 | 2 | 0/10 | Do. 6 per Cent. Preference | 1½ | 1¾ | 1½ | 2 | 6 0 0 | June and December | 1¾ | 1½ |
| £20,000 | 5 | 7% | Crompton and Co., 7 per Cent. Pref. Shares | 5½ | 5¾ | 5½ | 5¾ | 6 1 9 | January and July .. | .. | .. |
| £17,139 | 5 | .. | Edison and Swan United | .. | | .. | | .. | .. | .. | .. |
| £15,000 | 10 | 6% | Electric Construction | 7¾ | 8¼ | 7¾ | 8¼ | 7 5 5 | .. | .. | .. |
| £70,000 | 2 | 10/0 | Elmore's Patent Copper Depositing | 3½ | 4 | 3½ | 4 | .. | .. | 3⅜ | 3⅜ |
| £30,000 | 5 | .. | Fowler-Waring Cables (£4 paid) | 2½ | 3½ | 2½ | 3½ | .. | .. | .. | .. |
| £11,600 | 10 | 10/0 | India Rubber, Gutta Percha & Telegraph Works | 18 | 19 | 18 | 19 | 5 5 3 | February & August | 18¾ | 18½ |
| £300,000 | 100 | 4½% | Do. 4½ per Cent. Debentures, 1896 | 100 | 102 | 100 | 102 | 4 8 3 | March & September | .. | .. |
| £78,949 | 5 | 10% | Swan United (£3. 10s. paid) ..10% for year ...xd | 4½ | 5 | 4½ | 5 | 6 19 10 | May and November | 4⅝ | 4¾ |
| £37,350 | 12 | 12/0 | Telegraph Construction and Maintenance | 43 | 45 | 43 | 45 | 5 6 8 | March and July..... | 44 | .. |
| £150,000 | 100 | 5% | Do. 5 per Cent. Bonds, red. 1894 | 100 | 102 | 100 | 102 | 4 18 0 | January and July .. | 102 | .. |



# BEFORE ORDERING!

## ELECTRICAL PLANT & ACCESSORIES

(Statter's) WRITE FOR THE FOLLOWING PAMPHLETS TO THE (United)

## ELECTRICAL ENGINEERING CORPORATION, Ld.

PLANT WORKS: WEST DRAYTON, near LONDON.
FITTINGS WORKS: ALBERT WORKS, 36, ALBERT EMBANKMENT, S.E.
LONDON OFFICES: 3, PRINCES MANSIONS, VICTORIA STREET, WESTMINSTER.

"**ELECTRICAL DISTRIBUTION.**"—Commercially considered, with Estimates.
"**MACHINE DRIVING BY ELECTRICITY.**"—The Uses of Electro-Motors for Traction and Stationary Purposes.
"**THE TELPHER SYSTEM OF CHEAP TRANSPORT,**" for Minerals, Goods and Passengers.
"**ELECTRICAL SUPPLIES.**"—Prices and Particulars of the most approved Electrical Appliances

**ELECTRICAL PLANT ON VIEW.**


Digitized by Google

# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 656.—Vol. XXVI. FRIDAY, DECEMBER 12, 1890. Price Fourpence.


## NOTES.

A Paper of great interest and importance was read by Mr. Frank Bailey at the Society of Arts on Wednesday last, on "The Electric Lighting Progress in London." He gave a number of statistics of great value, based on a considerable experience. Mr. Bailey finds that the ratio of the maximum number of lamps lit at the time of heaviest load is about one-half of the whole number wired, and he gives the figures relating to their proportion, as experienced by the principal supply companies. Figures relating to the life of lamps of different sizes, and different voltages were given, and though some of these referred to old-fashioned lamps, we congratulate the author on having brought forward the great importance of keeping records of lamp life, and of adding to our general knowledge on this important question.

It was agreeable to find the engineer of the formidable rival to the London Electric Supply Corporation expressing his regret at the hard things that are being said against it. Mr. Bailey acknowledged frankly that we owe a debt of gratitude to the enterprise of Lord Crawford, who recommended the use of alternate current distribution at the Grosvenor Gallery, which was the first serious central station in London, and which at first gave wide satisfaction, as is amply proved by the very fact that their failures were due to the overloading of their plant when they were unhappily induced by a clamouring *clientèle* to connect them up to their overhead circuits. The resulting breakdowns have injured the Corporation to an extent which might be guessed by the shareholders, but they have injured the progress of electric lighting in this country to an extent which it is impossible to estimate.

These greatly abused overhead wires came in for a share of Mr. Bailey's sympathy. He reminded his hearers that with twenty-five miles of overhead wires in London not one single accident has happened which was directly attributable to them or the current which they carried. The prejudice, *pace* the æsthetic question, has been solely due to the accidents which have occurred, owing to the criminal carlessness of the work, in New York.

Mr. Crompton asserted at the Society of Arts on Wednesday that he designed and was ready to build central stations many years ago, the only one actually begun being that which now lights Victoria Station, and that he was then as well able to do so as he is at present. In making this rather startling statement, it must be remembered that he is alluding to low pressure distribution. Transformers were in those days as unheard of as Crompton-Howell batteries. Large dynamos were not made, and the special difficulties which have been found to arise from cross-induction were unknown. We venture to express some satisfaction that many schemes which were propounded then never reached the scale of twelve inches to the foot. The British public will stand a good deal, but it would not put up with the "pioneering" work of our American cousins.

The question raised by Mr. Richard Chamberlain in the House of Commons with reference to the Chelsea Electricity Supply Company resolves itself into the estimation of the accuracy of two assertions. He complains, in the first instance, that the light was bad. This is largely a matter of taste, some people prefer to overrun their lamps. But he refers to the indications of a voltmeter, and as the Board of Trade Standardising Laboratory is not yet open, and its volt is not yet legalised, it is obviously premature to press for any remedy. It might, indeed, be better to take the more circuitous course of a photometric determination of the candle-power of the lamp, seeing that we have a barbarous unit of light called a standard candle, but the lamps are sold under no warranty, and the lamp makers would be as powerless as is Mr. Chamberlain to come to any sound conclusion. Mr. Bailey, in the course of his most interesting Paper at the Society of Arts on Wednesday, seriously suggested that voltmeters might be calibrated by photometric measurement of glow lamps, so great is the accuracy with which they are made. The legalisation of the volt is, we believe, merely waiting for certain resistances. These are being leisurely compared with the standard coils, and we can only hope the results will be comparable with the time bestowed upon them.

It is not surprising that some complaint is made about the variation of 4 volts in 100 which is allowed by the Board of Trade, since the resulting variation of light is so considerable, but it must be observed that no other consumers in the Chelsea district are making any serious complaint—indeed, we have seen some most flattering testimonials as to the excellence of the supply—and it is evident, where batteries are used, and used so extensively as at Chelsea, that no sudden or serious fall of pressure is to be apprehended, such as might be felt on a circuit where the voltage is dependent directly on the speed of the dynamos which may be checked by a sudden demand. Mr. Richard

Digitized by Google

CHAMBERLAIN is undoubtedly very rash in adducing the evidence of a voltmeter when no legal volt exists, and his case is very ill-supported since he gives no idea of the accuracy of calibration of his instrument.

OF a different order altogether is the complaint of various firms who have suffered by the breakdown of the transformer station at the Grosvenor Gallery. Many of them imagine that the generating station from which they received their current has been destroyed; it is freely but erroneously asserted that the trouble has been due to the use of high-pressure or to the novel construction of the mains. Our readers have been informed of the exact cause, and will not be surprised to hear that so far from there being any anxiety to recommence the supply with undue haste, it has been proposed to defer it until the beginning of next month; the importance of thoroughly substantial work, the completion of which is merely a matter of time, being greater than the attempt to satisfy the immediate demands of the consumers.

THE result of the actions Watt *v* Maxim Electric Company and Maxim Electric Company *v.* Watt, a report of which is to be found in another column, will not prove pleasant reading to those who still cling to the belief that the hocus-pocus electrical finance of 1882-83 is entirely safe and highly remunerative. The one solitary good feature of the Electric Lighting Act of 1882 was that it saved the public from the rapacity of those who would have multiplied such companies as this. The electro-financial methods of that period were an unmitigated evil, and if investors still regard electrical enterprises with some suspicion, which, let us hope, has now no foundation in fact, it is due to their losses of seven years ago.

WHAT the electro-financial style of 1882-83 actually was when a Company got beyond the promotion stage, we are reminded by the lawsuits referred to above. In September, 1883, the Maxim-Weston Company obtained the services of a managing director at a salary of £600 per annum, plus 5 per cent. commission on net profits. In February, 1886, a time, be it remembered, when electric lighting in England was at its lowest ebb, this salary was increased to £1,000 per annum, with an annual increment of £100 up to £1,200 a year. Such valuable management could not obviously confine itself to ordinary modes of profit making, and the SOLICITOR-GENERAL had an easy task in proving his assertion that no genuine profits at all were earned between 1883 and 1887. Profits, however, were shown. Electrical plant was sent on sale to such active markets as Mauritius, and its invoice value was brought into the profit and loss account as cash. Patents were kept up in the books at their original values, and occasionally increased in value. Old stock was equally rejuvenescent. For example, "One clock, superior, £2," suddenly became "One clock, superior, £3 10s."; and vices, lathes, atmospheric-engines, dynamos, &c., all followed suit. With so remarkable a book-keeper is it surprising that the Maxim Electric Company has ended its existence "in liquidation" (whither are bound all similarly-conducted businesses), and that it has been found advisable for the late Managing Director to hand back £1,000 to the Company, and to pay its costs.

IT is surprising that while so much time has been devoted to rendering the dynamo highly efficient, the problem of the most economical method of distributing light for illuminating purposes has been so little studied. A difference of a few per cent. in the efficiency of two dynamos is regarded as important, while a much greater variation in the efficiencies of two electric lamps is altogether ignored. Yet it is obvious that the cheapness of a system of electric lighting is as dependent on the latter as the former. The investigation of Mr. LOPPÉ, an abstract of which we publish in another column, is interesting in connection with this subject, although it may be argued that the condition of most uniform illumination is not exactly what is wanted for practical purposes. It is no doubt, to a great extent, true for house lighting; and as in this case glow lamps are employed whose height from the ground approximates to their distance apart, the illumination is a maximum between the lights and is fairly uniform all over the room lighted. For street lighting the lamps are, however, placed much farther from each other than from the ground, and the illumination half-way between them is a minimum. Whether this minimum should be as near the average as possible is a questionable point. Mr. LOPPÉ assumes that the power required to produce a light varies as the candle-power of the light produced. This, of course, is unjustifiable, except as a simplification, but the truth of his results are not all dependent on this assumption. In determining the best height of lamp the candle-power is assumed fixed, so that the cost of the light, which depends only on the candle-power, is in this case constant, and the expression given for the height is still correct.

WE understand that the City and South London Railway will not be opened to the public on Monday next, as has been announced by a news agency.

**Society of Engineers.**—The annual dinner of this society was given at the Holborn Restaurant on Wednesday last.

**The Direct United States Cable Company.**—We have received a handsomely illustrated chart of this company's working.

**Reduction of Telephone Rentals.**—The annual subscription to the Belfast Telephone Exchange is to be reduced from £15 to £10.

**Leeds.**—The Corporate Property Committee has at last resolved to take steps to arrive as near as can be at the actual cost to the Corporation of electricity per lamp per hour.

**Electric Tanning in America.**—The American Tanning Company of New York has just been organised, and is now introducing the Worms and Balé process of electric tanning.

**Exeter.**—At a special meeting of the Exeter Town Council on Wednesday last it was decided, after nearly two hours' discussion, by 24 votes to 12, to apply for a Provisional Order.

**Newcastle.**—A special meeting of the Newcastle City Council was held on Wednesday last week for the purpose of considering whether the Council should consent to an application by the Newcastle and District Electric Lighting Company for a Provisional Order. Assent to the application of the company was refused by 37 votes to 10.

Digitized by Google

**Telephonic Communication with Lighthouses.**—Henley's Telegraph Works have recently manufactured a submarine telephone cable which has been laid between Hanzo, the most southern point of Finland, to a lighthouse 2½ miles from the coast.

**The Calais Submarine Cable Works.**—The new submarine cable works at Calais belonging to the Sociéte Générale des Téléphones are to be opened in the course of the present month in the presence of several representatives of the French Government.

**Royal Society.**—The members of the Royal Society intend raising a fund for the purpose of adding to their Gallery a portrait of Sir Gabriel Stokes, Bart., M.P. Sir John Lubbock, Bart., M.P., Sir Fred. Abel, and Sir Lyon Playfair are acting on the committee formed to arrange the preliminaries.

**The Electro Harmonic Society.**—A very agreeable evening was spent on Monday last by the members of this society and their lady friends at the St. James's Hall Restaurant, the enjoyment of the evening being more especially due to the instrumentation of Mr. T. E. Gatehouse and the singing of Mrs. Alexander Siemens, to both of whom a very hearty reception was accorded.

**Electric Traction at Southington, Conn.**—The smallest town in the United States which has an electric street railway in operation is Southington, Conn., with a population of 5,400. The cars are in service over two miles of track, and the average daily receipts are $9 per car. The power for the operation of this road is furnished by the local lighting company, and costs $1.25 per car per day.

**Lewes.**—The poll at Lewes on the electric light question was a complete failure. Only 329 ratepayers recorded their opinion. Of these the supporters of gas mustered 177, and electricity found favour in the eyes of 152 voters. The result is a majority of 25 in favour of gas, but the decision can scarcely be considered a final one, seeing that some 1,500 other persons remained neutral.

**Electric Motors in Mills.**—According to figures accredited to a New England cotton mill engineer of high reputation, says the *Electrical Engineer*, of New York, eight modern mills, with first class shafting, show that on the average 28·7 of the total horsepower is expended in driving the shafting. In one instance, to drive the shafting alone took 36·1 per cent. of the whole horsepower, and in another 39·2. The conclusion naturally arrived at by our contemporary is—why not employ electric motors?

**High Discharge Accumulators.**—The Electric Construction Corporation are now making a modified form of storage cell known as the K type, capable of giving a greatly increased rate of discharge. Taking the rate of discharge of the new K cell at 100, the comparative rates of discharge for the T (traction) and L (lighting) cells for equal plate area are respectively 70 and 47. The makers expect the new cell to have as long if not a longer life than previous types, and are of opinion that double the list rate of discharge can be maintained for short periods, say half an hour, without injury to the cell.

**The London Electric Supply Corporation and its Customers.**—Messrs. Mappin, Brothers, of Regent-street, in a letter to the *Times* of Monday, indignantly complaining of the recent electric lighting breakdowns, conclude as follows:—

"We think that you and a number of your readers will agree with us that it is a monstrous thing that any licence should be granted to a corporation professing to supply the public with what it so obviously does not possess or cannot control, and we write this in the interest of a large section of the public who might be (as we have been) put to great expense and enormous inconvenience owing to what can only be described as (to put it mildly) the utter incapacity of such electric lighting companies."

**Electrical Litigation.**—An action has been brought by the Electrical Supply Company of Chicago against the Great Western Electric Supply Company of the same city, to prevent the latter Company from using the name "Electric Supply" as a part of the title of the Corporation. The plaintiff Company alleges that it was the first Company in the United States to adopt the name "Electrical Supply," since which time it is asserted it has become popular, and a confusion which is detrimental to the Electrical Supply Company has resulted. It is stated that other actions will be commenced against other companies using the words "The Electrical Supply."

**An Electrostatic Experiment.**—At a recent meeting of the Académie des Sciences, M. Zenger described an interesting piece of apparatus devised to illustrate his theory of the electrodynamic rotation of the planetary bodies. A hollow glass globe, the inside of which is silvered, is placed midway between the poles of a Wimshurst machine, care being taken, however, that the line joining the centres of these terminals does not pass through the centre of the globe. When the Wimshurst machine is operated, the globe revolves on its axis at a speed governed by the speed of the handle of the machine. The globe must be kept several centimetres away from the discharging terminals to prevent sparking.

**Variations of Conductivity under Different Electrical Influences.**—In a paper on this subject read recently before the Académie des Sciences, M. Ed. Branly stated that if a circuit be formed with a Daniell's cell, a high-resistance galvanometer, and a very thin layer of copper deposited on a ground glass or ebonite plate, 7cm. long and 2cm. wide, only an insignificant current passes. An abrupt diminution of resistance is experienced, however, when electric discharges, from a Wimshurst machine or a Ruhmkorff's coil, are produced in the neighbourhood of the circuit. The action diminishes as the distance of the sparking apparatus increases, but it may be very easily observed, without special precautions, at several metres.

**The Bernados Welding Process.**—Sir Douglas Galton, Mr. W. H. Preece, Mr. Ashton (of the Royal Laboratory, Woolwich), and other gentlemen visited Messrs. Lloyd and Lloyds' Coombs Wood Tube Works on Friday last for the purpose of inspecting experiments in electric welding. The process used is that known as the Bernados process, which was fully described in the *Electrician* of November 25, 1887, the sole right to the use of which has been acquired by Messrs. Lloyd and Lloyd, and the welding is affected by means of an arc. Messrs. Lloyd and Lloyd have already applied the process in the manufacture of various articles in current demand, and they are also experimenting with it in other directions. The visitors expressed themselves most favourably as to the achievements and possibilities of arc welding.

**Electric Welding.**—Sir Douglas Galton, K.C.B, Mr. W. H. Preece, F.R.S., Mr. Ashton (of the Royal Laboratory, Woolwich), and other gentlemen visited Messrs. Lloyd and Lloyds' Coombes Wood Tube Works on Friday last for the purpose of inspecting their installation of electric welding. The process used is that known as the Benardos process, the sole right to the use of which has been acquired by Messrs. Lloyd and Lloyd, and the welding is effected by means of the arc. The firm have already applied the process in the manufacture of various articles in current demand, and are also experimenting with it in other directions. They have purchased the engines used for electric lighting at the French Exhibition in order to drive a larger installation which they are now completing. The visitors expressed themselves most favourably as to the possibilities of arc welding.

**Cable Extensions.**—A fourth cable has now been laid by the Eastern Telegraph Company from Suez to Aden, a distance of 1,400 miles, and by May next a third cable will be laid from Aden to Bombay, a distance of close on 2,000 miles. The Eastern Extension has duplicated its cable from Madras to Penang, which are 1,500 miles apart. There are now three cables between London and Australia. Besides these extensions, negotiations are in progress for the laying of a cable to connect Madagascar and the Mauritius with the Eastern and South African Company's cable at Zanzibar.—On the coast of South America the Western and Brazilian Company are doubling the line from Rio de Janeiro to Buenos Ayres; and nearer home we have just had 600 miles of new cable laid for the Great Northern Company between the North of England and Sweden.

**Technical Education in Manchester.**—At the recent annual meeting of the Manchester Technical School, it was resolved that its property, effects, and liabilities should be transferred to the Manchester Whitworth Institute. The Governors, says

Digitized by Google

*Industries*, wisely recognise that it is not quantity but quality which must be their chief concern. This they will be able to provide for under the scheme of incorporation. Our contemporary understands that the aim is to raise £100,000 for building purposes alone. Under the Technical Instruction Act the Town Council of Manchester has raised £4,000 for this year, and half of this has been allotted to the Technical School. The Governors are, therefore, justified in their hope that in a very short time there will be established and equipped in their city a technical school worthy of the greatest industrial centre of the world, a school which shall be made directly and readily accessible to the fit and capable of every class.

**Air Resistance at High Speeds.**—Some experiments on the resistance of trains on railways recently carried out on the State railways of France, and a brief account of which appears in the abstracts of foreign papers prepared by the Institution of Civil Engineers, bring out very clearly amongst other things the great importance at high speeds of the reaction of the surrounding atmosphere, the greater portion of which applies directly to the locomotive, the resistance of which, with high speed trains, amounts frequently to more than half the total resistance. Two engines, of which the resistance was measured separately and found to be 19·8lb. per ton at 37 miles per hour, were coupled together and again tried. The resistance fell to 14·31b. per ton; the second engine was masked by the first. It may be argued from this that by a suitable adaptation of the front of a locomotive, electrical or otherwise, a saving of from 8 to 10 per cent. of the effective power could be made.

**Electrical Cars on Heavy Gradients.**—In a Paper on "Street Railways," recently read before the Chicago Electric Club, Mr. T. P. Bailey remarks that among the numerous objections raised to the use of electricity in street car propulsion was that grades exceeding 5 per cent. could not be mounted. But experience, he says, has shown that grades as high as 14 per cent. can be ascended with safety and satisfaction. There is a grade of 13·2 per cent. on the street railway at Lynn, Mass., over which run 16ft. cars equipped with two 15 horse-power motors. At Milwaukee there is a grade of 10·3 per cent. successfully operated over by 20ft. cars, equipped with two 15 horse-power motors. A similar grade is met with at Newport, R.I., and Omaha, Neb., and numerous grades almost as heavy are seen in the electric railway systems at Des Moines and Davenport, Iowa, and Kansas City, Mo. The tendency, says Mr. Bailey, at the present time is in the direction of longer cars, double trucks, and heavier motors.

**Expiration of the Telephone Monopoly.**—On Monday night, in the House of Commons, Dr. Cameron asked the Postmaster-General whether, in view of the fact that the patent for the telephone in use by the company which possessed a practical monopoly of telephonic communication in Great Britain had now expired, and in view of the numerous complaints on the part of the public as to high rates and faulty service resulting from that monopoly, he would, with as little delay as possible, make known his decision as to applications for licenses submitted to the Post Office by proposed competitors desiring to introduce loud-speaking and long-distance telephones, and other forms of improved instruments. In reply, the Postmaster-General said he hoped to be able at an early date to announce the decision of the Government with regard to licenses for telephone exchanges. It should, however, he said, be borne in mind that the more important patents have not expired, and do not expire until July next.

**Paddington Vestry.**—At the last meeting of this Vestry, Mr. Fardell moved the following motion, "That as the draft agreement put forward by the Metropolitan Electric Supply Company under Clause 2, provides that 'either party may determine this agreement on giving three months' notice to the other,' it be referred to the Electric Lighting Committee to consider, in conjunction with the Vestry solicitor, and report to the Vestry at its next meeting, whether such agreement is in accordance with the provisions of the 'Electric Lighting Orders Confirmation (No. 12) Act, 1890,' inasmuch as that Act, while granting a monopoly to the above Company, expressly reserves the right to be supplied with electric energy to every owner and occupier, a right which the above cited agreement curtails." It was decided to leave the whole question in the hands of Colonel Barchard and Colonel Blair to write to the Company, and to report as to the result of the same.

**Electric Light Beacons.**—The United States Lighthouse Board, says *Iron*, is considering the feasibility and advisability of placing electric light beacons upon several of the new lightships to be stationed along the Atlantic coast. It was originally intended to equip these vessels with the best modern lights which could be obtained, the lenses and lamps to be of the highest order. It is thought possible, however, to obtain a better light by the use of electricity, in which case it would be desirable to equip the new lightship which is to be placed at Sandy Hook and one or two others with the electric light. In order to ascertain if the benefits which an electric beacon may possess over the regulation lamps will justify the additional expense, the Lighthouse Board will soon commence a series of experiments to be conducted at the lighthouse station on Staten Island. It is also proposed to equip two or three of the new lightships with flash lights, to be produced by means of revolving shades. The system of electric lights now in use on the buoys in Gedney's Channel, in New York Bay, is reported to give perfect satisfaction.

**Copper.**—Much satisfaction, says the *Statist*, has been expressed by persons interested in securities of copper mining undertakings at the statistics relating to the position of copper. For over eighteen months we have had a continual drain upon stocks, in consequence of the consumption exceeding the supplies. . . It is noticeable that for twelve months past to the end of November, and with consumption increasing about 30 per cent. over the corresponding twelve months, there has been no increase in supply such as might have been expected:—

| 12 months to end of Nov. | Supply. Tons. | Consumption. Tons. | Excess of supply. Tons. | Excess of deliveries. Tons. |
|---|---|---|---|---|
| 1890 | 110,664 | 145,208 | — | 34,544 |
| 1889 | 114,173 | 112,095 | 2,078 | — |
| 1888 | 123,587 | 70,802 | 52,785 | — |

According to Messrs. H. R. Merton and Co.'s statistics the copper stocks at the end of November amounted to 65,410 tons, against 99,984 tons this time last year. The supplies for November, 1890 and 1889, were respectively 8,415 and 9,859 tons, the deliveries 11,230 and 13,415 tons, and the prices £55⅜ and £50⅛ per ton.

**Aluminium Trolley Wheels.**—Aluminium trolley wheels are now being introduced in the States. Their total weight is only about two pounds, a great advantage, meaning lighter trolley poles, lighter springs, less danger of breaking down, and far less upward pressure against the wire necessary to produce good contact. Several of these trolleys (says the *Electrical World*) were exhibited at the Buffalo meeting of the American Street Railway Association last month, and scored a great hit. The construction of this trolley is in some respects peculiar. The wheel is fastened permanently upon a steel axis which revolves in the bearing. These are not metallic, but are formed of a thick lignum-vitæ bushing forced into the aperture furnished in the aluminium trolley holder. About the bushing an oil well is provided to keep up perfect lubrication. With an insulating bearing of this sort some special contact arrangement is evidently necessary to lead the current from the wheel to the holder, and this is furnished by a pair of washers, one resting on the axle against the wheel, the other pressed against it by a flat spring, which leads the current to the holder. This particular form of trolley wheel is due to a Mr. C. Lieb of New York.

**Test of a 500 Horse-power Electric Lighting Engine.**—The following results of a recent test of a 500 horse-power triple expansion engine now in service at the station of the Narragansett Electric Lighting Company at Providence, R.I., may be of interest. The engine was built by the E. P. Allis Company, of Milwaukee, Wis., and was operating arc lights. The test was conducted by Messrs. E. D. Leavitt and John T. Henthorn. The engine is of the Reynolds-Corliss condensing type, and its three cylinders are of 14, 25 and 33 inches diameter respectively, the length of the stroke being 48 inches. At the time of the test the street lights were burned to determine the load which came nearest to 500 indicated

Digitized by Google

horse-power. With 500 lights the aggregate load was 492 indicated horse-power, or 475·7 indicated horse-power, omitting the auxiliary engine working the condensers. From this it appears that ·984 indicated horse-power was required for each arc light. The test lasted 10 hours. The average speed was 99·12 revolutions, average steam pressure, 125·2lb., average aggregate indicated horse-power, 532·11; steam used per indicated horse-power per hour, 12·94lb.

**Fireproof Insulation.**—A patent has recently been taken out by Mr. Edison, says the *India Rubber Journal*, for a method of applying fireproof insulating covering to wires for electrical purposes. The material used as a basis for the compound is either balata or gutta percha; the gum is first dissolved in chloroform, and a stream of chlorine gas passed through the solution. This process eliminates the hydrogen from the material, and leaves a compound which is fireproof, and, if the chlorination is stopped at the proper time, pliable. During the passage of the chlorine, tests are made from time to time by depositing films of the composition on glass plates and igniting them; when the film refuses to ignite the proper stage has been reached and the supply of chlorine is cut off. The compound is then ready to be applied to the wire in the usual manner, by being reduced to a plastic condition and forced through a die. The process, says our contemporary, sounds more like a laboratory experiment than a practical method, and is likely to be both costly and dangerous, dangerous as regards the health of the *employés* employed. It is also questionable whether the resulting material would possess the very necessary quality of durability.

**London County Council.**—At the last meeting of the London County Council, Mr. Beresford Hope asked the chairman of the offices committee whether, in the case of the failure of the electric light, the Council had any remedy against the lighting company, as was the case when the supply of gas failed. Mr. Brereton, the chairman of the offices committee, replied that he should like to have notice of the question. He had received a letter from the London Electric Supply Company expressing their regret that their temporary measures to restore the supply of electricity had not proved effectual, and that they were consequently compelled to suspend the supply until the permanent apparatus could be replaced. The work was proceeding with all possible speed, although it might be some weeks before a full supply could be given.—Mr. Fardell, chairman of the theatres committee, stated that, at the last meeting of the Council, the theatres committee were empowered to engage the services of an electrician of eminence to report upon the danger, if any, of the various systems of electric lighting in theatres and large buildings. The committee had been in communication with Prof. John Hopkinson, and had engaged his services subject to the consent of the Council.

**The Chelsea Electricity Supply Company and its Customers.**—In the House of Commons on Monday last, Mr. R. Chamberlain asked the President of the Board of Trade whether his attention had been called to the long-continued default of the Chelsea Electricity Supply Company to furnish current at the statutory pressure of 100 volts, and to the serious loss of illuminating power sustained by consumers in consequence; and whether he would take steps to compel this company to keep faith with the public or to forfeit their concession. In reply, Sir M. Hicks-Beach said that if the Board of Trade Regulations with regard to the maintenance of a constant pressure were not complied with it was open to the consumer to proceed against the company for penalties. Mr. Chamberlain further asked whether the attention of the President of the Board of Trade had been called to the fact that the variation allowed by the Board of Trade was taken advantage of in order to supply the consumers not with an average of 100 volts, but of 97. Sir M. Hicks-Beach, in reply, said that if the company was in default the consumers had their remedy. It was not for the Board of Trade to enforce the law. Mr. R. Chamberlain then asked if he was to understand that he had no remedy unless they got below 96 volts. Sir M. Hicks-Beach replied in the affirmative.

**The De Morgan Medal.**—The following extract from an address to the London Mathematical Society by its President, on the recent occasion of the presentation of the De Morgan Medal to Lord Rayleigh, may be of interest:—"In 1869 Lord Rayleigh commenced the long series of papers and memoirs in mixed mathematics, which the Council had in view in making the award, with an article (*Philosophical Magazine*, Vol. XXXVIII., Third Series) 'On some Electro-magnetic Phenomena considered in connection with the Dynamical Theory,' founded on Clerk-Maxwell's celebrated 'Dynamical Theory of the Electro-magnetic Field' (*Phil. Trans.*, 1865), the subject being 'Examples of Electro-magnetic Problems illustrated by comparison with their Mechanical Analogues.' I may add, to complete the key-note thus struck, of Lord Rayleigh's scientific career, that these theoretical results were followed up in the next year by an account of 'An Electro-magnetic Experiment,' viz.: the magnetising effect of an induced current as dependent on the self and mutual inductions of the circuits—an early instance of the author's practice of making theory and experiment, or concrete example, illustrate one another. This combination of experimental with mathematical skill and fertility of resource has been conspicuous in Lord Rayleigh's later memoirs on the 'Determination of the Ohm and B.A. Unit of Resistance in Absolute Measure.'"

**Coral Growths on Submarine Cables.**—Submarine cables have before now rendered unexpected services to science, and the following is one of the latest:—Very little, it seems, is as yet known as to the rate of growth of corals, but some very interesting details have been published by M. Alexander Agassiz in the August number of the *Bulletin of the Museum of Comparative Zoology at Harvard College* with regard to a series of specimens which were taken in June, 1888, off the Havana and Key West cable, from a portion repaired in the summer of 1881; so that the growths could not be more than about seven years. It must be noted that this portion of the cable was laid at a depth of only from six to seven fathoms, and that the district in which it was laid was most favourably situated as regards food supply to the corals. Some of the specimens belong to species whose rates of growth have not yet been recorded. Verrill mentions that the thickness of the *Orbicella annularis* coral formed in 64 years was not more than about 8in.; the specimens from the Havana cable grew to a thickness of 2½in. in about seven years. *Manicina areolata* has grown to a thickness of 1in.; while *Isophylla dipsacea* shows a still more rapid growth, projecting 2½in. above the cable. Of course it is quite possible that these corals are of less than seven years' growth, but it is not probable that more than a short time passed before some of the swarms of pelagic coral embryos which must have floated past the cable found a place of attachment thereon.

**Obituary.**—We regret to record the decease of Hermann Gustav Erichsen, which took place in London on the 6th inst. He was born at Copenhagen on October 6, 1828, his father being a well-known Danish merchant. After having received a thorough commercial education at Copenhagen, which was completed by visits to several of the more important places on the Continent, he came to Newcastle-on-Tyne in 1848. Some few years after he established the firm of Hunter and Erichsen, which in a very short time he worked up to a position of good standing. Towards the end of the sixties Mr. Erichsen came into connection with the leading telegraph men in England, and took a large share in the formation of the Great Northern Telegraph Company, whose representative in England he remained up to the time of his death. He also participated to a great extent in the formation of other undertakings, especially in Denmark, and always took a great interest in everything relating to his native country. He was decorated by the Danish Government with the Order of Knight of Danebrog, as well as with the silver cross of the same Order, and held besides other foreign Orders. He was Chairman of the China and Japan Telephone Company, as well as a Director of the Tramways Union Company, the Central Borneo Company, and the Telephone Company of Ireland. The funeral service took place on the 10th inst., at the Tooting Graveney Parish Church, and was attended by the family, the Danish Consul, Mr. F. C. C. Nielsen, and nearly all the staff of the London office of the Great Northern Telegraph Company, Mr. W. R. Lyne, representing the Eastern Extension Telegraph Company, and some 50 other gentlemen.

Digitized by Google

## MAGNETISM IN IRON AND OTHER METALS.*—XXXVII.

BY PROF. J. A. EWING, F.R.S.

(*Continued from page 100.*)

§ 134. **Experiments showing Residual Effects of Stress.**—In the following case an iron wire† (previously hardened by permanent strain) was loaded with a weight of 18·5 kilos., or 42·5 kilos. per sq. mm. This weight was repeatedly applied and removed, then finally removed; the wire was demagnetised by reversals, and the magnetising process was then gone through, giving the magnetometer readings stated in column I. of Table XXIII. Then the wire was demagnetised: the weight of 18·5 kilos. was applied and removed, and then the process of magnetising was again gone through, giving the magnetometer readings in column II. Finally, the same thing was repeated, but with this difference, that the wire was briskly tapped after the load had been removed before beginning to magnetise; the results of this are given in column III.

TABLE XXIII.—*Magnetisation of Iron under the influence of previous loads.*

| H | Magnetometer readings. | | |
|---|---|---|---|
| | I. After demagnetisation with no load. | II. After the cycle 0 – 18½ – 0. | III. After the cycle 0 – 18½ – 0 and then vibration. |
| 0 | 0 | 0 | 0 |
| 1·15 | 5 | 8 | 5 |
| 2·01 | 11 | 19 | 10 |
| 2·87 | 19 | 40 | 17 |
| 4·31 | 44 | 73 | 35 |
| 5·75 | 78·5 | 110 | 70 |
| 8·62 | 149 | 176 | 150 |
| 11·50 | 212·5 | 230 | 214 |
| 14·37 | 267 | 278 | 268 |
| 17·25 | 314·5 | 321 | 314 |
| 20·12 | 355 | 358·5 | 354 |
| 23·00 | 390 | 394 | 388 |
| 25·87 | 420 | 420 | 422 |
| 33·12 | 472 | 472 | 471 |

Comparing the three columns, it will be clear that in the first and third case the metal is in substantially the same condition as to susceptibility. In the third case its susceptibility with respect to low magnetic forces, and even to moderately great forces has been raised, as a consequence of the molecular change brought about through application and removal of the load. The same change had occurred in the other two cases, but it had been undone by the demagnetising force in one, by vibration in the other.

Experiments of this kind lead to the conclusion that when we apply and remove stress in iron, even when the magnetic state is perfectly neutral, we cause some kind of molecular displacement in the relation of which to this applied stress there is hysteresis. When any load is applied and removed the change of molecular configuration lags behind the changes of stress. We accordingly find, if we stop at any intermediate value of the load and examine the susceptibility, that the result is not the same when the stoppage is made during the process of loading, as when it is made, at the same amount of load, during the process of unloading. Magnetic susceptibility may, of course, be thought of as a physical property of the metal, apart from the existence of any actual magnetisation. During the loading and unloading of an unmagnetised piece the susceptibility changes in a manner that involves hysteresis, just as the magnetism changes when we load and unload a magnetised piece.

In Table XXIV. four magnetisations of the same iron wire are exhibited, each pulling under a load of 3 kilos.‡ In I., the load had been previously raised to 18½ kilos., then reduced to 3 kilos. In II., the load had been directly raised to 3 kilos., after demagnetising under no load. In III. and IV. these conditions were repeated, but the wire was subjected to vibration before the magnetising process began. It will be seen that between I. and II. there is a marked difference, especially in the early portion of the curve; but in III. and IV. this difference has disappeared, the effects of hysteresis being destroyed by vibration.

TABLE XXIV.—*Magnetisation of Iron under the influence of previous loads.*

| Galvanometer readings. (To reduce to H multiply by 0·0575.) | Magnetometer readings. | | | |
|---|---|---|---|---|
| | I. Demagnetised with no load. Then 0 – 18½ – 3. Load = 3 kilos. | II. Demagnetised with no load. Then 0 – 18½ – 0 – 3. Load = 3 kilos. | III. Demagnetised with no load. Loaded to 18½, unloaded to 3 kilos., and *tapped* before magnetising. Load = 3 kilos. | IV. Demagnetised with no load. Loaded to 3 kilos. and *tapped* before magnetising. Load = 3 kilos. |
| 0 | 0 | 0 | 0 | 0 |
| 25 | 22 | 13 | 11 | 10 |
| 50 | 70 | 14 | 36 | 34 |
| 75 | 139 | 109 | 103 | 100 |
| 100 | 198 | 176 | 174 | 168 |
| 125 | 242 | 226 | 227 | 219 |
| 150 | 276 | 265 | 268 | 259 |
| 200 | 328 | 323 | 328 | 320 |
| 250 | ... | 365 | 369 | 365 |
| 300 | 398 | 398 | 403 | 400 |
| 350 | 424 | 425 | 429 | 427 |
| 450 | 461 | 462 | 467 | 466 |
| 588 | 491 | 494 | 499 | 498 |
| 0 | 274 | 275 | 277 | 276 |

Again, Fig. 113 shows two pairs of curves, two (I. and II.) taken under no load, and two (III. and IV.) taken under a load

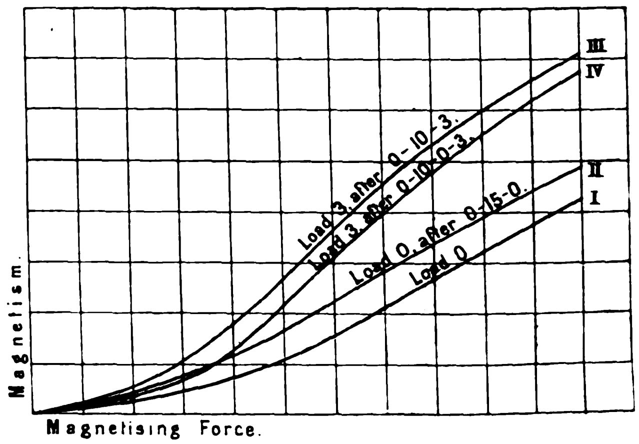



FIG. 113.—Residual Effects of Previous Loads.

of 3 kilos. In I., the wire was demagnetised immediately before the curve was taken. In II. it was demagnetised, then loaded with 15 kilos., and then completely unloaded. In III. it was loaded with 10 kilos., and unloaded down to 3 kilos. In IV. it was completely unloaded from 10 kilos., then reloaded up to 3 kilos. Very similar effects have been observed when annealed iron (not previously hardened by stretching) is tested under corresponding varieties of condition in regard to previous stress.*

The changes in molecular structure which, as these results show, are going on in iron or steel during the process of applying and removing stress sometimes result in producing a small amount of magnetism in a piece which, after being magnetised, has been brought into an apparently non-magnetic state by the application of a reversed force. There are, in such a case, superposed magnetisations which originally neutralise each other so far as external effect is concerned, but the balance is disturbed through the unequal action of the stress upon them.

* All rights are reserved.
† *Loc. cit.*, p. 614.
‡ One kilo. of load here corresponds to a stress of 2·3 kilos. per sq. mm.

* *Loc. cit.*, p. 618.

Digitized by Google

§ 135. **Other Evidences of Hysteresis in the Effects of Stress.**—These experiments show that the structure of iron changes, under variation of stress, in a manner that exhibits hysteresis, that is to say, the changes of structure lag behind the changes of stress. We may therefore anticipate that we shall find traces of hysteresis in other physical qualities besides magnetic susceptibility when we examine the variation of these qualities under variations of stress.

A remarkable instance is furnished by the thermo-electric quality of iron. Under variations of pull the thermo-electric quality of iron varies in a manner which strikingly resembles those variations of magnetic quality which have been described in this chapter. This is not a secondary effect, resulting from changes of magnetism, for it occurs even when care is taken to keep the iron wholly free from magnetisation during the experiment. Curves drawn to represent the relation of thermo electric quality to load show a very remarkable general resemblance to the curves of Figs. 108-110, which show the relation of magnetism to load. There are also interesting points of difference, but a discussion of these would be out of place here. The main point, which was discovered by E. Cohn*, and afterwards, independently, by the writer†, is that there is much hysteresis of thermo-electric quality with respect to stress—a result, no doubt, of the irreversible changes of molecular structure to which allusion has already been made. We shall see later, in connection with molecular theories of magnetism, how these irreversible changes probably occur.

Further, but slighter, evidence of the occurrence of irreversible molecular changes during the loading and unloading of an iron wire is found when we examine the amount of the extension in relation to the load. Though the amount of load be restricted so that it lies well within the so-called limit of elasticity, it is found that there is no exact proportionality of strain to stress; and when a cyclic process of loading is repeated often enough to make the elongation and retraction become also cyclic, it is found that, at any intermediate value of the load, the wire is longer during unloading than during loading. In other words, there is hysteresis in the relation of strain to stress. The amount of this hysteresis is small; but when means are taken to magnify the extension sufficiently it may be observed without difficulty. The amount of difference in length between the length at the mean load in loading and the length at the mean load in unloading, may be $\frac{1}{300}$ of the change of the whole extension. The effect in question has to be distinguished from quasi-plastic changes of length, which depend on the time-rate at which the loads are applied. It has been observed in wires of copper and brass, as well as iron and steel.‡ One obvious consequence of it is that any process of loading and unloading involves some dissipation of energy.

*(To be continued.)*

## DRUM ARMATURE WINDING.

BY F. M. WEYMOUTH.

*(Continued from page 137.)*

We may now proceed to the consideration of another type of drum-armature winding, which, especially as regards the end connections, differs entirely from any of the foregoing. This is the arrangement of Mr. Gisbert Kapp. Here the cross connections, instead of being laid as convolutes or discs, are arranged helically, in fact like the threads of a many threaded screw. In the case of copper plate connectors, a common carpenter's wood screw, with thin, flat, and deep threads, will convey perhaps the best approximate idea. Fig. 35 represents a part longitudinal section through an armature thus wound. The thickly placed vertical lines, O O, are sections through the series of helical connectors. These will be better understood, however, from the developed plan shown, Fig. 36. The inner ends of the connectors, it will be observed, are jointed to the short parallel bars, as at *a a*, while the outer ends are jointed to the long

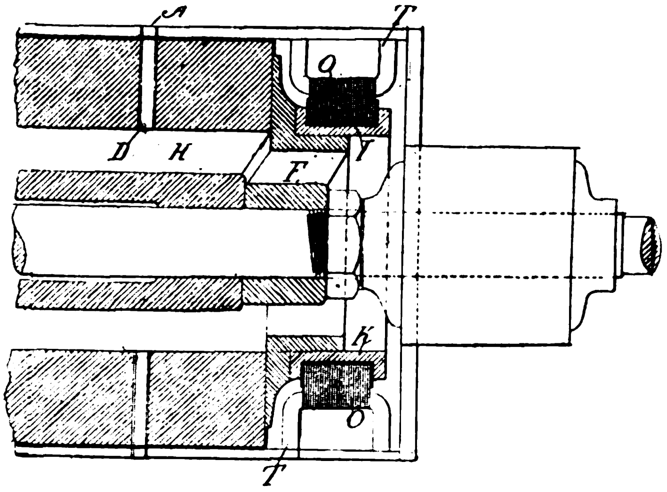



FIG. 35.—Kapp Winding. Longitudinal Section through Armature.

parallel bars at *b b*, the unions being effected by means of tags T T, Fig. 37, formed on the ends of the connectors for the purpose. A single helical connector is shown, Fig. 37. B B are the parallel conductors forming two sides of a coil,

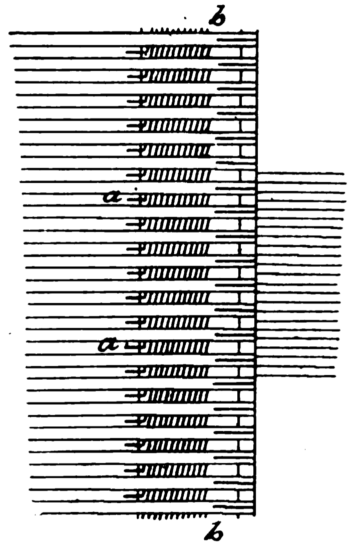



FIG. 36.—Kapp Winding. Plan of Helical End Connections.

T T the tags, and *s* the commutator lug. The dotted lines S S′ show a true segment of a circle, thus making clearer by comparison the helical or spiral form of the connector. Solid bar or wire connectors in the forms of insulated copper wire cable,

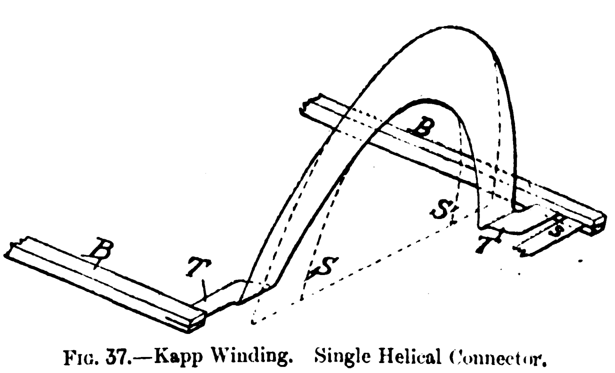



FIG. 37.—Kapp Winding. Single Helical Connector.

may also be used as shown in Fig. 38. A layer thus formed of bar or cable being of little radial thickness, other layers may be superimposed. As, however, the connectors in the outer layers must necessarily be longer than those in the inner layers,

* Cohn: Wied. *Annalen*, 1879, p. 385.

† *Proc. Roy. Soc.*, May 1881; see also a later and fuller paper in *Phil. Trans.*, 1886, p. 361 (Effect of Stress and Magnetisation on the Thermo-electric Quality of Iron), where curves are shown illustrating the hysteresis in thermo-electric quality referred to in the text.

‡ See a Paper "On Hysteresis in the Relation of Strain to Stress." Rep. Brit. Assoc., 1889, p. 502.

Digitized by Google

this latter method would appear not to have the symmetry of the helical plate arrangement.

Returning to the plate connectors, each helix, it will be observed, goes round approximately half a circle (for a two-pole machine). All the helices, insulated from each other, are laid together in an annular frame I (Fig. 35) of wood, or other insulating material, and are held there by taping or otherwise; this frame is in turn held in a metal sleeve K, which is mounted on a shoulder of the end-plate F. Thus this end-winding has the peculiarity of being quite self-contained, and so can be made up separately, and not put on the armature till complete in itself. It will be observed that as the helices are attached at their ends to *alternate* parallel bars, between which there can only be a minimum pressure, there will likewise be only a minimum pressure between adjacent helices. Only a slight amount of insulation is consequently needed between them.

An obvious advantage of this system over the convolute may be observed. If a large number of connectors are

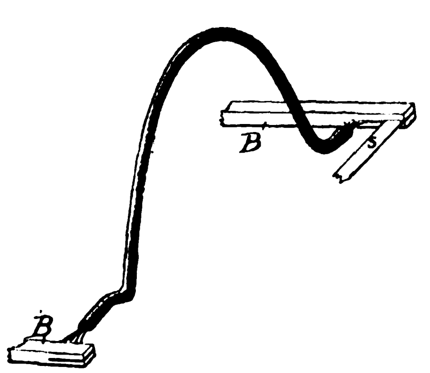



Fig. 38.—Kapp Winding. Single Helical Connector of Copper Wire Cable.

needed, it is not necessary to have two series, but merely to widen the one series in a direction parallel with the shaft. The "pitch" being thus increased, a greater number of any given thickness can be got in. As to ease of construction and replacement, it will be observed that all the joints are on the outside and accessible. In the core, at intervals, are placed metal discs with projecting horns A for driving the winding, and air spaces D at either side of these discs allow for ventilation. The core has a large central bore, admitting plenty of air, and is carried on a spider H as shown. It will be observed that, as with the Edison discs, these plate connectors require to

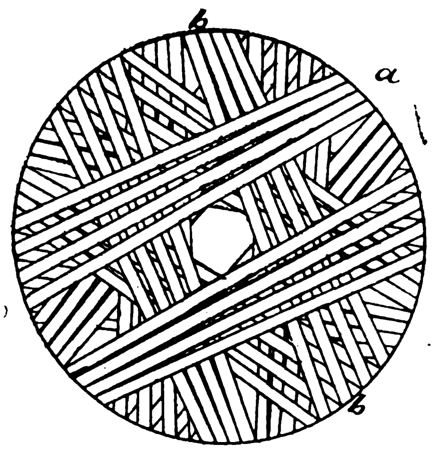



Fig. 39.—Swinburne's Chord Winding.

be stamped out of sheet: hence the same remarks as to waste of material and cost of labour, &c., will apply, the question remaining as to whether or not this is made up for by subsequent economy in labour of construction. This end-winding is very compact and symmetrical, with comparatively few joints, and these easily accessible, beside having the other advantages already mentioned, including free access for ventilation.

The next winding we come to is another of Mr. James Swinburne's. In this case the peculiarity exists that the coils, instead of being wound over diameters, are wound over chords of the circumference of the armature. An application of this principle to a wire-wound armature is shown in Fig. 39. It will here be seen that the end wrappings, lying in chords as at *a a* or *b b*, keep clear of the centre, and thus, especially when the chords subtend smaller angles at the centre than here represented, allow room for ventilation through the hollow of the core. For large low-pressure currents the method of coupling up across the ends is as shown, Figs. 40 to 43. Curved

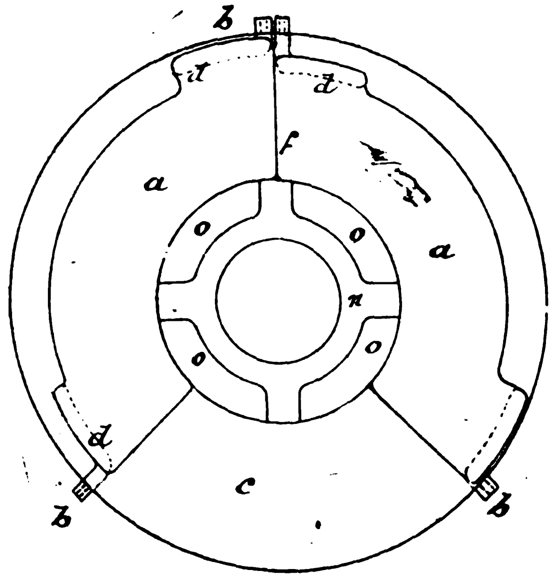



Fig. 40.—Swinburne's Chord Winding. End View of Armature, Two Connectors *in situ*.

stamped copper plates *a a* form the connectors. These are laid two in a plane normal to the axis of the armature, and with their edges butting as at *f* (Fig. 40). Connecting pieces *d d* are attached to the plates by means of which union with the bars *b b* is formed. The plates covering more than a third of a circle each, the space *c* may be kept clear for ventilation. Otherwise the plates may be laid slightly helically, and overlap one another. A spider *n* carries the core, passages *o o* being left for ventilation. Figs. 42 and 43 show separate views of one plate connector, with the addition of a tag *g* formed on the interior edge for interior union with the commutator, if such should be desired.

Foucault currents are dealt with by making each conductor bar of parallel strips or bars, and then connecting these up separately across the pulley end, as shown in Fig. 8 (*The Electrician*, November 21st, p. 72), it being borne in mind that

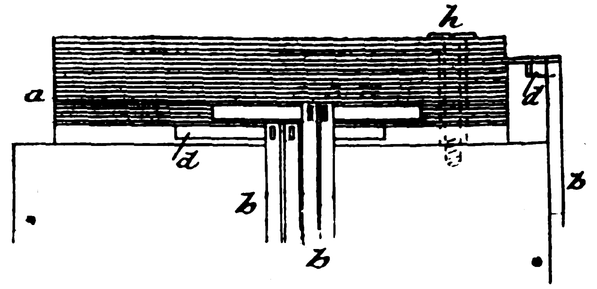



Fig. 41.—Swinburne's Chord Winding. Method of Connecting the Connector-plates to the End Plates of Armature Core by Insulating Screws *h*.

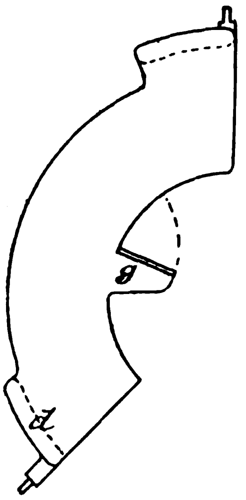
in the case before us these connectors will be taken across a chord and not a diameter.

It would appear that in this end winding, as with Edison's discs, the close proximity of connector plates of maximum and minimum volts is not avoided. It will be observed, further, that the sum of the areas enclosed by the coils is not so great as would be the case were the winding diametrical. The plates require to be stamped; while, on the other hand, the construction is simple, and all the joints are outside and accessible.

Digitized by Google

The connector plates are held in a mass to the end plates of the core by means of insulated screws, one of which is shown at *h*, Fig. 41. These screws of course also act as drivers, obviating the necessity of any special means for that purpose. Ventilation, as already intimated, is well provided for.

There are, however, some further points in connection with this winding which it may be of interest to consider. For the



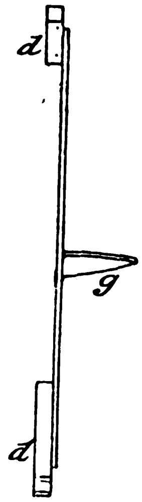




Fig. 42. Swinburne's Chord Winding. Fig. 43. Separate Views of a Connector.

better elucidation of these, a diagramatic representation of this system is appended in Fig. 44 A. The pulley end is here shown. The outer radial lines *y y* represent the commutator lugs at the further end extended on magnified diameters

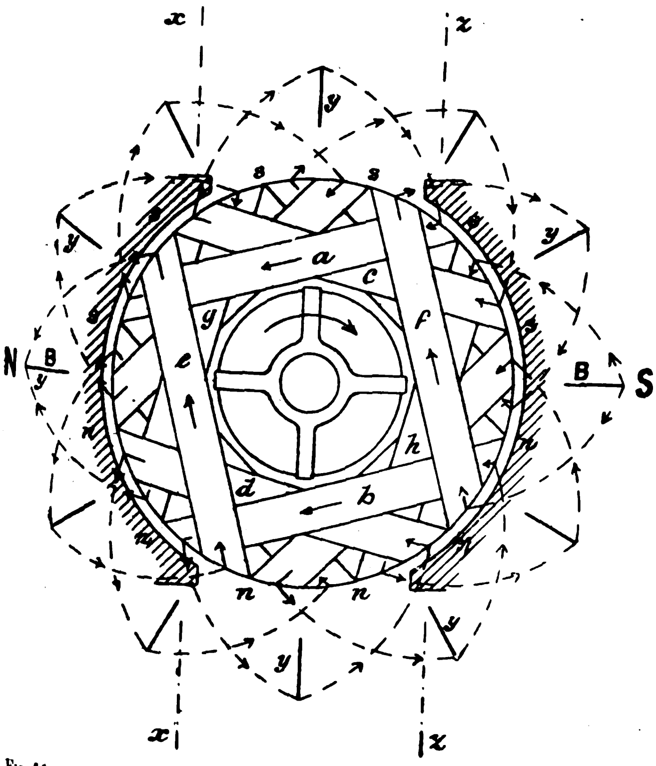



Fig. 44A.—Swinburne's Chord Winding. Diagrammatic Sketch of System.

to make them visible. The curved dotted lines indicate the connections thereto. The lugs lettered B B are those of the segments on which the brushes rest, the left-hand one being the positive brush of the machine and the right-hand the negative, while the union with the commutator is supposed to be from the middle of a connector. Inspection will make it clear that the current flow is as shown by the small arrows. The pole pieces are also indicated, **N** and **S**. The small letters *n* and *s* around outside the circumference of the armature show the polarity which each pair of parallel coils tend to produce. Thus the coils *a* and *b*, *c* and *d*, tend to produce between them a vertical polarity, each reinforcing the other, with a south pole above, and a north pole below. The pairs *e f* and *g h* tend to produce each an approximately horizontal polarity parallel with the field, but contrary to each other. These latter thus neutralise each other, with the result that the vertical polarity alone remains. In relation to the armature itself, this may be called its *primary* polarity. In relation to the field this is

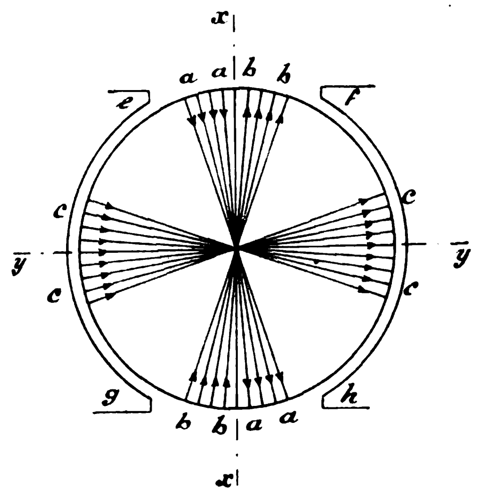



Fig. 44B.—Ordinary Diametrical Drum-winding. Diagram of Current Flow.

known as cross-magnetisation, or cross-induction, as it is at right angles to the field. Now it will be observed that on the upper and lower sides of the armature, as sketched in Fig. 44 A, the current is running in opposite directions in adjacent parallel conductors, while at the sides next the pole-pieces the current runs the same way in all on one side. It is claimed in Mr. Swinburne's patent, that by virtue of this arrangement of current direction, the cross-magnetisation is reduced.

In ordinary diametrical drum-winding, of the coils approximately parallel to the plane of commutation on either side of it, those on the one side neutralise the polarising effect of those on the other side. Thus in Fig. 44 B, where *x x* is the plane of commutation, the coils *a a* neutralise the effect of the coils

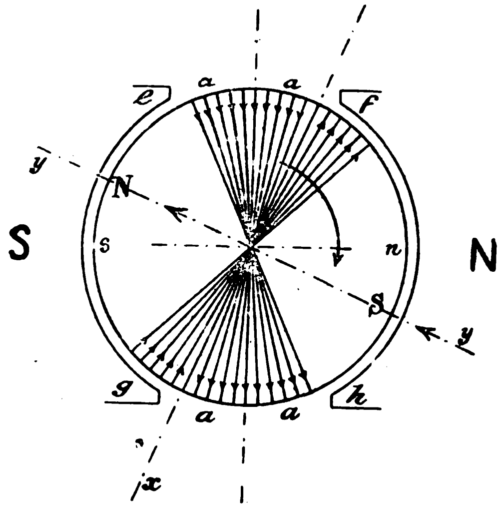



Fig. 44c.—Same as Fig. 44B. Brushes Shifted.

*b b*, in which the current is running in an opposite direction, as shown by small arrow-heads. On the other hand, the polarising effect of the horizontal coils *c c* is unopposed, and produces the vertical primary polarity of the armature coincident with the plane of commutation *x x*, which in relation to the field, as we have already mentioned, is known as cross-magnetisation.

Let us now suppose the brushes to require a lead. The plane of commutation becomes tilted as shown *x x* Fig. 44 c. Now note the effect. The coils *a a a a* are brought normal to

Digitized by Google

the field. Hence these will produce a polarity *parallel* to the field. In generating dynamos a north pole in the armature becomes opposed to the north pole-piece, and a south to the south, as indicated by small letters *n* and *s*, in direct opposition to the field. We thus find this polarity parallel with the field, termed, in the case of generators, the "back induction"; and its effect is to weaken the field. In the case of motors, wherein we may imagine the **N** and **S** pole-pieces to exchange places, the reverse holds good, and this parallel induction reinforces the field. Thus the further phenomenon arises, in the case of motors, that with an armature revolving between *non-magnetised* pole-pieces, and having a tilted plane of commutation, the south pole of this parallel induction will *induce* a north pole in the pole-piece opposed to it, and a south pole will similarly be *induced* in the other pole-piece. Thus, with induced pole-pieces only, a motor can be run in a primarily non-magnetised field, though it may not pay to do so in practice. It will thus be observed, that while a tilted plane of commutation is not on this account detrimental to a motor, but rather the contrary, it is detrimental in the case of a generating dynamo. Hence, to avoid this evil in the latter case, with its attendant consequences, the field is made so strong as to draw the primary cross polarity of the armature as nearly as possible parallel to itself. The ultimate effect is in any case a compromise between the armature polarity and the field; and in proportion as the disparity is lessened, so great is the "distortion of the field." Thus, in Fig. 44 c, the lines of force of the field, instead of running straight across through the armature from **N** to **S**, will pass through along *y y* as a centre line of their course, the angle between *y y* and the horizontal being the measure of their distortion. The peculiarity will thus be noted that the primary polarity of the armature, or cross-magnetisation, is just exactly drawn down into the line *y y*, along which there is *no* primary polarity, as already pointed out, owing to the neutralisation of the coils *a a* and *b b*. The cross-induction thus diverted does not oppose the field. Assuming the plane of commutation to have been originally vertical, but the field becoming distorted by the armature, the brushes will require to be moved over till the plane of commutation is brought perpendicular to the new direction of the field, guidance as to when the correct position has been found being obtained by the absence of sparking at the commutator.

It may be further observed, referring to Fig. 44 B and C, that the whole of the armature above the line *y y* being north, and below, south, the horns *g* and *f* are opposed, and *e* and *h* reinforced, by the armature primary polarity. It thus comes about, that whether the plane of commutation be tilted or not, the lines of force gather thick at the horns *e* and *h*, which are the "trailing" horns, while at the other horns they become comparatively sparse. The Roman letters N and S indicate the ultimate polarity of the armature. In the case of a distorted field, Fig. 44 C, the main body of the lines of force running from the lower half of the **N** pole-piece and through the upper half of the **S** pole-piece, and these two halves thereby carrying the most lines of force, this further increases the accumulation at the horns *e* and *h*. The lines being drawn away from the horns *g* and *f*, these may become magnetised the wrong way if care be not taken.

Returning now to Mr. Swinburne's chord winding, and the claim for reduction of cross-magnetisation referred to, we find it difficult to see how this is made good. Referring to Fig. 44 A, we have found the cross-magnetisation to be due to the coils *a b c d*. The mixed bars above and below have but little effect in this direction, owing to the obliquity of the coils to which they belong. The whole of the upper half of the armature is of one pole, without primary opposition, and the lower half the other pole. The coils being on chords instead of diameters, it may be convenient to speak of two planes of commutation here, as represented by *x x* and *z z*. While these planes are vertical back induction cannot arise, as pointed out. But neither does it in diametrical winding. If the planes are tilted by a lead given the brushes, then back induction immediately sets up, as, for instance, the coils *e* and *f* becoming vertical will exercise influence opposing the field. In fact, with a lead to the brushes, a preponderance of the north primary polarity of the armature will be thrown against the north pole-piece, and of the south against the south pole-piece, and all the attendant consequences will follow as in the case of the diametrical winding. Hence it is not clear how this claim is substantiated; and this failing, it follows that this chord system of winding will not compare favourably with the diametrical winding, owing to the much smaller total area enclosed by the coils; unless, indeed, there be occult reasons in its favour, which have eluded investigation.

*(To be continued.)*

## THE CAPACITY OF SUBMARINE CABLES.

BY HAROLD W. ANSELL AND JULIAN E. YOUNG.

In *The Electrician* of September 5th Dr. Muirhead published a correction for the error in the determination of electrostatic capacities, arising from unequal rates of absorption in different dielectrics. The necessity of this correction, when the time of charge exceeds a few seconds, has long been apparent; and, as the figures in the paper alluded to show, it appears to achieve its object satisfactorily. Unfortunately, there are other sources of error in such measurements which have scarcely received the attention they demand. In the case of a cable, the leakage and retardation of the charge must be taken into account, as well as the rate of absorption, before the true capacity can be arrived at.

The following table is given with a view to showing the magnitude of the error introduced by moderate leakage *alone*, the condensers compared having similar dielectrics, and therefore absorbing at the same rate. The correction applied to the result obtained by balancing the potentials of the charges according to the usual method is as follows:—

$$\text{true capacity} = \frac{\text{apparent capacity}}{k},$$

$$\text{where} \quad \log k = \frac{t}{2{\cdot}3026\,F\,R},$$

$t$ being the time of charge in seconds, F the approximate capacity to be measured in microfarads, R the resistance of the leak in megohms. This expression, based on the laws of fall of charge, has been found sufficiently correct for practical purposes, taking R, in the case of a cable, as the dielectric resistance at the fifth minute.

| Time of charge. | Leak.' | Standard condenser. | Slide reading. | Log K. | Apparent capacity. | Corrected capacity. | True capacity. |
|---|---|---|---|---|---|---|---|
| Seconds. | Megohms. | Mfs. | | | Mfs. | Mfs. | Mfs. |
| 2 | 1 | 19·2994 | 8074 | 0·011136 | 80·904 | 78·856 | 77·987 |
| 5 | 1 | " | 8127 | 0·027839 | 83 741 | 78·541 | " |
| 15 | 1 | " | 8312 | 0·083518 | 95·033 | 78·407 | " |
| 5 | 3 121 | " | 8060 | 0·008920 | 80·182 | 78·552 | " |
| 15 | 3·121 | " | 8120 | 0·026760 | 83·357 | 78 376 | " |
| 5 | 0·500 | 19·860 | 6120 | 0·217140 | 31·325 | 19 000 | 19·500 |

If the time of charge does not exceed two or three seconds, the correction for unequal rates of absorption (as Dr. Muirhead's tables prove) is so small that it may be neglected. It is questionable whether the time need ever be made to exceed three seconds, since this is all that would be required to overcome the retardation of long cables, that is, to establish a practically uniform potential throughout the entire length of the conductor. This having been done, the cable may be regarded as charged, assuming the capacity as being that for receiving electricity from the first contact, and as distinct from "electrification." On page 331 of Jenkin's "Electricity and Magnetism," fifth edition, a formula is given by which the time for any length of cable can be calculated.

Some uncertainty generally exists as to the real capacity of cables, more especially of long ones. Discrepancies are often met with between the values specified by manufacturers, those obtained immediately after submersion, and those observed at subsequent times. Since the localisation of faults not unfrequently depends on these last, the desirability of a more

Digitized by Google

rigorous definition of capacity is evident. The following suggestions present themselves:—(1) That the true capacity of a cable should always be taken as the value of the instantaneous charge of one knot of its core, multiplied by the length of the line. (2) That, after submersion, the apparent value of the capacity should be taken to a fixed standard of time and method of observation, and corrected for the observed leakage by the formula given above, to reduce it to the value assigned by the foregoing definition.

With reference to the example given in the number of *The Electrician* already referred to, viz., the Porthcurno-Gibraltar cable, assuming that line to have a dielectric resistance of about five megohms at the fifth minute, which we understand is not far from the truth, the true capacity of that section would be about four microfarads less than 458·17. This value, which is quoted as standard, was presumably the sum of sections of considerable length, each involving leakage (not deduced from the knot-charge), and consequently too high. Both the standard and the corrected results cited would thus tend to coincide, although neither would represent *true* capacity.

## NOTE ON THE PROBABLE EXPLANATION OF A PECULIAR CLASS OF FAULTS OCCURRING IN SUBMARINE CABLES.

BY J. PARRY LAWS.

Some time ago I had my attention directed first by Mr. Saunders, of the Eastern Telegraph Company, and subsequently by Mr. Herbert Taylor, of Messrs. Clarke, Forde, and Taylor, to a particular class of faults occurring in submarine cables. The distribution of these faults is decidedly limited, occurring, as they do, only in water having a moderately high mean temperature, and in positions where it is not very deep. When the core is examined, it presents, strictly speaking, an appearance of simple decay, the gutta percha having undergone some chemical change, which renders it extremely brittle, and causes it to shrink in volume. I say chemical change advisedly, as there are no signs whatever of mechanical erosion; indeed, many of these faults are taken, I am informed, from parts of the cable where the outer covering of wire remained intact; the hemp, however, at the particular spot was entirely destroyed. These faults have therefore caused considerable speculation as to their origin, and the explanation I am about to suggest seems to me, on due consideration, to be at least feasible.

Taking into consideration the high temperature of the water, and the very limited position of these faults, I have come to the conclusion that they may probably be produced by the action of putrefying organic material either in actual contact with the cable or in close proximity to it. Guided by this hypothesis, I made some experiments on a laboratory scale to determine whether organisms, such as occur in putrefying fluids, or the products of their life, would have any effect on the core of submarine cables. The few experiments I have made show conclusively that putrefaction does exert a very marked effect upon gutta percha, some classes of putrefaction producing more effect than others. The few experiments I have been able to carry out are certainly confirmatory of the above suggestion, the gutta percha being considerably eroded and pitted after remaining in a putrid fluid for some time.

I hope to make experiments in greater detail, and publish the above as a mere suggestion, in the hope that others may collect facts tending to establish or disprove it.

## ON THE ILLUMINATION OF A HORIZONTAL PLANE.*

BY F. LOPPÉ.

The writer considers the problem of lighting a horizontal plane by means of a number of similar lights arranged so that the illumination at no place on the ground shall be less than a given quantity, E, and so that the energy expended in producing the light shall be as small as possible.

Two special cases are treated. In the first a large area is supposed to be illuminated by means of many lamps placed in rows, so that the poles stand at the corners of squares of equal size. In the second a street is supposed to be illuminated by means of lamps placed alternately on each side of the road, in the manner usual in practice.

It is assumed for simplicity that the energy required for producing the light is proportional to the amount of light produced. The problem may, therefore, be stated in the following way:—Given a certain amount of light, which, with certain limitations, may be distributed in any manner, how shall this light be apportioned so that the minimum illumination of the surface may be as great as possible?

The author first considers the illumination of a square (side $2a$), lighted by four lamps (height $h$) placed at the corners. It is shown that the light at the centre of the square is

a minimum if $h < a\sqrt{3}$

and a maximum if $h > a\sqrt{3}$

As in practice the first condition always holds, since lamps are placed farther apart from each other than from the ground, the illumination at the centre of the square is a minimum; and in the problem of lighting an area in the manner stated above, the quantity E refers to the centres of the squares.

In working out the condition that the total light used to produce the minimum illumination E may be as small as possible, it is shown that $L/4a^2$ must be a minimum where L is the candle-power of each lamp, and where the relation expressed by the following equation:—

$$2a^2 = \left(\frac{4h}{E}\right)^{\frac{2}{3}} L^{\frac{2}{3}} - h^2$$

connects the three unknown quantities, $a$, $h$, and L, with the quantity E, which is supposed given. If we assume one of the former three quantities known, we can find the best relation between the other two. By assuming L, or the candle-power of the lamps used, to be known, the best value for $h$ is shown to be

$$h = 0{\cdot}87\sqrt{\frac{L}{E}}$$

where E is measured in terms of the illumination produced by a candle placed at unit distance from the surface lighted.

If, on the contrary, $h$ is assumed known, the best value for L is given by the equation

$$L = 1{\cdot}30\, E h^2.$$

The second case, that referring to street lighting, is then considered, and it is shown that if L is fixed, the best value of $h$ is

$$h = 0{\cdot}62\sqrt{\frac{L}{E}}$$

while if $h$ is known, the best value for L is

$$L = 0{\cdot}92\, E h^2.$$

* Abstract from *L'Electricien*, October 18, 1890.

## THE BUDAPEST ELECTRIC TRAMWAY SYSTEM.

From a pamphlet just issued by Messrs. Siemens and Halske, we gather the following particulars of their electric tramway on the open conduit system now in operation at Budapest.

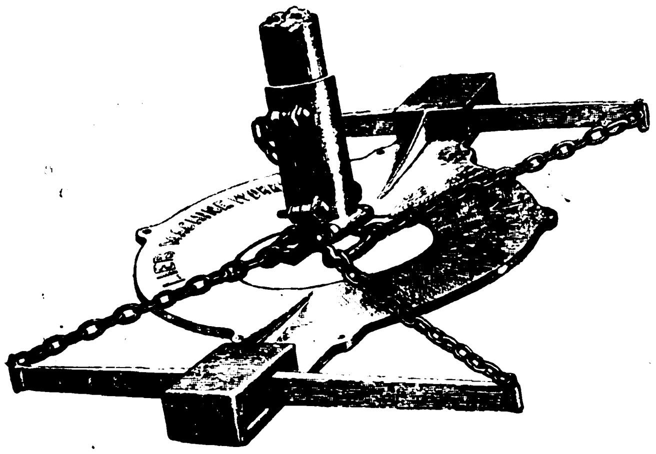
The channel has a uniform breadth of 11·2in. The slot giving access to the conductors is placed in the groove of one of the running rails, so that there is no more metal exposed in the roadway than is the case with horse tramway lines. At intervals of 4ft. along the channel, iron chairs 7·2in. broad serve to support the running rail, and also to carry insulators, to which the conductors are attached. The bottom of the channel, which is formed of concrete, is at a depth of 22·8in. below the surface of the roadway, and the slot between the rails which form its roof is 1·3in. wide. The conductors, of which there are two (positive and negative), consist of angle iron, and are placed at the sides of the channel so as to be out of sight and out of reach. The cars carry a single motor, geared to one of the axles, and four groups of resistance frames for regulating the speed. The current is supplied at a pressure of 300 volts.

Three lines with an aggregate mileage of five and a-half miles are at present in operation on the above system. A fourth line is at present building, but on this an overhead conductor is to be used. At the central station there are at present three 100 horse-power compound engines, each driving a dynamo by means of rope belts. A speed of 9½ miles per hour is allowed, and at certain parts this may be increased to over 11, whilst at others it has to be reduced to 6 and to 3¾. The day's work ranges from 75 to 95 miles per day per car.

Digitized by Google

## THE LIEB TROLLEY BASE.

Since the electric railroad has come into general use (says the *Electrical World*) the ingenuity of inventors has been taxed to produce a trolley base having the combination of qualities most desirable for railway service. Flexibility in all directions without readjustment, combined with springs powerful enough to give the proper contact against the trolley wire, is, however, a hard condition to fulfil. A recent effort in this direction is that illustrated herewith. It is due to the ingenuity of Mr. Charles Lieb, of New York. The figure shows the general arrangement of springs. As will be seen, the spiral spring which has been almost universal in trolley work has been abandoned, and its place has been taken by two flat steel springs like carriage springs. These are supported on a single casting, which is bolted to the roof of the car. The socket for the trolley pole is provided at its lower end with a pair of wide links hinged upon each other; to each of these are attached two chains, one running to either spring. As a result, the socket is supported by four tense chains, and movement in any direction whatever tends to shorten these, and, consequently, gives the necessary upward pressure against the trolley arm. A special peculiarity of this form of spring is that when the pole is depressed below a certain point, the position of the links is such that it can be swung down parallel to the car roof with but little additional pressure, the maximum upward thrust being somewhere midway in the arc through which the pole can swing. This is a great convenience in passing under low bridges, and in laying up the car for the night, for this can be readily done without unshipping the pole.



Lieb Trolley Base.

The whole arrangement is singularly simple and strong, and possesses great flexibility in adapting itself to the various positions that must be taken by a trolley pole from time to time. It is usually fitted by Mr. Lieb with a wooden trolley pole supporting an aluminium trolley.

## THE PHYSICAL SOCIETY.

At the meeting of the Physical Society on Friday, November 28th, Prof. S. P. Thompson communicated a note, entitled,

### "An Illustration of Ewing's Theory of Induced Magnetism."

The author stated that he had never seen Prof. Ewing's model, illustrating the properties of a magnetic substance, and while casting about for the best means of building up such a model capable of being used for lantern demonstrations, he had found that small compass needles, already mounted in cases with glass at top and bottom, could be obtained at a very cheap rate in Clerkenwell. The model which he then exhibited to the Society simply consisted of a large number of these small compass needles, placed as close together as possible on a horizontal glass plate, through which the beam of light from a lantern was thrown. The only inconvenience attending the use of these ready-made compass needles was that owing to their shortness in comparison with the size of the cases in which they were mounted, their mutual influence was not strong enough to overcome the earth's magnetic field, which had, therefore, to be partly neutralised by means of a permanent magnet. This inconvenience, however, was more than counterbalanced by the facility with which the little needles could be arranged in various groupings, owing to their not all being attached to the same base.

The author proceeded to adjust the position of the permanent magnet until the needles showed no average set in any one direction. A magnetising coil with its axis east and west was then brought close to the model and excited by a gradually increasing current, when it was seen that successive groups of needles became unstable and assumed a definite set. The greater the distances between the needles, the more necessary it became to neutralise the earth's magnetic field; and the author thought that this might throw some light on the following phenomenon observed by him.

Magnetite or loadstone is found in two distinct forms, one consisting of a homogeneous mass of octohedral crystals, and the other being formed of heterogeneous crystalline masses. He had found that good natural magnets were always of the second kind, the regular form having little or no magnetic retentiveness. It would seem that in the former case the effective groups of particles were too far apart for their mutual forces to overcome even the weak magnetic field due to the earth.

#### DISCUSSION.

Mr. C. V. BOYS stated that a few weeks since, Prof. Rücker, who *had* seen Prof. Ewing's model, had devised an apparatus very similar to that just exhibited to the Society for the purpose of lantern demonstration; and Prof. Rücker, being unavoidably absent, had requested him to bring it before the Society. Prof. Rücker had not been aware that the small needles could be obtained already mounted, and they had therefore been prepared by cutting off a number of pieces of fine watch-spring, of equal lengths, and bending them by means of a tool into the form of the letter U. Small pieces of capillary glass tube, closed and rounded at one end, were fixed between the limbs of each of the magnets, which were then suspended upon a number of needle-points fixed with the points upwards into small leaden discs, which were cemented at a uniform distance apart, upon a circular glass plate, mounted in a wooden ring. The requisite magnetic field was produced by winding a few turns of wire across the ring in grooves cut for the purpose. This model showed very clearly that no instability is produced until the current reaches a certain strength, and that when the strength was reduced with sufficient slowness, the system remained magnetic.

Mr. SWINBURNE observed that Ewing's theory would lead to the conclusion that the magnetic susceptibility must be negative when the temperature of demagnetisation was attained, and he had written to Prof. Ewing on the point, and understood from him that he *had* observed some indications, that this might be the case. He did not see how Ewing's theory explained the great loss of energy in a rotating mass of iron such as the armature of a dynamo. He would like to see some experiments carried out to try whether any state of unstable equilibrium could be found in such a rotating mass.

Prof. AYRTON stated that some years ago he had heard from Prof. Lodge that he was trying to detect the existence of negative susceptibility. The sudden drop in the characteristic curve of a dynamo might possibly be due to this, if it existed.

Mr. H. TOMLINSON observed that it was easier to experiment in this direction with nickel than with iron, owing to its losing its magnetism at about 300°C. instead of at about 700°C. as in the case of iron. He stated that he had looked for negative susceptibility in nickel with exceedingly delicate apparatus; but though his experiments extended over a range of from 300°C. up to over 500°C., he had been unable to discover any trace of negative susceptibility.

Mr. T. H. BLAKESLEY also read a Paper on

### "The Solution of a Geometrical Problem in Magnetism."

The author proposed the following problem:—Given the two poles of a magnet, and a straight line intersecting at right angles its axis, produced at a given point, to determine at what point this line is parallel to the field. He pointed out that the solution was of some theoretical interest, because if the points were experimentally known, the distance between the virtual poles of the magnet could be determined; moreover, the question was of practical importance from its bearing upon the question of the deviation of a compass needle in certain cases.

Let A B (Fig. 1) be a long, uniformly magnetised rod, having poles at A and B. Say A is the north pole, and let O D be its equatorial plane. Then the field at P is always parallel to, and in the direction of, A B, which he calls the positive direction. Let the space C D be cut away, leaving a gap, having the same equator. Then a south pole will be formed at C, and a north pole at D; and these will produce at P a negative field parallel to D C. The resultant field will be negative or positive, according as P is near to O, or remote from it. There must, therefore, be a point at which the field will vanish, and at which, therefore, two rods, A C and D B, would produce no compass deviation, whatever the bearing of the ship carrying the system. Such a pair of permanent magnets would produce what is known as semi-circular deviation of a compass needle situated at any distance from O except the critical one, that is to say, through one semicircle the deviation would be easterly, and through the other westerly, but these would be inverted by passage through the critical point. If, however, the rods A C and D C were of soft iron, so as to be liable to magnetisation by the action of H, the horizontal component of the earth's magnetism, the general effect would be that the direction of the deviation would change sign after every quadrant, the devia-

Digitized by Google

tion being the same in opposite quadrants, the sign for any pair of opposite quadrants depending on the position of the compass relative to the critical position. The critical point is clearly one for which the field due to either magnet A C or D B alone would be entirely along O P. That is, at right angles to the axis of the magnet.

Let M and N (Fig. 2) be the positions of the poles of a magnet, and P, a point at a distance $d$ from O, O being in the axis of the magnet produced, and P O being at right angles to O M N. Let O M$=m$, and O N$=n$, and let $p$ be the numerical value of each of the poles M and N. Then the condition that the component

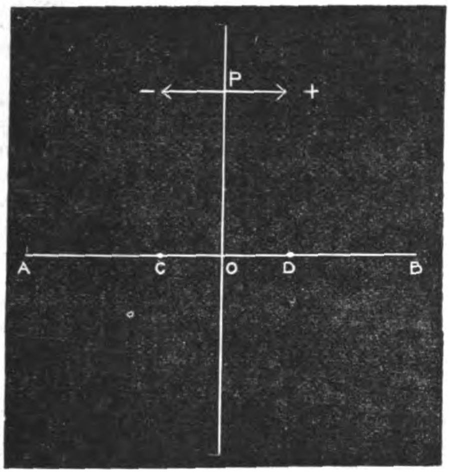



Fig. 1.

parallel to the magnet of the field produced at P by $p$ at M shall be equal and opposite to the same thing produced by $p$ at N is

$$\frac{m}{(d^2+m^2)^{\frac{3}{2}}} = \frac{n}{(d^2+n^2)^{\frac{3}{2}}} \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

from which $d$ can be determined.

This equation can be transformed into

$$\frac{d^3}{2mn} - \frac{3}{4} \cdot \frac{d^2}{2mn} - \frac{1}{4} \cdot \frac{m^2+n^2}{2mn} = 0 \quad . \quad . \quad . \quad . \quad (2)$$

The solution of this equation is facilitated by comparing it with the formula in hyperbolic trigonometry.

$$\cosh^3\theta - \frac{3}{4}\cosh\theta - \frac{1}{4}\cosh 3\theta = 0 \quad . \quad . \quad . \quad . \quad (3)$$

for if we make $$\frac{m^2+n^2}{2mn} = \cosh 3\theta \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

we have $$\frac{d^2}{2mn} = \cosh\theta \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

So that $d$ can easily be found from the author's "Tables of Hyperbolic Sines and Cosines," recently published by the society.

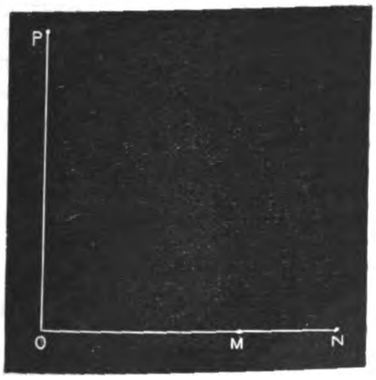



Fig. 2.

By applying the proposition inversely, the virtual distance between the poles may be determined.

To produce this state of things practically arrange a small magnetometer needle in the meridian, and find the direction of the axis of the needle by the condition that a long magnet laid in that line will not affect the position of the magnetometer needle. Then place that magnet or another one at right angles to this position, and move it in the direction of its length until the needle of the magnetometer returns to its former position. Then $d$ is known, and also $m+n$, because the distance of the middle point of the magnet perpendicularly from the axis of the magnetometer needle is $l=\frac{m+n}{2}$. The whole distance $m-n=2a$ may be obtained from equations 4 and 5, for

$$\frac{m-n}{m+n} = \frac{2a}{2l} = \frac{a}{l} = \tan h\,\frac{3\theta}{2},$$

where $$\frac{l}{d} = \sqrt{\frac{\cosh 3\theta+1}{4\cosh\theta}},$$

a function which can easily be determined by the aid of the tables.

Experiments of this kind showed that the virtual distance between the poles rapidly approached the full length of the magnet as the latter increased. The expression for the strength of the field under the circumstances is

$$\frac{4\,\text{M}}{d^3}\;\frac{\cosh^2\theta}{(4\cosh^2\theta-1)^{\frac{3}{2}}}$$

Where M is the moment $p\,(n-m)$.

This expression may be simplified by choosing $d$, so that $\cosh^2\theta = \frac{5}{4}$. Then the strength of the field is $\frac{5\,\text{M}}{8\,d^3}$; but

$$\cosh\theta = \frac{\sqrt{5}}{2}\;;\;\cosh 3\theta = \sqrt{5}.$$

$$\therefore \frac{l}{d} = \sqrt{\frac{\cosh 3\theta+1}{4\cosh\theta}} = \left(\frac{\sqrt{5}+1}{2\sqrt{5}}\right)^{\frac{1}{2}}$$
$$= \cdot 850651.$$

DISCUSSION.

Prof. PERRY did not like going back to the idea of magnetic poles in the case of actual magnets. He suggested that the problem proposed by Mr. Blakesley might easily be found by the aid of large scale diagrams of the magnetic lines of force, such as are given in Maxwell. It would only be necessary to draw through the point on the axis of the magnet produced a straight line at right angles to this axis, and to determine the point at which it touched a line of force.

In reply to this the author pointed out that it would be extremely difficult to determine the touching point with any exactness.

Prof. S. P. THOMPSON did not think there was any such thing as a definite distance between the virtual poles of a magnet, but that this distance depended upon the special circumstances of the experiment. He had been led to this result by some experiments in which he had observed the deflection of a magnetometer needle by two different sets of magnets. The result of the two sets of determinations gave different values for the distance between the virtual poles of the magnetometer needle.

Prof. AYRTON thought that the expression "pole of a magnet" was only definite when the special circumstances of the experiment were exactly defined.

Prof. S. P. THOMPSON considered that the magnetic pole must be definite in position, provided the magnet were not acted upon by any external magnetic force, because in that case the surface distribution of magnetism was definite. The distribution, however, would not be centrobaric except in the case of a long thin magnet.

Mr. BAILEY thought that the real way of looking at the question was that in the neighbourhood of one point the lines of force approximated to those which would result from a pair of poles fixed at a certain pair of points, while the field in the neighbourhood of some other point would approximate to that due to a differently situated pair of poles.

## MEETINGS OF SCIENTIFIC SOCIETIES, &c.

**FRIDAY, December 12th.**

Physical Society.

*5 p.m.* Papers to be read: "Some Experiments with Selenium Cells," by Shelford Bidwell, F.R.S.; "Note on Electrolysis," by James Swinburne; and "Alternating Current Condensers," by James Swinburne.

**MONDAY, December 15th.**

Society of Arts.

*8 p.m.* Cantor Lecture I. 4. "Gaseous Illuminants," by Prof. Vivian B. Lewes.

**TUESDAY, December 16th.**

Institution of Civil Engineers.

*8. p.m.* Ordinary Meeting. Papers to be further discussed: "The Lansdowne Bridge over the Indus at Sukkur," The New Chittravati Bridge, Madras Railway."

**WEDNESDAY, December 17th.**

Royal Meteorological Society.

*7 p.m.* Papers to be read: "Note on a Lightning Stroke presenting some features of interest," by Robert H. Scott, F.R.S.; "Note on the effect of Lightning on a Dwelling House," by Arthur Brewin, F.R.M.S.

Society of Arts.

*8 p.m.* Ordinary Meeting. Paper to be read: "Impressionism in Photography," by George Davison.

**THURSDAY, December 18th.**

Chemical Society.

*8 p.m.* Paper to be read: "The Theory of Dissociation into Ions and its consequences," by G. S. N. Pickering.

Digitized by Google

# The Electrician.

**Published every Friday, Price Fourpence; Post Free, Fourpence Halfpenny.**
**Editorial, Publishing, and Printing Offices:**
**SALISBURY COURT, FLEET ST., LONDON, E.C.**
*Telephone No.* 2714. *Telegrams:* "ELECTRICIAN NEWSPAPER, LONDON."

*All Letters relating to Subscriptions, Advertisements and other business matters should be addressed to the Publisher,* "THE ELECTRICIAN," *Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to* "THE ELECTRICIAN" *Printing and Publishing Company, Limited, and be crossed* "*Coutts and Co.*" *All other letters to be addressed to the Editor.*

*All letters intended for insertion in* "THE ELECTRICIAN," *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

"THE ELECTRICIAN" *is published every Friday morning, in time for the morning mails. Subscribers should receive their copies by the first post on Friday morning.*

"THE ELECTRICIAN" *is on sale at the railway bookstalls throughout the Kingdom on Friday morning, and can be obtained of all Booksellers and Newsvendors; or direct from the Publishing Offices as above.*

*New Volumes of* "THE ELECTRICIAN" *commence in May and November.*

## SUBSCRIPTION RATES.

The rates for Subscriptions to "THE ELECTRICIAN" are as follows:—

| | 3 months. | 6 months. | 12 months. |
|---|---|---|---|
| | s. d. | s. d. | s. d. |
| For the United Kingdom | 5 0 | 10 0 | 19 6 |
| For Foreign Parts and Colonies:— | | | |
| Within Postal Union | 6 6 | 12 6 | 24 0 |
| Aden, Borneo, Ceylon, China, India, Japan, Java, Labuan, Mozambique, New Caledonia, Persia, Philippine Islands, Siam, Transvaal, and Zanzibar | 7 6 | 14 6 | 28 0 |

## TO ADVERTISERS.

"THE ELECTRICIAN" *offers exceptional advantages to Advertisers.* **It has by far the largest circulation of any English Electrical paper, and circulates all over the World.**

*Particulars relating to Advertisements will be promptly forwarded on application to the Offices as above.*

TRADE ADVERTISEMENTS *intended for the current issue must reach the Offices not later than First Post on Thursday morning. Renewals of expiring advertisement orders and alterations to standing advertisements should be in the Publisher's hands by Wednesday at latest. No alteration can be made in Wrapper advertisements after Wednesday evening.*

SMALL PREPAID ADVERTISEMENTS *(for Rates see page xvii.) are accepted up to 4 p.m. on Thursday.*

## TECHNICAL PRINTING.

"THE ELECTRICIAN" PRINTING AND PUBLISHING COMPANY (LIMITED) *inform Electricians, Electric Light Engineers, &c., that they make a specialty of Technical Printing, and have a large Staff thoroughly acquainted with Electro-Technology. They can, therefore, promise Accuracy and Despatch in the Printing of Electro-Technical Literature, &c.*

## "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. (Royal 8vo.)

*Early in each year is issued* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. *The* DIRECTORY *was established in 1883, and the 1890 Edition consisted of about 850 pages of printed matter. The names and addresses of all persons engaged in the Electrical Industries at home and abroad may be relied upon as accurate. Useful Tables and Electrical Formulæ, and information specially compiled for this work are given, together with popularly-written Biographical Notices of the leading Electricians, Electrical Engineers, &c., accompanied in many cases by Portraits.*

*Orders for the 1890 issue should be forwarded* AT ONCE *to the Publishing Offices, Salisbury-court, Fleet-street, London, E.C.*

*The 1891 Edition is now preparing, and New Names, &c., can now be received.*

## ELECTRICAL BOOKS AND PUBLICATIONS.

*All Books, Newspapers, and other publications, dealing with Electrical and kindred subjects, can be ordered direct of* "THE ELECTRICIAN" *Printing and Publishing Company, who are proprietors of the well-known* "ELECTRICIAN" *Series of Standard Electrical Works, and are agents for all the leading publishing houses at home and abroad.*

## CONTENTS OF THE CURRENT NUMBER.

NOTES ... 159
Magnetism in Iron and other Metals.—XXXVII. By Prof. J. A. Ewing, F.R.S. Illustrated. Continued ... 164
Drum Armature Winding. By F. M. Weymouth. Illustrated Continued ... 165
The Capacity of Submarine Cables. By Harold W. Ansell and Julian E. Young ... 168
Note on the Probable Explanation of a Peculiar Class of Faults occurring in Submarine Cables. By J. Parry Laws... 169
On the Illumination of a Horizontal Plane. By F. Loppé ... 169
The Budapest Electric Tramway System ... 169
The Lieb Trolley Base. Illus... 170
Physical Society—
An Illustration of Ewing's Theory of Induced Magnetism ... 170
The Solution of a Geometrical Problem in Magnetism ... 170
Meetings of Scientific Societies. 171
THE INSTITUTION OF ELECTRICAL ENGINEERS ... 172
The New Council of the Institution of Electrical Engineers .. 172
Reviews ... 174
Books Received ... 174
Charge and Discharge Curves of Secondary Cells. Illustrated 174
Notes on the Chemistry of Secondary Cells. By Prof. W. E. Ayrton and Messrs. C. G. Lamb, B.Sc., and E. W. Smith. *Discussion* ... 176
The Electro-Magnet. By Prof. Silvanus P. Thompson, D.Sc., B.A., M.I.E.E. Illus. Continued ... 177
American Notes ... 180
CORRESPONDENCE—
Forces between Currents—Oliver J. Lodge and Jas. Erskine-Murray ... 180
Mr. Richard Chamberlain and the Chelsea Electricity Supply Co.—J. I. Courtenay .. 181
The Tommassi Multitubular Accumulator—A. Shippey. 182
Legal Intelligence ... 182
Smithfield Club Show ... 183
COMPANIES' MEETINGS, &c.—
Montevidean and Brazilian Telegraph Company (Ltd.) 184
The Fowler-Waring Cables Company (Limited) ... 185
Electric Construction Corporation (Limited) ... 185
Reuter's Telegram Company (Limited) ... 188
The Gülcher (New) Electric Light and Power Company (Limited) ... 189
New Companies Registered ... 189
City Notes, &c. ... 189

## THE INSTITUTION OF ELECTRICAL ENGINEERS.

A special general meeting of the Institution of Electrical Engineers, to which members only were admitted, was held last night for the purpose of considering a resolution for the alteration of the tenth, twelfth, and twenty-second articles of association, with the intention of confirming it at a subsequent meeting. The meeting being announced for 7.45, a quarter of an hour before the general meeting, suggests that it was expected that there would be very little to say about the proposed changes. This expectation was, indeed, justified by the nature of the amendments which, considering their aim and intention, are of somewhat disappointing character. The connection between this Institution and the Institution of Civil Engineers is more intimate than appears at first sight. Not only are its ordinary meetings and its council meetings held in the home of the latter body, but a considerable portion of the audience is composed of members of the older society who, being entitled to attend the meetings of other societies, do not trouble to become members of the lesser institutions. In view of this relationship and of the immense prestige and importance of the Institution of Civil Engineers, which is due to its admirable management rather than to its mere seniority, it is not surprising that the junior societies should both recognise their shortcomings by comparing themselves with such a standard, and seek, as they grow, to introduce improvements suggested by it.

The first of these articles, according to the proposed amended form, provides that associates shall, except in the case of those transferred from the class of students, be persons of more than twenty-one years of age; the second permits a student (who may enter at an earlier age than that of eighteen, which was specified under the old rules) to be eligible for transfer from the class of students to the class of associates two years after his election, and, "if not so eligible for transfer at the

Digitized by Google

end of three years from the date of his election he shall, if he have then attained the age of twenty-one years, and otherwise on attaining that age cease to be a student of the Institution, or to be otherwise connected therewith." The profession of electrical engineering is very remarkable for the number of youths who profess to be, and indeed are, "electrical engineers." Any stranger attending the meetings is at once struck by the youthful character of the audience, and might reflect whether there can be any possible connection between a young science and the age of those who are occupied with it.

It has been stated, and with good reason, that an electrical engineer should first be a mechanical engineer, and should then take up electrical science. We cannot expect every young man who intends to be an electrical engineer to go through a three years' pupilage at a regular engineer works, and to devote his attention to the general construction of machinery, without spending much, if any, time on the study of electricity. Few can afford to lose so many years; but those that can will never regret the training. There are too many "electricians" and too few who can really be called electrical engineers; and the fact that the Institution which should do all in its power to encourage sound training, appears to assume that the stage of studentship should cease at so early a period is much to be regretted. Why should so young an electrical engineer consider himself a qualified member of his profession, which embraces both mechanical and electrical science, when the Institution of Civil Engineers orders that associate members shall be more than twenty-five years of age, and allows its students to continue in that stage until they attain the age of twenty-six years? The old Article 10, dated May, 1883, limited associates to persons of more than twenty-one years of age; the new rule does not permit men to become associates earlier than formerly, but it allows students to enter at an earlier age, in fact, no particular age is mentioned. On the other hand, it permits anyone who has begun to study electrical science or engineering at a later period in life to join the Institution. He could not do so as an associate, being without the necessary qualification, but he can be admitted as a student. If this will really benefit the Institution and its junior members, we should be among the first to welcome it.

The remaining amendments at present proposed appear to relate merely to entrance fees and minor points arising out of the alterations. The admission of students demands no severe conditions. They must be either serving a pupilage to an electrical or telegraph engineer, who need not (as with civil engineers) be a member of the Institution, or they may be merely "studying electrical science or telegraphy." Pupilage in electrical engineering is already in a very lax condition, and is in some cases neither creditable to the employer nor useful to the pupil. It is with anything but radical principles that we would hail with satisfaction some much more important reforms than this one of junior or student membership. The *members* should be individuals who are properly entitled to write the mystic letters M.I.E.E. after their name. Everyone who actually is, or who is in the process of becoming an "electrical engineer," should be allowed to participate in whatever benefits may accrue from reading the journal and listening to the debates. Members are, however, more substantially benefited, and extreme care should therefore be taken to keep this class not exclusive, but select. And we think that the time has come when something more should be asked of candidates for admission as associates than that they should be "connected with electrical or telegraphic science or engineering, either professionally or otherwise, or who are so intimately associated with electrical or telegraphic science that the Council consider their admission as associates would conduce to the interests of the society." Our friends the plumbers are useful members of society, and with commendable enterprise they are "taking up" electrical engineering, but are they as useful to the Institution as the Institution membership is to them? A versatile tradesman in Paddington calls himself "architect, builder, undertaker, gas, hot water, and electrical engineer." We know of an electrical engineer who was asked to give his advice on sanitary work; but how many associates of the Institution would not be accurately described by the graceful term "sanitary engineers." The "personal knowledge" is a very informal matter with the electrical body, while it is a somewhat important condition in election to corporate membership, whether associate or otherwise, of the Institution of Civil Engineers, since the signatures of five members are required other than those on the council.

There are two sides to this question. Some would welcome all who contribute by their work to the practice or advancement of the electrical industry, from the highest to the lowest, from the stoker, whose conscientious services are essential, to the company promoter, who is a necessary evil. Others would object, with no small reason, that neither these individuals nor the "sanitary engineer" can be said to *be* electrical engineers in any sense. Although they may be "connected with electrical . . . engineering." Selfish as it may appear to some, we would advocate the well-being of the Institution rather than that of those who seek to become members. Architects, surveyors, patent agents, and many other professions, such as dentists, have all prescribed conditions and qualifications for membership of a distinct body; chemists are talking of doing the same. We do not, at present, go as far as this. It savours rather too much of the mystery and exclusiveness of the old guilds and craftsmen. Individuals can or ought to take care of themselves. What we wish to see improved is the Institution of Electrical Engineers.

## THE INSTITUTION OF ELECTRICAL ENGINEERS.

At the annual general meeting of the Institution of Electrical Engineers held last night, the following members of council were elected for the year 1891:—

**Council for 1891.**

*President.*

W. Crookes, F.R.S., Past President Chem. Soc.

*Vice-Presidents.*

| | |
|---|---|
| Prof. W. E. Ayrton, F.R.S. | R. E. Crompton, M.Inst.C.E. |
| Alexander Siemens. | Sir David Salomons, Bart., M.A. |

*Members of Council remaining in Office.*

| | |
|---|---|
| Sir James Anderson. | Gisbert Kapp, Assoc.M.Inst.C.E. |
| Sir Albert J. L Cappel, K.C.I.E. | Sir Henry Mance, C.I.E., M.Inst.C.E. |
| Major Philip Cardew, R.E. | Prof. Silvanus P. Thompson, B.A., D.Sc., F.R.A.S. |
| Sir James Douglass, F.R.S. | |
| Colonel R. Raynsford Jackson. | |

*New Members of Council.*

| | |
|---|---|
| Major G. W. Addison, R.E. | Professor George Forbes, F.R.S.S (L. & E.). |
| Prof. J. A. Fleming, M.A., D.Sc. | W. M. Mordey. |

*Associate Members of Council.*

| | |
|---|---|
| I. Probert. | R. W. Wallace. |
| Captain A. M. Stuart, R.E. | |

It was announced in the course of the reading of the annual report that the Institution Premium had been awarded to Mr. W. B. Esson for his paper "On Some Points in Dynamo and Motor Design," the Paris Exhibition Premium being awarded to Mr. W. H. Melhuish for his paper "On Signalling Across Rivers in India," and the Fahie Premium to Mr. K. L. Murray for his Paper on "The Electric Lighting of the Melbourne Exhibition."

It was also announced that the offices of the Institution would shortly be transferred to 2, Victoria Mansions, owing to the expiration of the lease of No. 4, The Sanctuary.

Digitized by Google

## REVIEWS.

**A Treatise on Electro-Metallurgy.** By WALTER G. McMILLAN, F.I.C., F.C.S. (Charles Griffin and Co., Exeter-street, Strand.) Series: Griffin's Scientific Text-books.

It is perhaps no part of the duty of a critic to suggest to an author that he ought to have written a different class of book from that under review, provided that the author sets out clearly his object and successfully carries it out. In the present case the preface lays down the author's opinion that the subject of this book should be treated from a *technological* rather than from a *technical* standpoint, and from this point of view there is much to commend the book to the student, or as a useful work of reference. So also to the actual worker in electro-metallurgy, who perhaps desires to utilise some additional features of the art, the book will be of service; but if we consider the case of an engineer or electrician called up to carry out some electro-metallurgical operations, this work will not give him much assistance. One feels, in fact, that the author is a chemist, a metallurgist, and perhaps an electrician; but not an electro-metallurgist who knows the difficulties of the subject, and the "wrinkles which enable these to be overcome.

In the purely electrical part of the work various more or less obsolete dynamos are described, whilst many very popular forms, used much in Birmingham and other metal-working centres, are not mentioned. We wonder, by-the-way, seeing how the Brush machine with "a teazer" figured in the recent compound winding case, whether any of these machines are doing practical work in this country for electro-metallurgical purposes? There are in the course of the book many valuable tables and details as to solutions, their strengths, and the current densities required for their proper working, but these would be much improved if their specific resistances at the working temperatures, together with the volts required to overcome the action of polarisation, were stated. The author gives some interesting notes relating to the historical part of the subject, and figures, we observe, also in a prophetic *rôle*, when, on page 147, speaking of the Elmore process, he says, "the application of the principle may be expected to develop, perhaps, in other directions than those at present contemplated." So far his words have proved startlingly correct. Can he now tell us what is to follow "the Trust?"

**Impianti di Illuminazione Elettrica.** By EMILIO PIAZZOLI. (U. Hoepli, Milan, 1891.)

This manual, for those who may either have to equip or look after a central station for lighting, is intended to fill up the gap left between scientific works on electricity on the one side and popular treatises on the other. The opening chapter gives the principal points of the theory clearly and concisely, although a few sacrifices have been made for the sake of simplicity. In the chapters on the practice, the advisability of inserting makers' price lists is open to question, though, considering the object of the book, there is a great deal to be said in favour of their admission. At the same time, in the dynamo list a column giving the floor space occupied by the various machines would be of more practical use than that showing the price per kilogram. Also some of the space at present devoted to primary batteries might with advantage be occupied by particulars of some of the types of steam and water motors. In spite, however, of a few such defects in arrangement, the work on the whole is an excellent one, and is well worthy of a place amongst the books of the English as well as of the Italian engineer. The chapters on conductors in particular will be found extremely useful.

## BOOKS, &c., RECEIVED.

"Glasgow District Telephone Directory, 1891." (Glasgow: National Telephone Company.)

"Proceedings of the Royal Society of Edinburgh," (Vol. xvii., p. 247-400.)

## CHARGE AND DISCHARGE CURVES OF SECONDARY CELLS.

We are indebted to Mr. Crompton and Mr. Reckenzaun for the following diagrams, referred to by them in the discussion on Prof. Ayrton's Paper on the "Chemistry of Secondary Cells."

Figure 1 is a series of discharges taken at different rates from an eleven-plate Crompton-Howell cell, the plates being approximately 8 × 8 × ½in. thick. These are the plates that have been and continue to be used for the regular batteries for central station work. The figures under each curve show the rate at which the cell was discharged, namely, from 11 amperes up to 66 amperes, or at the rates of 1, 2, 4, 5, and 6 amperes per plate. The reduction of capacity in the cell by heavy rates of discharge is very remarkable. In these experiments no attempt was made to see to what extent a second discharge, if any, could be obtained from the cell, but such second discharges can be obtained in every case, and the amount of the second discharge is in proportion to the amount which the original discharge fell short of what is known to be the capacity of the cell when discharged at low rates. It will be noted that in this case the form of the curve is very definite; the downward bend, as soon as the E.M.F. falls to 1·8, being very rapid.

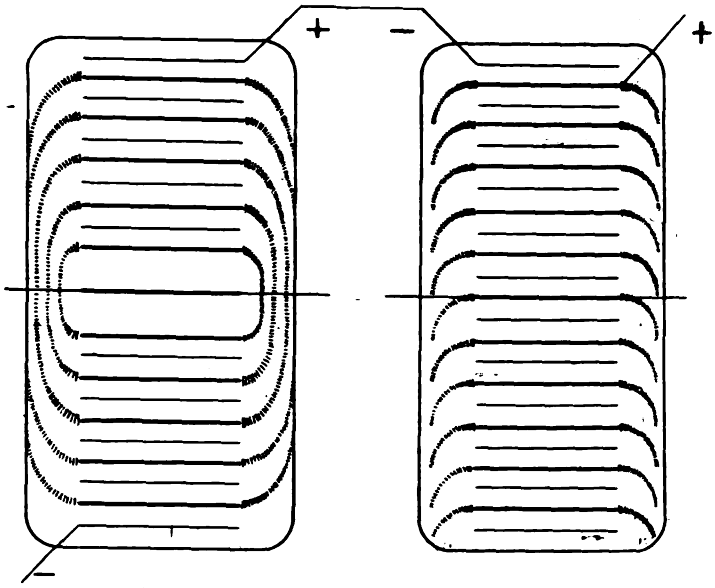



FIG. 3.—Diagram showing Colouration Curves in the Electrolyte of a Crompton-Howell Cell.

Figure 2 shows the result of a similar set of experiments applied to a cell of approximately the same capacity, but made up of only seven plates, these plates, however, being increased in thickness, so that the weight of the seven plates was exactly the same as the 11 plates of the first cell. In this case the loss of capacity is even more marked than in the former, and the shape of the curve is somewhat different. The advantage of these thicker plates is that they are mechanically very strong, and the cell is more quickly put together, and is in many respects easier to handle.

The discolouration shown in the two cells M and L (Fig. 3) is very peculiar. That in M appears to consist of a series of claret coloured bands or shells apparently extending from the surface to the bottom of the electrolyte. These bands have very sharply defined edges, and the space between them is perfectly clear and free from discolouration. The bands are shown connecting both edges of the positive plates. In cell L, where, it will be observed, the circuit is completed at one end only of the cell the positive plates showed a series of grooved horns. The edges of these horns were sharply defined, but the extremities when seen from above had the appearance of brushes. Besides the two arrangements shown this discoloration arranges itself in many other forms, sometimes in that of horizontal strata of varying thicknesses, but in all cases there is a very sharp line of demarcation between the clear liquid and the coloured liquid.

Digitized by Google

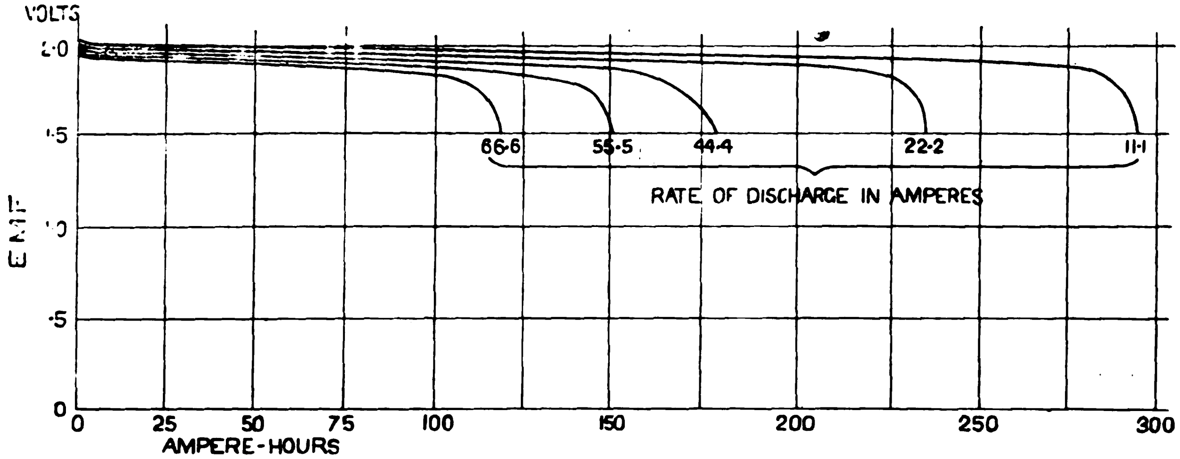



FIG. 1.—11-Plate Crompton-Howell Cell. Curves showing Capacity in Ampere-hours at different Rates of Discharge.

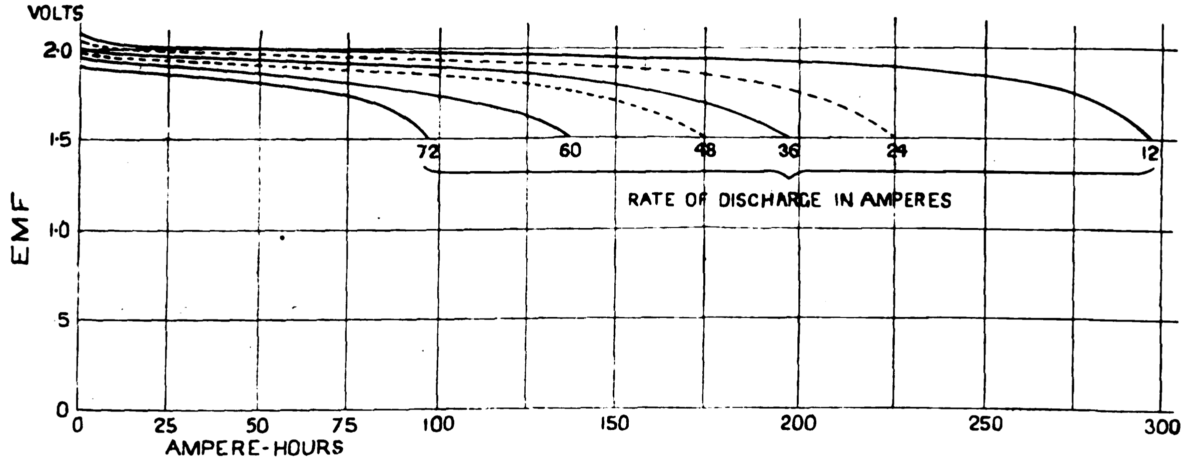



FIG. 2.—7-Plate Crompton-Howell Cell. Curves showing Capacity in Ampere-hours at different Rates of discharge.

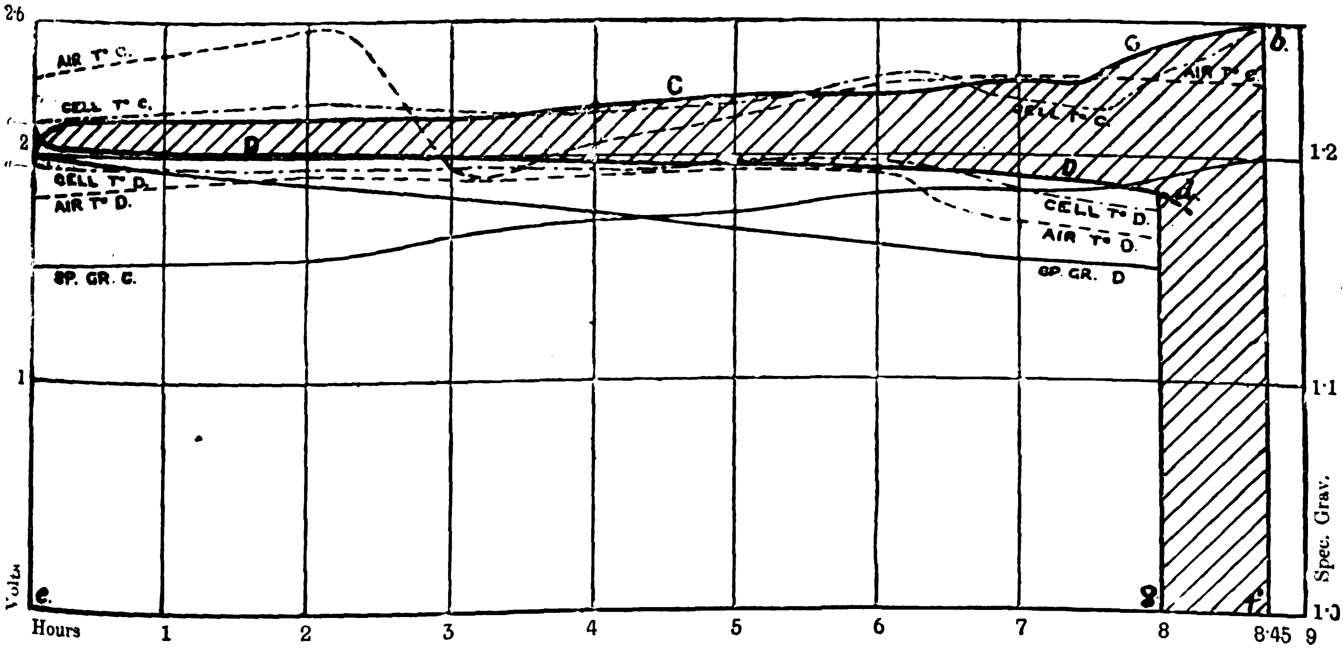



FIG. 4.—Test of 15A Cell. Communicated by Mr. Reckenzaun.

Charge 40 amperes, 8¾ hours = 350 ampere-hours shown by the full line C, C. Mean E.M.F., 2·27 volts.
Energy, 794 watt-hours represented by area *a, b, f, e*.

Discharge 40 amperes, 8 hours = 320 ampere-hours shown by the full line D, D. Mean E.M.F., 1·966 volts.
Energy, 629 watt-hours represented by area *e, d, g, e*.

$$\text{Ratio } \frac{629}{794} = 79\,\%.$$

Scale of temperature of cell and of air in degrees Centigrade, 10° corresponds with ordinate of 1 volt.
20° corresponds with ordinate of 2 volts.

Digitized by Google

In spite of Mr. Swinburne's and other gentlemen's remarks, Mr. Crompton states that analysis shows no trace of permanganic and ferric gases, the only thing present being very minute traces of gold. Mr. Crompton is, therefore, led to believe that the phenomenon is due to very minute traces of metallic gold, suspended in the liquid in a state of almost infinitely fine division, the colour corresponds very closely with what one would expect from gold in this state.

## NOTES ON THE CHEMISTRY OF SECONDARY CELLS.*

By Professor W. E. Ayrton, Vice-President; C. G. Lamb, B.Sc., and E. W. Smith, Associates.

DISCUSSION. (Authorised Abstract.)

Dr. GLADSTONE said, in opening the discussion, he had been greatly interested in the points brought out by the authors, and in the account of the elaborate experiments described. He was rather surprised that taking out so many plugs from the cell had not greatly damaged it. The chemical results arrived at, he considered, confirmed the views put forward by himself and Mr. Tribe about nine years ago, as to the action of cells, resulting in the formation and reduction of ordinary lead sulphate. Since that time, however, many statements had been made attributing important functions to subsulphates, but so far as he and Mr. Hibbert had investigated the matter, such statements had not been confirmed. They now believed that the so-called subsulphates are probably mixtures of ordinary sulphate and peroxide. Referring to the difficulty experienced by Mr. Robertson in analysing the powdered sulphate, he pointed out that ammonium acetate could be used for dissolving out the sulphate. Results obtained by this method showed the sulphate to be the normal one, and he did not think the solvent would alter any subsulphates if such were present. In his opinion there could be no doubt but that the sulphate surrounding the granules of peroxide would act as stated in the paper, and diminish the capacity of the cell. Speaking of the gas given off by the negative plate, he said the fact had been alluded to in a paper by Mr. Hibbert and himself recently published in the *Phil. Magazine*. They, however, had not observed the great differences in the hardness of plugs at different parts of the plates. This result he considered very important, and thought it would lead to a modification in the form of plates.

Mr. CROMPTON said that for some time past he had been working on the subject of secondary cells, and had arrived at results similar to those brought forward in the paper. One great advantage, however, of the results contained in the communication under discussion, arose from the fact that they were obtained from cells of a different type from those he had experimented on, for if he himself had brought the results before the Institution, it would have been thought that the actions were peculiar to his kind of cell. As regards the gassing of cells, he had found it due in a great measure to light. Both sun-light and arc-light increased this action, and quantitative experiments were now being made. He was glad to see the statements of the advocates of secondary batteries, as regards efficiency, had been confirmed. They had, he said, been accused of exaggerating their efficiency, and not without cause, for the cells themselves behave peculiarly, as, for example, the 105 per cent. quantity efficiency mentioned in the paper. Such results seem impossible, and, showed the necessity of getting cells into what the authors had called "the steady working state." He regretted that "proof plates" had not been used in the experiments on the running down of cells. He had used them for a long time, and always found the negatives discharged first. If, however, very thick negatives were used, there was no sudden drop in the potential difference, such as indicated in Figs. 2 and 3. In endeavouring to measure the resistance of the cells with a view to determining the best proportions of plates and liquid, he had met with great difficulties, and he now believed that what is usually measured is of the nature of a back E. M. F.; this he supported by saying that the so-called resistance did not seem to vary, either with the thickness of the plates, or their distance apart, or with the density of the acid. During his investigations a rosy colouration of parts of the liquid had been noticed in some cells; the coloured portions may either appear as strata, lines, or in tree-like forms, and in some cases resemble the shapes of magnetic lines of force. These peculiarities, he hopes, may give some idea of the electric stresses and strains within the electrolyte. The recuperative power of discharged and reversed cells was very marked, for he had observed it in cells that were half charged in the reversed direction, and on cutting up the plates, layers of different materials could be seen. This fact shows how important it is to thoroughly charge cells of the Planté type during formation by reversals. Until quite recently negative plates had been considered faultless, and the positives blamed for defects which were in reality due to imperfections in the negatives. He knew of no case in which positives had gone bad when their negatives had sufficient capacity, and for this reason the negatives ought to be made thicker or larger than the positives. "Sick cells," he said, get partially sulphated and the negatives run down; when the E. M. F. falls below 1·3, heavy sulphating of the positive occurs, and so-called "irreducible sulphate" is formed. In his opinion the reducibility or irreducibility is merely a question of its position, or of its contact or want of contact with the conducting material. In conclusion, he suggested that E. P. S. cells might be improved by reducing the size of the plugs, so as to bring the active material closer to the lead backing.

The discussion was adjourned to the 27th inst.

Thursday, November 27th.

Mr. CROMPTON directed attention to three diagrams which he had prepared since last meeting. One of these showed the character of the colouration seen in the electrolyte when viewed from the top. Curved lines or shells start from the positive plates and turn away as if repelled from the cell terminals. In one cell, which had its + and − terminals at opposite ends, the lines curved towards the middle of the cell, whilst in another, where the terminals were both at the same end, they bent towards the opposite end. The second diagram exhibited the influence of the rate of discharge on the capacity of a cell having eleven 5lb. plates. When discharged at one ampere per plate, its capacity was 300 ampere hours; but at six amperes, only about half. The fall of volts was very sudden at the end of each discharge. The third diagram related to the discharge of an experimental cell containing seven 9lb. plates, and showed that, although the capacities were not very different from those of the eleven-plate cell, the fall in volts was not nearly so sudden.

Mr. RECKENZAUN said the papers under discussion were very important ones, and contained much that had never been published before; many of the facts, however, were known to those engaged in the manufacture. The question of efficiency, he thought, was not likely to be settled, since, according to the authors, it may vary between 105 and 58 per cent., depending on the previous history of the cells. In his own experiments on the effect of prolonged rest, he had found a similar loss of efficiency, and he believed this to be due to sulphating of the negatives. The negatives were always played out first, and this defect could not be got over by making them abnormally thick, or by increasing their surface; for if thickening be tried, the interior is not acted on, whilst greater surface gives no advantage on account of the material being at different distances. To test the deficiency of negative plates, he had discharged cells as low as possible, and then put the positive with a newly charged negative; from these a fair E.M.F. and discharge were obtained. He had also tried amalgamated zinc instead of a newly charged negative, and got 40 per cent. of the original capacity. These facts account for the existence of 30 per cent. of $PbO_2$ in the positive plugs when the cell was supposed to be completely discharged. In his opicion it would be better to say that the negatives discharged about 30 per cent. too soon. The negative of Planté cells, especially those formed by the nitric acid process, soon lose their virtue, and this was attributed to the difficulty in removing all the forming acid. In the course of his remarks, Mr. Reckenzaun said he had received a very interesting diagram from his brother in America, showing the E.M.F. current, density of acid, temperature of cell and of surrounding air, &c., during the charges and discharges of a secondary battery. This diagram he would place in the hands of the Secretary.

A communication from Mr. Hall was then read. This related to a pair of E.P.S. plates recently taken from the battery under his charge at the P. and O. Company's Offices, where they had been in constant use for six years. During that period the cells had supplied about 150,000 ampere hours, and were still in good condition, as was indeed evident from the appearance of the plates shown. His experience confirmed the observations of the authors on the effect of rest. In the working of the battery the density of each cell had been carefully watched, and any defect promptly removed.

Mr. W. HIBBERT, referring to the Edinburgh Paper, said he would first deal with the explanation of the high E.M.F. at the end of a charge and its rapid fall on breaking the circuit. In a communication made to the Physical Society last June, Dr. Gladstone and himself had shown reason for believing this to be due to concentration of acid about the positive plate and its subsequent rapid diffusion, and he thought the results plotted in Fig. 4 of the paper under discussion, showing the effect of making and breaking the circuit of a charged cell on its E.M.F. and P.D., were consistent with this idea. Further on in the same paper the authors say that the concentration hypothesis will not explain the rise of P.D. in a cell discharging after a long rest. On this point he, Mr. Hibbert, said that the reaction in such states were very complex; but still, he thought it would be possible to find an explanation of this phenomenon based on similar lines. Referring to the later paper, he thought the authors had rather exaggerated the effect of peroxide on the negative plate in causing the volts to fall, for, in his own experiments, only a small quantity was formed. The simultaneous weakening of the acid round the plates would tend to give a rapid fall in the E.M.F. and the effect of both these actions must be studied if the subject is to be properly understood.

Dr. E. FRANKLAND said he had read the papers with great interest and considered them most important contributions on the subject. In one place the authors deplore the lack of knowledge of the chemical actions in cells, and not without reason. He, however, thought physicists were more to blame than chemists, for the physical actions could be readily determined, whereas the chemical changes present formidable difficulties. The substances used and produced were mixtures, and it was very difficult to separate and analyse them, without producing decompositions. A valuable part of the communications was that relating to the quantity of $PbO_2$ formed and decomposed during the working of cells. On this point he thought the values put down for $PbO_2$ may be either the sesqui—or the three-quarters oxide; and, in fact, the crux of the whole subject lay in the exact nature of the compound formed. Dr. Gladstone and himself had, apparently, arrived at different conclusions, but their differences might admit of explanation, if care and time were taken in considering the matter. Another important point was the quantity of $SO_3$ absorbed during discharge, viz., 3·08 grammes per ampere-hour. If this be translated into hexabasic acid, which he believed to be present, it gives 5·71 grammes. From his own experiments on a 10-plate cell, he had found about 4·7 grammes of hexabasic acid absorbed per ampere-hour, whilst discharging

* Paper read before the Institution of Electrical Engineers on Thursday, November 13, 1890

Digitized by Google

at an E.M.F. averaging 1·9 volts; but when the cell was run down and discharged at an E.M.F. averaging 0·3 volt, he found the rate about 3·3 grammes. He did not wish to put these numbers in conflict with those obtained by the authors, but he was strongly impressed with the idea that the two different quantities, 4·7 and 3·3, pointed to the existence of two distinct chemical reactions, one resulting in an E.M.F. of about 2 volts and the other of ·3 volt.

Mr. F. KING said the results of the tests were very gratifying to the makers of cells. He commended the skill and ingenuity displayed in devising the automatic apparatus, for the labour involved in working a laboratory day and night without such apparatus is enormous. The inequality of current distribution over the surface of the plates was, he said, well known, and the hanging type of cell was devised to remedy this defect. The first form of this type was abandoned, but more recently they had made another form, one of which was exhibited at the meeting. The current is led into the positives at two points on the top and leaves the negatives at the bottom. With this cell they had doubled the normal rate of discharge without diminishing the capacity, and also obtained a longer life. Moreover, the loss of capacity for high rates of discharge, due to the shrinkage of the negative paste, and which is so marked in ordinary types, had been avoided. The positive plates somewhat resemble those of the Tudor cell, having deep horizontal grooves along each side in which the active material is placed. The negatives are made according to Sellon's invention, in which a kind of double grid is used, the parts being displaced diagonally, so that each plug on one side communicates directly with four plugs on the opposite side, and through them with every other plug in that division of the plate. This construction causes any shrinkage of the paste to bind itself more firmly on the grid. As a result of tests on the new cell it has been found that the capacity is greater after 500 or 600 discharges than at the beginning, whereas that of ordinary cells is considerably reduced by 400 discharges. The life of negative plates he believed was not well understood, but with reference to positives he said that those used on tramcars (9 plates 8in × 5¼in.) had a useful life of 70,000 ampere-hours. After one year's use their capacity is reduced 33 per cent. Speaking of the resistance of battery connections, he pointed out the advisability of burning the lugs together so as to give as complete a metallic surface as possible. Respecting the pasting and formation of E.P.S. plates referred to in the second paper, he said that the particulars there given were totally wrong.

Mr. SWINBURNE thought there had never been any valid reason for doubting the formation of normal lead sulphate. The old ideas about reduction and oxidation, &c., had obscured the subject until Dr. Gladstone and Mr. Tribe brought people to order about eight years ago. The difficulty of reducing ordinary sulphate electrically had been given as a reason why it could not be formed, but now its reduction, or non-reduction, was known to be a mere question of making contact with it. Seven years ago he had brought forward a theory that the sulphate is not a secondary product at all, and that the output of a cell is is mainly dependent on the affinity of sulphion for lead. This, together with the other chemical actions, leaves some E.M.F. to be accounted for by Peltier effects, and these effects would show in the temperature coefficient. He was not aware whether calorimetric data had been obtained for the sub-sulphates which Dr. Frankland supposed to be present, but if so, then by working backwards, evidence for or against their existence might be procured. The action of finely-divided lead on sulphuric acid had, he said, been known for years, and this limited the best strength of acid to about 1 in 4. As regards the equilibrium between the plates of a cell, he was inclined to attribute this either to the absence of $PbO_2$ from the positive, or of spongy lead from the negative, rather than to the presence of $PbO_2$ on both plates. He also thought the percentage of material really active was much less than that stated in the paper, for in some experiments of his own he had only found about five per cent. useful. Speaking of Mr. Crompton's colour observation, Mr. Swinburne said they were due to ferric acid formed by the action of $PbO_2$ on iron salts in the commercial acid. In his opinion, the virtues of sulphate of soda had been greatly exaggerated, and he believed its action to be due to its enabling bad contact sulphate to be reached more easily.

Sir D. SALOMONS said he had noticed colourations in one or two of his cells, but had attributed them to impurities. The unequal action on different plugs had been to him a subject of common remark, and he had taken steps to equalise the distribution of current by burning on strips of lead, with good results. The bending of negatives could be prevented by building up the sections rigidly. His experience with soda differed from that of Mr. Swinburne, for he had found caustic soda in the proportion of one ounce to nine gallons very advantageous. Cells supplied with this electrolyte had been left charged for six weeks without injury, and had commenced to boil freely ten minutes after the charging current was started. With ordinary acid two or three hours' charging would be required to produce the same results. In his opinion makers give extreme limits for the so-called normal working rate of cells; and if these were divided by two or three, better results would be obtained, and would be cheaper in the long run. As regards efficiency, he thought 70 per cent. to be a very fair average. The large amount of $PbO_2$ not acted on resulted from the interior of the plugs being, as it were, waterproofed by the sulphate outside. On this account thick plates possessed little or no advantage. Increasing the quantity of electrolyte, however, gives more capacity up to a certain point; but when the plates are put far apart the loss of volts becomes serious. Speaking of pasting positives with $PbO_2$, he said he had made good plates in this way by using very strong acid (nearly pure) in making the paste.

Mr. BERNARD DRAKE, whilst adding his testimony to the value of the papers, thought he ought to mention one or two points of detail which might lead to wrong conclusions. For example, the loss of efficiency, due to rest, might lead clients to suppose that their cells ought to be used even when they were away from home. This, he said, would be a great mistake, for the loss of capacity is due to the negatives, whereas the repairs were chiefly restricted to the positives, whose lives are inversely proportional to the amount of use. In a paper read before the British Association in 1886, he and Mr. Gorham had shown that the whole success of storage cells depended on whether the positives could be made to last a reasonable time, and to effect this, it had been found necessary to overcharge them. The actual plates sent by Mr. Hall from the P. and O. offices had been badly sulphated some time ago, and were condemned; he, however, recommended overcharging, with the result now known. In these cells the density of acid used to be from 1,350 to 1,400, and although he did not now recommend such a high specific greatly, yet he thought the subject required more attention than it had received. As to the proportions of the plates, he said the negatives were intentionally made to give out first, so that the positives might not be run down, for a kind of protecting coating is formed on the positives by charging, and this is removed by discharging them below a certain point. If this coating is continually re-formed, the plates expand and buckle, and the plugs eventually drop out. Speaking of the cooling action during discharge and also after charging has commenced, he did not see any explanation excepting perhaps that it might depend on the same cause as the rise of specific gravity which occurs after charging has stopped. This he had found to be due to the heavy acid, formed during charging, falling to the bottom of the cell, and afterwards diffusing into the general body of the liquid, thus affecting the hydrometer. In this connection he inquired whether the temperature was taken at the top or bottom of the cells. The rise of E.M.F. during the first part of a discharge after rest he attributed to the surface of the negatives being coated with a sulphate, which was reduced by the discharging current. In reference to the shrinkage of negatives, mentioned by Mr. King, he said, that in order to avoid blistered negatives a mixture of litharge and sulphate had been used for pasting, instead of litharge only. This method, although it prevented blistering, necessarily left the plugs of a porous nature, and was liable to permit shrinkage.

The discussion was adjourned to December 11th.

## THE ELECTRO-MAGNET.*

BY PROFESSOR SILVANUS P. THOMPSON.

*(Continued from page 154.)*

### EFFECT OF USING CONED PLUNGERS.

But now if, instead of employing a cylindrical core, you employ one that is pointed, you find this completely alters the position of the maximum pull, for now the point is insufficient to carry the whole of the magnetic lines which are formed in the iron rod. They do not come out at the point, but filter through, so to speak, along the sides of the core. The region where the magnetic lines come up through the iron into the air is no longer a definite "pole" at or near the end of the rod, but is distributed over a considerable surface; consequently when the point begins to poke its nose out, you still have a larger portion of iron up the tube, and the pull, instead of coming to a maximum at that position, is distributed over a wider range. I am now making the experiment roughly with my spring balance and a conical plunger, and I think you will be able to notice a marked difference between this case and that of the cylindrical plunger. The pull increases as the plunger enters, but the maximum is not so well defined with a pointed core as it is with one that is flat-ended. This essential difference between coned plungers and cylindrical ones was discovered by an engineer of the name of Krizik, who applied his discovery in the mechanism of the Pilsen arc lamps. Coned plungers were also examined by Bruger. In Fig. 63 are given the curves that correspond to the use of a coned iron core, as well as those corresponding to the use of the cylindrical iron rod. You will notice that, as compared with the cylindrical plunger, the coned core never gave so big a pull, and the maximum occurred not as the tip emerged, but when it got a very considerable way out on the other side. So it is with both the shorter and the longer coil. The dotted curves in Fig. 64 represent the behaviour of a coned plunger. With the longer coil represented, and with various currents, the maximum pull occurred when the tip had come a considerable way out; and the position of the maximum pull, instead of being brought nearer to the entering end with a high magnetising current, was actually caused to occur further down; the range of action became extended with large currents as compared with small ones. Bruger also investigated the case of cores of very irregular shapes, resembling, for example, the shank of a screw-driver, and found a very curious and irregular force-curve. There is a good deal more yet to be done, I fancy, in examining this question of distributing the pull on an attracted core by altering the shape of it, but Bruger has shown us the way, and we ought not to find very much difficulty in following him.

* A series of four Cantor Lectures delivered before the Society of Arts, January—February, 1890.

Digitized by Google

### Other Modes of Extending Range of Action.

Another way of altering the distribution of the pull is to alter the distribution of the wire on the coil. Instead of having a coned core used a coned coil, the winding being heaped up thicker at one end than at the other. Such a coil, wound in steps of increasing thickness, has been used for some years by Gaiffe, in his arc lamp; it has also been patented in Germany by Leupold. M. Tiève has made the suggestion to employ an iron wire coil, so to utilise the magnetism of the iron that is carrying the current. Tiève declares that such coils possess, for an equal current, four times the pulling power. I doubt whether that is so; but even if it were, we must remember that to drive any given current through an iron wire, instead of a copper wire of the same bulk, implies that we must force the current through six times the resistance; and, therefore, we shall have to employ six times the horse-power to drive the same current through the iron wire coil, so that there is really no gain. Again, a suggestion has been made to enclose in an iron jacket the coil employed in this way. Ironclad solenoids have been employed from time to time. But they do not increase the range of action What they do is to tend to prevent the falling off of the internal pull at the region within the mouth of the coil. It equalises the internal pull at the expense of all external action. An ironclad solenoid has practically no attraction at all on anything outside of it, not even on an iron core placed at a distance of half a diameter of the aperture: it is only when the core is inside the tube that the attraction begins; and the magnetising power is practically uniform from end to end. Last year I wished to make use of this property for some experiments on the action of magnetism on light, and for that purpose I had built, by Messrs. Paterson and Cooper, this powerful coil, which is provided with a tubular iron jacket outside, and a thick iron disc perforated by a central hole covering each end. The magnetic circuit around the exterior of the coil is practically completed with soft iron. With this coil, one may take it, there is an absolutely uniform magnetic field from one end of the tube to the other; not falling off at the ends as it would do if the magnetic circuit had simply an air return. The whole of the ampere-turns of exciting power are employed in magnetising the central space, in which, therefore, the actions are very powerful and uniform. The coil and its uses were described in my lecture last year at the Royal Institution on "Optical Torque."

### Modifications of the Coil-and-Plunger.

In one variety of the coil-and-plunger mechanism a second coil is wound on the plunger. Hjörth used this modification, and the same thing has been employed in several arc lamps. There is a series of drawings upon this wall depicting the mechanism of about a dozen different forms of arc lamp, all made by Messrs. Paterson and Cooper. In one of these there is a plunger with a coil on it drawn into a tubular coil, the current flowing successively through both coils. In another there are two separate coils in separate circuits, one of thin wire and one of thick, one being connected in series with the arc, and one in shunt.

### Differential Coil-and-Plunger.

There is a third drawing here showing the arrangement, which was originally introduced by Siemens, wherein a plunger is drawn at one end into the coil that is in the main circuit, and at the other end into a coil that is in shunt. That differential arrangement has certain peculiar properties, of which I must not now stop to speak in detail. It is obvious that where one core plunges its opposite ends into two coils, the magnetisation will depend on both coils, and the resultant pull will not be simply the difference between the pull of the two coils acting each separately. There is, however, another differential arrangement, used in the Brockie-Pell and other arc lamps, in which there are two separate plungers attached to the two ends of a *see-saw* lever. In this case the two magnetising actions are separate. In a third differential arrangement there is but one plunger and one tubular bobbin, upon which are wound the two coils, differentially, so that the action on the plunger is simply due to the difference between the ampere-turns circulating in the two separate wires.

### Coil-and-Plunger-Coil.

When one abandons iron altogether, and merely uses two tubular coils, one of wide diameter, and another of narrower diameter, capable of entering into the former, and passes electric currents through both of them, if the currents are circulating in the same fashion through both of them they will be drawing into one another. This arrangement has also been used in arc lamps. The parallel currents attract one another inversely, not as the square of the distance, but approximately as the distance. This is one of those little details about which it is as well to be clear. About once a year some kind friend from a distance writes to me pointing out a little slip that he says occurs in my book on electricity, in the passage where I am speaking about the attraction of parallel wires. I have made the terrible blunder of leaving out the word square; for I say the attraction varies inversely as the distance, and my readers are kind enough to correct me. Now when I wrote that passage I considered carefully what I had to write, and the attraction does not vary inversely as the square of the distance, because two parallel wires do not act on one another as two points. They act as two straight lines or two parallel lines, and the attraction between two parallel lines of current, or two parallel lines of magnetism, or two parallel lines of anything else that can attract, will not act inversely as the square, but simply inversely as the distance in between.

### Intermediate Forms.

Now this property of the coil-and-plunger of extending the range of action has been adopted in various ways by inventors whose object was to try and make electro-magnets with a sort of intermediate range. For certain purposes it is desirable to construct an electro-magnet which, while having the powerful pull of the electro-magnet, should have over its limited range of action a more equable pull, resembling in this respect the equalising of range of the coil and plunger. Some of these intermediate forms of apparatus are shown in the following diagrams. Here (Fig. 65) is a peculiar form of electro-magnet; it combines some of the features of the iron-clad electro-magnet with those of the movable plunger; it has a limited range of action, but it is of great power over that range, owing to its excellent magnetic circuit. It was invented, in 1870, by Stevens and Hardy, for use in an electric motor for running sewing machines.

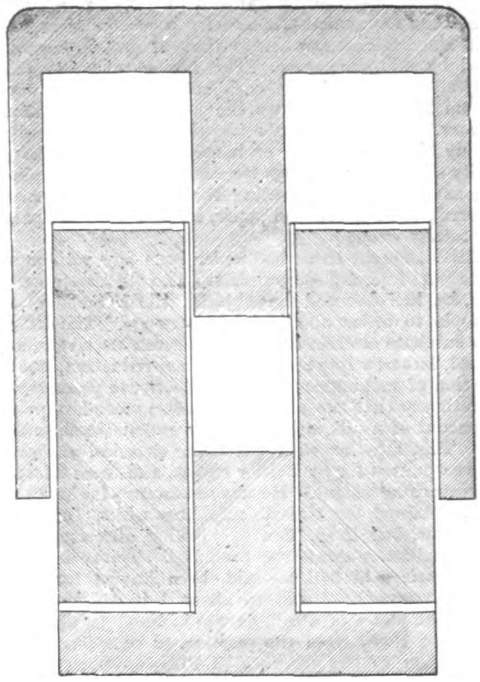


Fig. 65.—Plunger Electro-magnet of Stevens and Hardy.

A very similar form is used in Weston's arc lamp. A form of plunger electro-magnet, invented by Holroyd Smith in 1877, resembles Fig. 65 inverted; the coil being surrounded by an iron jacket, whilst a plunger, furnished at the top with an iron disc, descends down the central tube to meet the iron at the bottom.

Then there is another variety, of which I was able to show an example last week by the kindness of the Brush Company, namely, the plunger electro-magnet employed in the Brush arc lamps. A couple of tubular coils receive each an iron plunger, connected together by a yoke; whilst above, the magnetic circuit is partially completed by the sheet of iron which forms part of the enclosing box. You have here, also, the advantage of a fairly complete magnetic circuit, together with a comparatively long travel of the plunger and coil. It is a fair compromise between the two ways of working. The pull is not, however, in any of these forms, equal all along the whole range of travel; it increases as the magnetic circuit becomes more complete.

There are several other intermediate forms. For example, one inventor, Gaiser, employs a horse-shoe electro-magnet, the cores of which protrude a good distance beyond the coils, and for an armature he employs a piece of sheet-iron, bent round so as to make at its ends two tubes, which enclose the poles, and are drawn down over them. Contrast with this design one of much earlier date by an engineer, Roloff, who made his electro-magnets with iron cores not standing out, but sunk below the level of the ends of the coils, whilst the armature was furnished with little extensions that passed down into these projecting tubular ends of the coils. Some arc lamps have magnets of precisely that form, with a short plunger

Digitized by Google

entering a tubular coil, and met half-way down by a short fixed core inside the tube.

Here (Fig. 67) is one form of tubular ironclad electro-magnet that deserves a little more attention, being the one used by Messrs. Ayrton and Perry in 1882 ; a coil has an iron jacket round it, and also an annular iron disc across the top, and an annular iron disc across the bottom, there being also a short internal tube of iron extending a little way down from the top, almost meeting another short internal tube of iron coming up from the bottom. The magnetic effect of the enclosed copper coil is concentrated within an extremely short space, between the ends of the internal tubes, where there is a wonderfully strong uniform field. The range of action you can alter just as you please in the construction by shortening or lengthening the internal tubes. An iron rod inserted below is drawn with great power and equality of pull over the range from one end to the other of these internal tubes.

### Action of Magnetic Field on Small Iron Sphere.

In dealing with the action of tubular coils upon iron cores, I showed how, when a very short core is placed in a uniform magnetic field, it is not drawn in either direction. The most extreme case is where a small sphere of soft iron is employed. Such a sphere, if placed in even the most powerful magnetic field, does not tend to move in any direction if the field is truly uniform. If the field is not uniform, then the iron sphere always tends to move from the place where the field is weak to a place where the field is stronger. A ball of bismuth or one of copper tends, on the contrary, to move from a place where the field is strong to a place where the field is weaker. This is the explanation of the actions called "dia-magnetic," which were at one time erroneously attributed to a supposed dia-magnetic polarity opposite in kind to the ordinary magnetic polarity. A simple way of stating the facts is to say that a small sphere of iron tends to move up the *slope* of a magnetic field, with a force proportional to that slope ; whilst (in air) a sphere of bismuth or one of copper tends, with a feeble force, to move down that slope. Any small piece of soft iron—a short cylinder, for example—shows the same kind of behaviour as a small sphere. In some of Ayrton and Perry's coiled-ribbon amperemeters and voltmeters, and in some of Sir William Thomson's current-meters, this principle is applied.

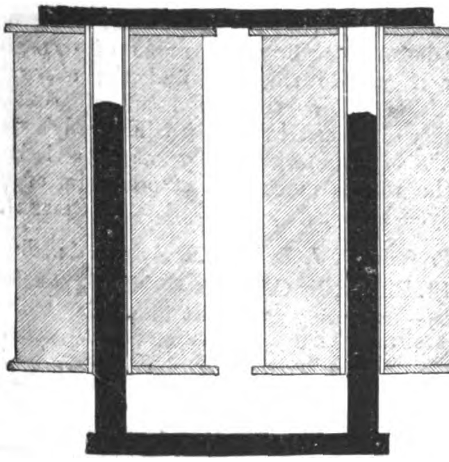


Fig. 66.—Electro-magnet of Brush Arc Lamp.

### Sectioned Coils, with Plunger.

An important suggestion was made by Page, about 1850, when he designed a form of coil-and-plunger having a travel of indefinitely long range. The coiled tude, instead of consisting merely of one coil, excited simultaneously throughout its whole length by the current, was constructed in a number of separate sections or short tubes, associated together end to end, and furnished with means for turning on the electric current into any of the sections separately. Suppose an iron core to be just entering into any section, the current is turned on in that section, and as the end of the core passes through it, the current is then turned on in the section next ahead. In this way an attraction may be kept up along a tube of indefinite length. Page constructed an electric-motor on this plan, which was later revived by Du Moncel, and again by Marcel Deprez in his electric "hammer."

### Winding of Tubular Coils and Electro-Magnets.

The mention of this mode of winding in sections leads me to say a few final words about winding in general. All ordinary coils, whether tubular or provided with fixed cores, are wound in layers of alternate right-handed and left-handed spirals. In a preceding lecture I mentioned the mistaken notion, now disproved, that there is any gain in making all the spirals right-handed or all left-handed. For one particular case there is an advantage in winding a coil in sections ; that is to say, in placing partitions or *cloisons* at intervals along the bobbin, and winding the wire so as to fill up each of the successive spaces between the partitions before passing on from one space to the next. The case in which this construction is advantageous is the unusual case of coils that are to be used with currents supplied at very high potentials. For when currents are supplied at very high potentials there is a very great tension* exerted on the insulating material, tending to pierce it with a spark. By winding a coil in *cloisons*, however, there is never so great a difference of potentials between the windings on two adjacent layers as there would be if the layers were wound from end to end of the whole length of coil. Consequently, there is never so great a tension on the insulating material between the layers, and a coil so wound is less likely to be injured by the occurrence of a spark.

Another variety of winding has been suggested, namely, to employ in the coils a wire of graduated thickness. It has been shown by Sir William Thomson to be advantageous in the construction of the coils of galvanometers to use for the inner coils of small diameter a thin wire ; then, as the diameter of the windings increase, a thicker wire ; the thickest wire being used on the outermost layers ; the gauge being thus proportioned to the diameter of the windings. But it by no means follows that the plan of using *graded wire*, which is satisfactory for galvanometer coils, is necessarily good for electro-magnets. In designing electro-magnets it is necessary to consider the means of getting rid of heat ; and it is obvious that the outer layers are those which are in the most favourable position for getting rid of this heat. Experience shows that the under layers of coils of electro-magnets always attain a higher temperature than those at the surface. If, therefore, the inner layers were to be wound with finer wire, offering higher resistance, and generating more heat than the outer layers, this tendency to overheating would be still more accentuated. Indeed, it would seem wise rather to reverse the galvanometer plan, and wind electro-magnets with wires that are stouter on the inner layers, and finer on the outer layers.

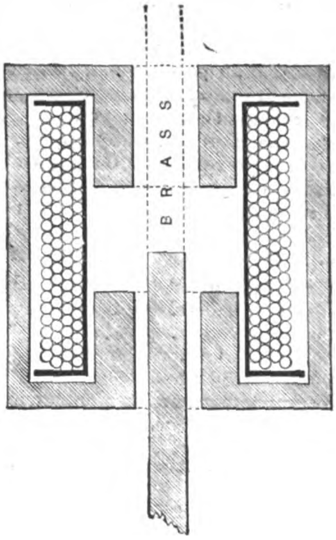



Fig. 67.—Ayrton and Perry's Tubular Ironclad Electro-Magnet.

Yet another mode of winding is to employ several wires united in parallel, a separate wire being used for each layer, their anterior extremities being all soldered together at one end of the coil, and their posterior extremities being all soldered together at the other. Magnetically, this mode of winding presents not the slightest advantage over winding with a single stout wire of equivalent section. But it has lately been discovered that this mode of winding with *multiple wire* possesses one incidental advantage, namely, that its use diminishes the tendency to sparking which occurs at break of circuit.

### Extension of Range by Oblique Approach.

I now pass to the means which have been suggested for extending the range of motion, or of modifying its amount at different parts of the range, so as to equalise the very unequable pull. There are several such devices, some electrical, others purely mechanical, others electro-mechanical. First, there is an electrical method. André proposed that as soon as the armature has begun

* The tension on the insulating material, tending to pierce it with a spark, is proportional to the square of the difference of potentials (per unit thickness) to which the insulating material is subject. It is incorrect to talk about the tension of the conductor or about the tension of the current ; for the tension or electric stress is always an action affecting the di-electric or insulating material.

Digitized by Google

to move nearer, and comes to the place where it is attracted more strongly, it is automatically to make a contact, which will shunt off part of the current and make the magnetism less powerful. Burnett proposed another means; a number of separate electro-magnets acting on one armature, but as the latter approached these electro-magnets were one after the other cut out of the circuit. I need not say the advantages of that method are very hypothetical. Then there is another method which has been used many times with very great success, the method of allowing the motion of the armature to occur obliquely, it being mechanically constrained so as to move past, instead of towards the pole. When the armature is pulled thus obliquely, the pull will be distributed over a definite wider range. Here is a little motor made on that very plan. A number of pieces of iron set on the periphery of a wheel are successively attracted up sideways. An automatic device breaks the circuit as every piece of iron comes near, just at the moment when it gets over the poles, and the current being cut off, it flies on beyond and another piece comes up, is also attracted in the same way, and then allowed to pass. A large number of toy motors have been made from time to time on this plan. I believe Wheatstone was the first to devise the method of oblique approach about the year 1841. He made many little electro-magnetic motors, the armatures of which were in some cases solid rims of iron arranged as a sort of wheel, with two or more zig-zag internal teeth, offering oblique surfaces to the attraction of an electro-magnet. Such little motors are often now used for spinning Geissler's vacuum tubes. In these motors the iron rim is fixed, and the electro-magnet rotates. The pole of the electro-magnet finds itself a certain distance away from the iron ring, it tries to get nearer. The only way it can get nearer is by swinging round, and so it gradually approaches, and as it approaches the place where it is nearest to the internal projection of the rim the current is cut off, and it swings further. This mode may be likened to a cam in a mechanical movement. It is, in fact, nothing else than an *electro-magnetic cam*. There are other devices, too, which are more like electro-magnetic *linkages*. If you curve the poles or shape them out you may obtain actions which are like that of a wedge on an inclined plane. There is an electro-magnet in one of Paterson and Cooper's arc lamps wherein the pole-piece, coming out below the magnet, has a very peculiar shape, and the armature is so pivotted with respect to the magnet, that as the armature approaches the core as a whole, its surface recedes from that of the pole-piece, the effect being that the pull is equalised over a considerable range of motion. There is a somewhat similar device in De Puydt's pattern of arc lamp.

*(To be continued.)*

## AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *November* 28, 1890.

**The Edison Company.**—This company has recently taken the aggressive by cutting prices of all its apparatus to a point far below anything that has previously been reached. This will undoubtedly have the double tendency of increasing its sales and making it very lively for small competitors. Some few of the new Edison arc machines have already been put into use, but it is too early yet to say very much as to the results that have been obtained.

**Electrical Railways.**—Much interest has been excited in this country by the reports of the opening of the City and South London Railway. It will probably not be very long before active efforts are made to adopt the motor for more severe service than street cars in this country. The proposed elevated railroad of the West End Company in Boston will undoubtedly be operated electrically; and the same is probably true of one of the new elevated railroads in Chicago. Now that the way has been pointed it is more than likely that further progress will be comparatively rapid.

**Electrical Execution.**—Next week there will, in all probability, be another electrical execution, this time at Sing Sing Prison. The greatest care has been exercised to avoid the possibility of difficulties like those that attended the Kemmler execution. There will be far less publicity than in the former case, and in allprobability very much less public excitement. The daily papers are taking comparatively little notice of this second execution.

**Railway Headlight.**—I recently saw the electrical headlight, of which much has been heard recently, in operation on a western road. The result of its use is very striking. The light is of the most intense brilliancy, and the track is made almost as bright as day for a long distance in front of the locomotive. The use of this piece of apparatus is extending rapidly, and bids fair to become an important adjunct in railway operation.

## CORRESPONDENCE.

### FORCES BETWEEN CURRENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR,—The enclosed letter, which I received a few months ago, but did not then read, you may perhaps choose to insert in your journal, as an attempt to press further some of the analogies between electric and hydraulic currents.

It may, however, be useful if I remark that the stresses and strains mentioned by Mr. Erskine-Murray as existing in an elastic medium through which a liquid is flowing have their analogues in the electro-static actions of currents, and are not immediately and obviously connected with a current's electro-kinetic actions, which depend on a distribution of kinetic energy in the medium, and appear to require something corresponding to spinning wheels for their complete mechanical representation.

May I also take the opportunity of saying that, although in a letter on page 83 of your issue of November 21, I emphasised once more the mode of transmission of energy by cog-wheels as on the average radial, I did not mean to enter into detail regarding the mode of engagement of the teeth; for if we do this, we find the energy-path to be a special form of curve, the locus of contact of pairs of teeth, fully discussed in Professor Kennedy's "Mechanics of Machinery." My remarks apply more strictly to friction gearing—the wheels in contact at one point of their circumference only.—Yours, &c., OLIVER J. LODGE.

*To Professor O. J. Lodge, F.R.S., &c., &c., Liverpool.*

St. Fillans, by Crieff, Perthshire, September 17, 1890.

DEAR SIR,—In reading your most interesting book on "Modern Views of Electricity," I noticed that on page 91, article 40, you say that a certain series of facts about electric currents must be considered *suorum generum*, not having any hydraulic analogue.

Now, there are some things concerning the motion of fluid through cavities in a solid, which, though they may not be strictly analogous, yet appear, to me at least, helpful towards understanding movements of electricity. (Fig. 1).

First and foremost, the phenomena connected with the flow of water do not occur solely *inside* the pipe.

(1.) Consider an indiarubber tube lying on a level surface, and attached at one end to a supply of water at a high pressure, produced, say, by compressing a large elastic reservoir, in which sufficient water is stored. If there be a current of liquid in the pipe, the tension in the walls of it will be greater at a point near the reservoir than at a point near the open end. But this is not quite analogous to the electric case, partly because the electric current is in almost all cases (except submarine cables) surrounded by dielectric, which fills the entire space inside the contour of the current, while the tube is surrounded by air which is dikinetic (transmits energy by diffusion of motion) like an electric conductor.

(2.) Now consider a block of incompressible elastic solid traversed by a straight tunnel of circular section through which a current of incompressible but viscous (in any degree) fluid is made to flow.

First then, the normal pressure on the sides of the tunnel, and consequently the stress in the surrounding solid, will decrease in the direction of flow; also the diameter of the tunnel will be increased by an amount depending on the elasticity of the solid and the normal pressure at the point. The solid will be slightly displaced in directions normal to the surface of the tunnel, and perpendicular (very nearly) to its central axis.

Secondly, since the liquid is viscous, there will be a tangential force on the surface of the tunnel, causing a shear in the surrounding solid. This stress will be the same per unit surface all along the tunnel if the tunnel be not appreciably conical.

Consider now the effect of this shear on the solid medium, and through it on any other tunnels or cavities containing fluid that may exist in the block. Suppose the block infinite in size.

Digitized by Google

Let A B (Fig. 2) represent a tunnel conveying a current. Let P Q R S be a small cube of the unstrained solid at some distance, say $a$, from the tunnel A B. Let $p\ q\ r\ s$ represent its form and position when the solid is sheared by the action of the current.

Draw $p\,r'$ & $q\,s'$ parallel to P R & Q S.

Then $rr'/pr' = \sigma$ represents the shear produced by the current A B at the distance $a$.

Now let there be another tunnel, conveying a fluid current, in the block. Examining all the positions it may have while a point of it is kept at a fixed distance from A B, we see that the stress in the intervening solid caused by the combination of the shears due to both currents is *least* when the currents are parallel and in the same direction. We see, further, that the *nearer* the parallel currents are to one another the less will be the average stress in the intervening solid, since the shears due to each more and more counteract one another. There will be a small displacement of the whole intervening solid in the direction of the currents.

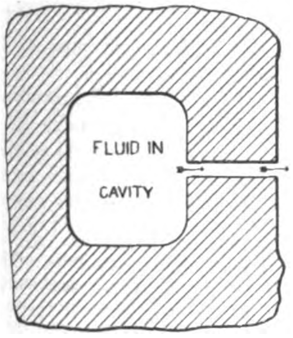



Fig. 1.

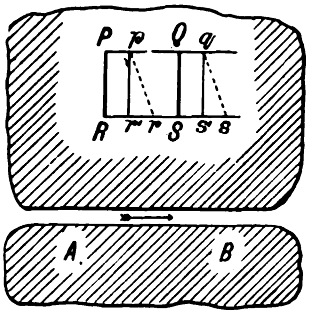



Fig. 2.

In this case, unless the currents be separated by an infinite distance, the average potential energy stored in unit volume of the solid is *less between the currents* than outside them.

But suppose the currents to be in one plane, parallel to one another, and contrary in direction. The farther apart they are the less will be the stress per unit volume in the intervening solid. But unless they be at an infinite distance apart it will always be greater than the stress outside. They will therefore repel one another.

Do not these cases seem to some extent analogous to the attraction and repulsion of electric currents? [Mentioned in (2) art. 40 of your "Modern Views of Electricity."]

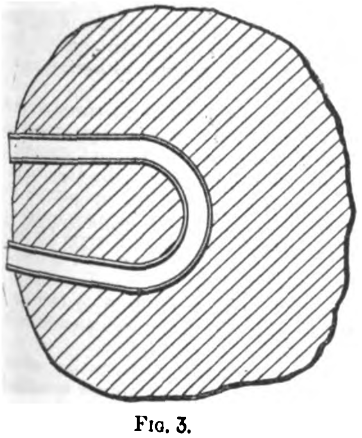


Fig. 3.

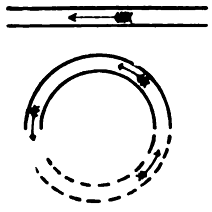


Fig. 4.

The difference is that the electric stress appears to be applied by a medium in which the conductor is free to move; while the current of liquid in the tunnel can get no farther than a mere ineffectual repulsion: unless it be actually true that a current flowing, say, in a thin indiarubber tube buried in cobbler's wax would really become circular in time. (Fig. 3).

You will see that the same principle of considering the form of current which produces minimum average stress in the solid provides an analogue for (3) article 40.

Also the starting, stopping, or varying of a current in one tunnel will certainly disturb the equilibrium of fluid in any other tunnel in the same block.

Take, also, the case of a current flowing in a tunnel shaped as a ring or helix. (Fig. 4). If there be another tunnel conveying a current, in the same block of solid, it will tend to turn so as to lie in the plane of the ring, or in a plane perpendicular to the axis of the helix. This, of course, corresponds to the action of a solenoid.

The mistake which you notice on page 166 as to the effect of a current of fluid on the form of a pipe seems rather to be due to an omission in the analogy.

Would not the following do?

| | |
|---|---|
| A tunnel in *a block of* elastic solid, conveying a fluid current, tends to become a circle; or, . . . is in the position of minimum potential energy when a circle. | A wire surrounded by dielectric, and conveying a current of electricity, tends to form a circle. |

The comparison of the cable and electric tramcars shows well the contrast of circumstances in which we are usually placed in comparing electric and mechanical phenomena. On page 96 of "Modern Views of Electricity" you have . . . "energy reaches the [cable] car viâ the rope and connector" (which transmit energy by static stress: not viâ the air which transmits energy by diffusion of motion with loss through heating). Again, "energy reaches the [electric] car . . . through the general insulating medium between cable and earth."

The only difference seems to be that the car in the one case is surrounded by fluid (a *conductor* of motion) and connected to the motive power by a rope of solid, which transmits the energy; in the other case the car is surrounded by dielectric (solid to *electricity*), and has only a rope of *conductor* (fluid to electricity).

I hope I have not annoyed you by writing so long a letter; my only excuse is that I am deeply interested in the subject, and I felt that it was a pity not to point out the amplification by which, I believe, your analogy between fluid and electric flow is made good. It had been my original intention merely to write a short note to tell you of it, but finding that the consideration of the flow of fluids in tunnels leads to the apparently useful results and analogies which I give above, I determined to include them. Hoping you will excuse the liberty I have taken, I remain

Your obedient servant,

Jas. Erskine-Murray.

Stud. Nat. Phil., Glasgow University.

## MR. RICHARD CHAMBERLAIN AND THE CHELSEA ELECTRICITY SUPPLY COMPANY.

**TO THE EDITOR OF THE ELECTRICIAN.**

Sir: On behalf of my Company may I ask you to kindly publish this letter in reply to Mr. Richard Chamberlain's very unfair attack upon the Company in the House of Commons on the 9th inst., an attack which Sir M. Hicks-Beach's reply showed was based by Mr. Chamberlain on complete ignorance of facts.

Mr. Chamberlain's question was whether the attention of the President of the Board of Trade had been "called to the long-continued default of the Chelsea Electric Supply Company to furnish the statutory current of 100 volts, and to the serious loss of illuminating power sustained by consumers in consequence," and he finished up his question by also asking whether the Board of Trade would take steps to compel the Company "to keep faith with the public or forfeit their concession."

Now, on behalf of my Company, I have to state specifically: 1. The Chelsea Company has not failed to keep faith with the public. 2. The pressure for this year has averaged over 100 volts (the statutory standard); but the regulations of the Board of Trade necessarily and specifically allow a variation of pressure of 4 per cent. above and below 100 volts, a variation, I may add, which of necessity takes place, and which is imperceptible to the consumer without the use of a delicate instrument. 3. There has never been a failure of light, and hardly any complaints (except from Mr. R. Chamberlain) have been received from customers, and these few have been remedied at once.

Why Mr. R. Chamberlain should use his position as a Member of Parliament to the detriment of a trading concern honestly doing its best, I am at a loss to understand; and if his remarks were made outside instead of inside the assembly to whom they were addressed, he would be brought to account for them. It is true my Company has not used Messrs. Chamberlain and Hookham's meter; but Mr. R. Chamberlain, I believe, possesses a "voltmeter," and, being a gentleman of leisure, studies this instrument with a view, if they fall below the statutory pressure, of pouncing upon the Company, he being ignorant of the standard. Whatever Mr. Richard Chamberlain's motives may be, my Board protests most emphatically against his attack (based upon an absolutely

Digitized by Google

erroneous view of the statutory rights and obligations) upon a Company which has not broken faith with the public, but which has, under great difficulties, successfully given a good and constant supply of electric light to a large and important district—a supply, I believe, more perfect than any other in the United Kingdom.—Yours, &c.,

J. IRVING COURTENAY, Chairman,
Chelsea Electricity Supply Company (Limited).
Draycott-place, Chelsea, S.W., December 10, 1890.

## THE TOMMASSI MULTITUBULAR ACCUMULATOR.

TO THE EDITOR OF THE ELECTRICIAN.

SIR,—My attention has been called to a note on the Tommasi secondary battery, which appeared on p. 130 of your last issue. This leads one to believe that this new battery is the invention of M. Donato Tommasi. This is not so. It is an exact description of Dr. Woodward's new battery, patent No. 6176, of 1890, a description of which I will supply you for publication at an early date, also a list of Dr. Woodward's many inventions taken out in connection with the electrical industry since 1874, which, I may say, include the first patent for an incandescent lamp, the sub-division of electricity, the multiple arc distribution of light, the modern storage battery, and numerous other inventions, many of which are worked and believed to be the inventions of others, probably without a knowledge of previous work actually done by Dr. Woodward. However, I believe in giving credit to those to whom credit is due.—Yours truly, ARTHUR SHIPPEY.

London, December 11, 1890.

# LEGAL INTELLIGENCE.

### Watt v. Maxim Electric Company—Maxim Electric Company v. Watt.

These two cases came before Mr. Justice Romer on Thursday last week. Mr. Rigby, Q.C., Mr. Sidney Woolf, Q.C., and Mr. G. F. Hart appeared for Mr. Watt; the Solicitor-General, Mr. Haldane, Q.C., and Mr. Marten for the Company. In the first action Mr. Watt claimed a large sum for salary due to him as managing-director, commission, rent of offices, money paid, and damages for wrongful dismissal from his office of managing-director, and for royalties on certain patents. In the second action, the Company claimed an account against Mr. Watt and damages on the ground of alleged improper dealing on his part, in taking commissions not really earned, for profits made by him on transactions in the shares of the Company, for neglecting to keep on foot certain patents, and for expenses of experimenting in connection with the patents which Mr. Watt now asserted to be his property.

Mr. WOOLF opened the plaintiff's case in the first action. He said the Company was originally known as the Electric Light and Power Generator Company, and some time in 1882 or 1883 Mr. Watt joined the Board. The Company was then in a low state, and by Mr. Watt's exertions it was put on a sound basis, and he altered its name to that of the Maxim Electric Company. In September, 1883, an agreement was entered into by which Mr. Watt became managing-director for three years, at a salary of £600 a year, and a commission of 5 per cent. on the net profits for each year. That agreement was acted on for three years, and on February 1, 1885, by endorsement, it was extended for another three years from Jan., 1886, but with this variation—that his salary was to be £1,000, £1 100, and £1,200, subject to six months' notice on either side. The plaintiff received his salary down to the end of 1886, and £1,000 for 1887, leaving £100 due to him, which formed the first head of claim. Then he claimed £70. 16s. 6d. commission on the profits for 1887. The plaintiff continued to act as managing-director to August 1, 1888, and the next claim was for seven months' salary, at the rate of £1,200 a-year. The next claim was for wrongful dismissal. The next item of claim was for money paid to clerks between August and October, 1888. The next claim was for a share of the Directors' fees, and the next for rent. An arrangement was made under which Mr. Watt's offices, 78, Queen Victoria-street, were to be used as the Company's offices, at a rent of £200, which was paid up to the end of 1887, and the books, &c., having been removed in June, 1888, plaintiff claimed six months' rent, and another nine months' in lieu of notice up to March, 1889, which would have been the earliest time when the Company could have properly determined the tenancy. The next claim was for royalties on certain patents for dynamos and lamps, in respect of which the defendant Company claimed to charge plaintiff for wages, and materials expended thereon in experimenting. Lastly, he claimed damages for the non-registration of transfers of shares executed by him, and that was now limited to 5,416 shares, though originally the number was put at 7,376.

The SOLICITOR-GENERAL opened the case for the Company, as above summarised.

Mr. HUGH WATT, M.P., was then called by Mr. WOOLF, and gave evidence in support of his own case.

The hearing was then adjourned.

FRIDAY, DECEMBER 5TH.

On the resumed hearing of this case Mr. HUGH WATT continued his evidence in support of the various claims he set up.

The item first dealt with was the royalties claimed by Mr. Watt on patents for the Watt dynamo and arc lamp, and the cross-claim by the Company for the expenses of experimenting with these patents. The minutes of the Board were referred to, authorising an arrangement for working the patents. Without using the patents the Company could not have carried on its operations. The patent for the dynamo was in his name, and he undertook to defray all charges in connection with it; the other patent was in Mr. Lee's name, and he had an assignment of it in August, 1888, but had arranged to purchase it previously. The Company could not find the money to purchase the patents, and he agreed to accept a royalty instead. The Company had all the machines and lamps which were manufactured under these patents to the value of £1,500. As settled by himself and the works manager, they had sold all their assets to a new company. He never concealed from the Company that he was the owner of these patents. He told the Board of his negotiations with Mr. Farquharson, the inventor of the dynamo, and that he would buy it and let the Company have the benefit. He did not recollect when he sent in his claim for the royalties, but he explained the whole circumstances to a general meeting.

The next item gone into was the claim for damages for non-registration, and the counter-claim by the Company for 5s. a share on 2,710 shares.

Mr. Watt was then examined as to the claim by the Company for excess commission overpaid in the years 1884 and 1885. The balance-sheet for 1884 was put in. It was submitted to the shareholders' meeting on February 18, 1885, and adopted. He believed it showed the true state of affairs, and his commission was paid accordingly, viz., £248. 15s. 6d., after the general meeting. On February 8, 1886, a Board meeting was held, when the accounts for 1885 were adopted and ordered to be circulated. There was a letter from the auditor accompanying his certificate, in which he said the balance-sheet was of an exceptional character. There was a general meeting on February 19th, when the balance-sheet was presented. The report and accounts were adopted. The profit shown for that year was £5,284, on which he received his commission, after deducting the balance brought forward of £2,430 and adding £3,606. 5s., which was carried to a reserve fund, being premiums on new shares. He received his cheque for £323 commission on February 2nd.

The SOLICITOR-GENERAL pointed out that this was before the balance-sheet had been adopted.

His LORDSHIP said the plaintiff was clearly liable to refund 5 per cent. on £3,606.

Mr. WATT, continuing, said he considered he had a right to treat the book debts appearing in the balance-sheets for 1884 and 1885 as good; the articles sent abroad were invoiced at prices fixed by the Board. In some cases the arrangement was that they should be paid for in six months; in others they were to be paid for when sold. The Company had a large stock, and the Board desired to realise it. The goods sent to the Mauritius he considered were sold out and out; the others were merely consignments. Including these accounts did not increase his commission; they would otherwise have appeared as stock, and the result on profit and loss would have been the same. With regard to the alleged profit made on the sale of shares in the Company, there was no truth in the allegation. With regard to allowing the patents to lapse, it was the duty of the secretary to see to those matters on the report of the patent agent. Those which lapsed were useless; they were all early patents, with one exception, which expired after he left the Company.

Mr. WATT was then cross-examined by the Solicitor-General as to the number of companies whose offices were at 32, Queen Victoria-street, as to the clerks employed by him on behalf of the Maxim-Weston Company, and as to the appointment of Mr. Howell as Director. Mr. Dever, in his letter of March 21, 1888, drew attention to the fact that the patents stood at a much higher figure than in the previous year, the increase being made up by transfers from the working expenses account of charges for experiments on the Watt dynamo and arc lamp. Witness at first denied that this was the case, but on being pressed admitted it. One item was £750, proportion of managing-director's salary; that was held to increase the value of the patents by that amount, and so to bring out a profit balance on which he was entitled to commission.

The remainder of the afternoon was occupied with questions as to the goods sent abroad on sale, the invoice prices of which were brought into the profit and loss account, and commission charged accordingly. Mr. Watt said he believed the accounts would have stood exactly the same if these goods had not been sent out.

The case was then adjourned.

SATURDAY, DECEMBER 6TH.

On Saturday Mr. WATT again took his place in the witness box for further cross-examination by the Solicitor-General.

Mr. WOOLF said he had had an opportunity of consulting his leader, Mr. Rigby, and he did not propose to contend further that Mr. Watt was entitled to commission on the £3,600 which was brought into the balance-sheet for 1885, and reckoned as profit, though it consisted mainly of premiums on shares. He also gave up the claim for nine months' rent of offices in lieu of notice, and to £70. 17s. 6d. commission on the profits for 1887, the balance-sheet for that year not having been duly certified, as it was evident now that Mr. Howell was not properly appointed a Director.

The SOLICITOR-GENERAL then continued his cross-examination with regard to the goods sent abroad, the invoice prices of which were brought into the account as cash; but after a few questions Mr. Watt said he had looked into the books and was willing to concede £100 on that head (the total amount claimed by the Company being £137), and the Solicitor-General said he would accept that rather than incur the expense of a minute inquiry into the exact figures. He then went into

Digitized by Google

the claim of £100 balance of salary for 1887. The Solicitor-General read out a list of twelve cheques to Mr. Watt during 1887, one in each month, of £100 each, and they were all entered in the books as for salary. Mr. Watt examined the cheques and admitted they were correct. The Solicitor-General pointed out that, instead of Mr. Watt being entitled to £100 more, he had been overpaid £100. The Solicitor-General next dealt with the claim for salary for the year 1888. Being an annual engagement, he thought he might contend that nothing was due for an uncompleted year.

After a little discussion, Mr. Woolf gave up the claim to the seventh month, the claim being admitted to the extent of £600, or six months.

The SOLICITOR-GENERAL said the next point he wished to establish was that no profits whatever were made from 1883 to 1888, and that none of the £323 paid to Mr. Watt as commission on profit ought to have been paid; £18C had already been struck off, and he would now show that the balance must also go.

One item put was Ralli Brothers, £42. 10s., for goods supplied in July, 1884, for which a cheque for £8. 11s. was accepted in settlement in October, 1884, but the full amount appeared in the accounts for 1885. Mr. Watt said he did not recollect the particulars of this case. Several other cases of a similar character were put, and the same answer given. The estimate of bad debts for 1885 in the report was £600, but it was not deducted in the balance-sheet. He admitted he was not entitled to commission on that £600, and that that allowance afterwards turned out to have been insufficient. In 1883, 1884, 1885, and 1886 he assisted Mr. Tough, the works manager, in valuing the stock. The value was held up at the original cost. Dynamos did not deteriorate by standing; they might get obsolete. He stated the facts to the shareholders at each general meeting; they followed the practice of their predecessors in this respect. In the year 1886 he directed those who prepared the balance-sheet to put up the price of some things in the stock-sheet, which had been at a lower price the previous year. Some dynamos had been unwound, and were afterwards rewound. He did not direct a Pooley's weighing machine, which had been previously valued at £5, to be put at £10. 10s. He should take the value of all such matters from Mr. Tough. The same answer applied to five vices taken in 1885 at £10, then increased to £13. The same with regard to a drilling-machine increased from £12 to £30, and subsequently in 1887 reduced again to £12. He knew nothing about the value of these things. He certainly did not suggest the over-valuing of stock in order to increase the apparent profit. The other Directors had a contingent interest in the profits, having a commission over 6 per cent. Several other items of a similar character were put. If he had noticed any such remarkable cases of increased value in the same machines he should have asked for some explanation from the works manager. A list of articles alleged to have been over-valued in this way was put in, and also the stock lists for 1835 and 1856, signed by Mr. Watt and the works manager. These books, when signed, were put before the auditors. Rough books or sheets were prepared beforehand. The rough book for 1887 was next shown to the witness, who was asked why the amounts therein were altered in pencil. He said they were not altered by him. Asked to read one of the alterations, he read, "One clock, superior, £2;" altered to £3. 10s. He thought that was in the writing of Mr. Wright, the secretary. Another entry to which his attention was called was "25cwt. steel, £20;" altered, in pencil, to 75cwt., £55; and then, again, altered to £60. The last figure was not his writing. He saw no figures in the book in his writing. He should make no alteration from interested motives. The only interest of anyone connected with the Company was to have the figures correct. He knew nothing about an atmospheric engine, put down first at £50, then altered in pencil to £100. It was not an engine which he referred to in a letter as having had at his own house, and ordered to be taken away as it was no good; that was a gas engine.

The SOLICITOR-GENERAL said his clients did not possess the signed stock sheet for 1887, but from the balance-sheet for that year it was evident that the signed list put before the auditors was made from the rough list now put in, and according to the increased figures.

Cross-examination continued: Electrical patents were constantly diminishing in value. From 1883 to 1887 the only reduction in the value was in 1885, when they were reduced one-half, and they were afterwards put up to about £40,000. They were entitled to any improvements made by the Maxim-Weston patentees. He did not know what the value of those American improvements would be. There was never any real valuation of the patents—he did not see how it could have been done; no depreciation was written off them. The auditor drew attention to the matter, but when it was brought before the shareholders they took the opposite view, and objected to reducing the value. The Solicitor-General said that on February 6, 1885, there was a meeting of the Directors, when the report and balance-sheet were ordered to be printed. Mr. Dever's letter was also read, in which he drew attention to the fact of the patents being held up at the previous valuation, and said he had the assurance of the chairman that that was justified. The general meeting was held on February 18th, and no notice appeared in the report of the meeting of Mr. Dever's letter being read. The Solicitor-General read an extract from Mr. Watt's speech at this meeting, in which he said that the new patents acquired by the Company within the previous 20 or 21 months were intrinsically worth the whole amount charged against the patents account, independent of all the others, and the improvements of the American Company to which they would be entitled up to 1887. At that time the patents stood at £70,000, but at the end of the year they were suddenly reduced to £35,0C0.

Mr. WATT, in answer to questions, said he could not remember what the new patents were to which he referred. Several patents were allowed to lapse, and by March, 1888, only three remained out of 14, besides the Watt dynamo and arc lamp patents. The Board decided in each case, as to allowing the patents to lapse, after consultation with the works manager. These things ought to be recorded in the minutes, but they might not always have been entered. Patents were allowed to lapse from 1883 onwards. Those which were abandoned were of no value. The three patents which remained were the principal ones on which the Company worked. He considered that the Company had made profits. Two dividends were paid. When he left the Company there was a very small cash balance; there were £10,000 outstanding accounts which could not be collected, owing to the disputes. The three patents remaining were not separately valued. They were judged of commercially, according to the amount of business they enabled the Company to do.

A considerable time was spent in endeavouring to obtain from Mr. Watt an explanation of the manner in which the value of the patents was arrived at, but without much light being thrown upon the question. Ultimately, in answer to his Lordship, he said that at the time he left the Company the three remaining patents were practically valueless, the only ones of importance being the Watt dynamo and arc lamp patents, which he acquired in order to enable the Company to compete with other manufacturers.

The case was then adjourned.

MONDAY, DECEMBER 8TH.

On the resumption of the case on Monday, the Solicitor-General gave a summary of the claims he still had against Mr. Watt.

After some discussion, Mr. Justice ROMER suggested that it might save a deal of time and trouble if, without going through all the items one by one, some general settlement could be arrived at between the parties. If there were a likelihood of this being done, he would rise for a short time to allow the parties to consider it.

Counsel on both sides expressed the hope that a settlement might be arrived at, and thanked his lordship for the suggestion. The Solicitor-General added that, as he appeared for official liquidators, he could only accept a settlement which received the sanction of the Court.

Mr. Justice Romer then left the Court.

The parties having consulted for about an hour, his lordship returned into Court.

Mr. RIGBY stated that a settlement had been arrived at. The settlement was to include all questions as between the Company and Mr. Watt, whether properly raised in this action or not. Mr. Watt would pay the liquidators a certain sum standing to his credit in respect of shares purchased by the liquidators. That sum, which had been put down at £330 14s., was standing to the joint account. The other money standing to the joint account would also be paid to the Company. Mr. Watt would, in addition, pay a sum of £669 6s. to make up, with the previous sum, £1,000. Then, as the actions had got so mixed up together, he had agreed, though there might have been some argument raised about it, to pay the taxed costs as between party and party of both actions. Further, it had been concluded, in order to make a settlement of all matters, that Mr. Watt should not pay any costs in reference to the winding-up petition, but in the costs proper of both actions those of the motion to rectify the register would be included.

The SOLICITOR-GENERAL, on behalf of the Company, merely added that the liquidators were anxious, as he had stated previously, to obtain his Lordship's approval of any terms at which they might arrive. He trusted the Court would consider, having regard to what had taken place, that the settlement stated was a proper one.

His LORDSHIP said he thought so, and that the parties had acted very wisely in the matter.

## SMITHFIELD CLUB SHOW.

The ninety-third annual show of the Smithfield Club has been held during the current week, and closes this day (Friday). The exhibitors include a number of well-known engineering firms, amongst whom may be mentioned Messrs. W. Allchin, the Atlas Engine Company, Brown and May, C. Burrell and Sons, Clayton and Shuttleworth, W. Foster and Co., John Fowler and Co., Garrett and Sons, Gibbons and Robinson, E. S. Hindley, Richard Hornsby and Sons, E. Humphreys, Marshall, Sons, and Co., Priestman Brothers, Ransomes, Sims, and Jefferies, Robey and Co., Ruston and Proctor, W. Tasker and Sons, E. R. and J. Turner, Wallace and Stevens, Weyman and Co., Woods and Co., Barford and Perkins, Blackstone and Co., and A. Dodman. A large display of machine belting was also shown, the principal stands being those of Messrs. Willcox and Co., W. W. Cobbett, J. Dawson and Son, the Gandy Belting Manufacturing Company, D. B. Hooke, Rands and Jeckel, J. Walker and Co., W. Eddington, T. H. Haagen, Son and Co., S. E. Norris and Co., Sheaf Brothers, and G. Thurlow.

Messrs. MARSHALL, SONS, and Co. are represented by a 10 horse-power nominal compound stationary steam-engine, erected underneath a locomotive multitubular boiler, fitted with Hartnell's patent automatic expansion gear, automatic sight-feed lubricator, and a steam-trap for draining the cylinder jackets, the engines being specially adapted for electric lighting purposes. This firm also show a 7 horse-power nominal portable engine, mounted on wrought iron travelling wheels with shafts; a 6 horse-power traction engine of great strength, with two speeds of crucible cast steel driving gear arranged inside the frame. The chief features of interest to our readers in Messrs. Marshall's exhibits are:—(1) A new pattern class "M" independent vertical engine cylinder, 6¼" × 10", fitted with Moore's crankshaft governor and automatic cut-off balanced slide valve, and a patent automatic sight-feed lubricator,

Digitized by Google

&c. This engine is specially adapted for electric lighting, ample provision being made for thorough lubrication, and the governor controls the engine, so that there is practically no variation in the speed with a shifting load. (2) A self-contained engine of the horizontal type, with cylinder 10″×14″. This engine has a force pump added; and Messrs. Marshall claim for it that it will be found a perfect engine for electric lighting or other machinery requiring very steady running.

Messrs. ROBEY and Co.'s exhibit includes a Compound "Robey" Engine and Locomotive Boiler combined, largely used for electric light installations, and for driving machinery where perfectly steady running is necessary, for which work it is specially adapted. This engine is extremely economical in fuel, consuming under 2lb. of best Welsh coal per indicated horse-power per hour. A High-speed Vertical engine is also shown, which has been specially designed for driving electric light machines on board ship, in flour mills, and where great power is required in a small space. It works with a high steam pressure, and may be arranged to run at various speeds. It is self-lubricating. When used for electric lighting it is mounted on a cast iron bed-plate, the other end of which carries the dynamo. The base-plate is provided with lugs and adjusting screws, so that the driving belt can be tightened without stopping the machinery, and forms a strong, durable, and compact motor. Messrs. Robey also show a long-stroke horizontal fixed engine, and several of their well-known portable and vertical engines.

As is usual at these shows, the electric light was conspicuous by its absence.

## TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

PRIMARY BATTERY INSTALLATION FOR SALE.—Our advertisement columns contain a notice of a sale by tender of a complete electric primary battery installation, comprising battery cables, volt and ampere meters, switches, and 36 hanging lamps with shades and holders. For further particulars application should be made to Messrs. C. Wallington and Co., Chartered Accountants, 4, Tokenhouse-buildings, London, E.C., to whom tenders are to be sent on or before Thursday, December, 18, 1890, at 3 o'clock.

TENDERS RECEIVED.—The request for tenders for installing the electric light at the Mullingar District Lunatic Asylum, Co. Westmeath, resulted in the following being sent in:—Siemens Bros. and Co., London, £3,713; Latimer Clark, Muirhead, and Co., London, £3,067; Rashleigh, Phipps, and Dawson, London, £3,064; W. T. Goolden and Co., London, £2,904; Edmundson, Dublin, £2,805; Fowler, Lancaster, and Co., Limited, Birmingham, £2,400; Crompton, Limited, Chelmsford, £2,310; Mather and Platt, Manchester, £2,310; Sharp and Kent, London, £2,277; Drake and Gorham, London, £2,261; B. Verity and Sons, London, £2,259; Manchester Edison-Swan Co., Limited, £2,205; Electric Engineering Co. of Ireland, £2,090; Gülcher Electric Light Co., Limited, London, £2,045; J. D. F. Andrews and Co., London, £1,950; J. E. H. Gordon, London, £1,850; Woodhouse and Rawson United, Limited, London, £1,790; Electric Engineering Corporation, West Drayton, £1,755.

BRISTÖL'S PORTABLE LAMPS.—Mr. Bristöl was recently awarded the diploma and gold medal at the International Exhibition of Mining and Metallurgy held at the Crystal Palace. This was, we are informed, the highest and only award given for electric safety lamps at the exhibition.

MR. JAMES JOHNSTONE.—Mr. James Johnstone, iron and metal agent, 51, St. Vincent-street, Glasgow, has been appointed agent for the Northern Electric Wire and Cable Manufacturing Company, Halifax, and for Messrs. V. George-Frère, Charleroi, Belgium.

THE LIGHTING OF THE GLOBE THEATRE.—In our note of last week we incorrectly stated that the contract for lighting the Globe Theatre had been given to Messrs. Dickenson and Co. The firm who have secured the contract are Messrs. C. E. Gilbert and Co., of 16, Hanway-street, Oxford-street, W.

MESSRS. GIRDLESTONE, TATHAM, AND CO. The members of the cricket and football club in connection with this firm held a smoking concert on Friday evening last, December 5th, at the Horse Shoe Hotel, Tottenham Court-road. The chair was occupied by Mr. Tatham, and there was a good attendance of the members and their friends.

MESSRS. A. AND E. ROBINSON.—We have received from this firm illustrated price lists and particulars of their patent air engine. Accompanying the price lists are testimonials from users of the engine, for which Messrs. Robinson claim several advantages, and more particularly its usefulness where room and attention are not available.

## PATENT RECORD.

### APPLICATIONS FOR PATENTS.

**NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.***

November 27, 1890.

19,308. J. S. SWINBURNE. Teddington. Improvements in and connected with electrical distribution of power by alternating currents, and their measurement.

19,315. H. NUNNS. London. Improvements in electric arc lamps.

19,344. E. PLACET and J. BONNET. London. Improvements in electrolysis in general, and particularly in electrolysis of metals.

19,345. A. J. BOULT. London. Improvements in suspension devices for incandescent lamps. (H. Rentzsch, Germany.)

19,355. S. BACON. London. An improved electrical connection or plug.

November 28, 1890.

19,406. E. HARTMANN and W. BRAUN. London. Improvements in electric current meters.

19,418. G. HANNAH. London. Improvement in electrical tell-tales for twin-screw steamers.

19,423. E. A. DUCRETET. London. Improvements n apparatus for the electrolytic production of gases.

November 29, 1890.

19,467. J. P. BAYLY. London. Improved electric arc lamp. (A. Wagnière, U.S.A.)

19,485. H. E. G. EARLE. Southampton. Automatic railway signalling by electricity.

19,486. A. R. BENNETT. Manchester. Improvements in telephonic switching apparatus.

19,496. J. F. MUNSIE. London. Improvements in insulators.

19,505. A. WYLIE. London. Improvements in the method of, and in the machinery for the manufacture of lead or metallic boxes and plates for electric accumulators, and other kinds of lead or metallic boxes, plates, tubes, rods, and strips of irregular section, or plain, ribbed, corrugated, and fluted by hydraulic pressure.

December 1, 1890.'

19,509. W. H. PIKE. London. Electric sewing needles, knitting needles, pins, pens, and the like.

19,555. F. A. OETZMANN. London. A portable room for telephone.

### SPECIFICATIONS PUBLISHED.

1889.

18,361. DE FERRANTI. Electric meters. (Price 6d.)

19,285. CAMPBELL. Ships' electrical signalling apparatus. (Price 8d.)

20,645. DEARLOVE. Telegraph cables. (Price 4d.)

20,955. WOOD. Dynamo electric machines. (Price 1s. 5d.)

1890.

16,124. FAIRGRIEVE. Electric clocks. (Price 8d.)

16,322. CURRIE. Electric batteries. (Price 8d.)

16,324. LLOYD. Battery plates. (Price 8d.)

## COMPANIES' MEETINGS & REPORTS.

### Montevidean and Brazilian Telegraph Company (Limited).

An extraordinary general meeting of this Company was held at the offices, Langthorn House, Copthall-avenue, on the 10th inst., Dr. Cameron, M.P., presiding, when the subjoined resolutions, which were passed at the extraordinary general meeting of the Company, held on the 25th ult., were submitted for confirmation as special resolutions.

1. *That the Company be wound up voluntarily under the provisions of the Companies' Acts.*

2. *That George Fraser, F.C.A., be and he is hereby appointed the liquidator to conduct such winding up.*

3. *That the agreement submitted to this meeting, dated November 3, 1890, and expressed to be made between this Company, of the one part, and the Western and Brazilian Telegraph Company (Limited), of the other part (being an agreement for the sale and transfer to the Western Company of the whole of this Company's undertaking), be and the same is hereby approved. And that the liquidator be and he is hereby authorised, in pursuance of Section 161 of the Companies' Act, 1862, and of all other powers enabling him in that behalf to carry said agreement into effect with such modifications (if any) as he may think expedient.*

4. *That the liquidator be and he is hereby authorised to receive, and when received to distribute amongst the holders of Preferred shares in this Company the rent accruing to this Company from the Western and*

Digitized by Google

*Brazilian Telegraph Company (Limited) for the year ending December 31, 1890.*

5. *That the shares in the Western and Brazilian Telegraph Company Limited), to be received as the consideration for the sale and transfer to them of this Company's undertaking, shall be appropriated as follows:—*

*To the shareholders in this Company in exchange for their shares at the rate of one share in the Western and Brazilian Telegraph Company (Limited) for each two shares in this Company.*

*To the holders of Debentures of this Company in exchange for such Debentures at the rate of ten shares for each £100 of Debentures.*

*To the liquidator in satisfaction of his remuneration, and to the Directors and officers of this Company, as compensation for the loss of their offices, 155 shares.*

*The remaining shares to be sold, and the proceeds after payment thereout of the expenses of the liquidation, other than the liquidator remuneration, to be distributed amongst the shareholders in this Company pro rata, according to the number of shares held by them respectively.*

The SECRETARY (Mr. James Fraser) read the notice convening the meeting.

The CHAIRMAN said that the only business was the confirmation of the resolutions passed at the late meeting.

Mr. POTTER (the only shareholder, as such, who attended the present meeting) was at the former meeting, of which the shareholders had been furnished with a full report. He had nothing to add to what he then said, except that they had received as emphatic approval, in the shape of proxies, for the confirmatory meeting as they received for the recent meeting. They had, on the present occasion, received proxies for 7,613 shares. He concluded by proposing the confirmation of the resolutions.

Colonel MACAULEY seconded the motion, expressing the opinion that the shareholders had got very well out of the affair. The property was depreciating every day.

The CHAIRMAN put the motion, and it was unanimously agreed to.

Mr. POTTER proposed a vote of thanks to the Chairman, adding that he thoroughly appreciated what had been done by the Directors, as, no doubt, did the other shareholders.

Mr. CRISP (the solicitor) seconded the motion. If Dr. Cameron had not come into the concern when he did, and taken the helm of affairs, he was sure that the whole thing would have gone to pieces.

The CHAIRMAN, in reply, said that since he had been in the Company he had had the most cordial relations with the shareholders.

The meeting then separated.

## The Fowler-Waring Cables Company (Limited).

The second ordinary general meeting of the Fowler-Waring Cables Company (Limited) was held at Winchester House, Old Broad-street, London, on Friday, December 5, 1890, under the presidency of William Fowler, Esq.

The SECRETARY (Mr. George Neill) having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen, I have to move "that the report and accounts, as delivered to the shareholders, be received and adopted." When I met you here almost to a day a year ago, I certainly anticipated that we should have made rather further progress than we have during that time. We have had, as stated in the report, unexpected delays, and the consequence has been that we have not been as far forward as we expected to have been a year ago; but I am glad to tell you that we have now obtained that which we always intended to have, namely, a factory in most excellent order, and ready to do a very large and, I think, hope, and believe, a very profitable business in the future. You will all agree with me, I am sure, that these delays are almost a matter of course in all industrial undertakings. They certainly have been greater than we expected; but it is of no use troubling ourselves about that if we are now in the position we desired to be in: and in reference to that there is one very important observation that is, the question of management. Now, for some months past we have had a manager who, I believe, will prove to be—as I think he has proved to be—a most excellent manager. I do not think I ever met a man who impressed me more favourably in his position, and I am thoroughly satisfied that we have now got the management we wished to have; and that, I need hardly say, is the most important question we have to consider. If we have good management, I do not think there is the smallest doubt that we shall have a profitable business; but if we have not good management, no business of this kind—or, in fact, of any kind—can be profitable. I wish also, with reference to that, to say that the manager is not merely a man who goes down from London and looks at the place, and comes back again, but he resides in the factory, and is therefore able to maintain a continual supervision, which is of the utmost importance, as I think you will all agree. Now I should very much like for any shareholder who feels any doubt about the present position of the Company to go down and make an arrangement with Mr. Mavor to look over the place. I think he will then agree with me in the feeling which I had when I was last there—a few days ago—that the position of the factory is a remarkable one—not only the position as regards the place where it is, but the excellence of the supervision and the most superior quality of the work. If anyone desires to see what the work is, an inspection of the samples made at the factory which are at the offices of the Company at 85, Queen-street, Cheapside, would satisfy anyone with the slightest knowledge of the subject that the work done is of the most excellent character. Now, the report states so clearly—combining the Directors' report and the manager's report—the exact position of the business that it is not necessary for me to enter into details. I have stated generally that we regret the delays, and we regret that we have not been able to pay you a dividend in the first year of our existence. We ought not, perhaps, ever to have expected to do so; but we had hoped we should. I have one observation to make, which is somewhat of a personal character, namely, that as we have not made any profit for you, we have taken no fees ourselves. We have, however, had very hard work, I can tell you, and a great deal to do and think about; but we have taken nothing for our work, considering that we have not made a profit for you. I wish also to make another personal observation. Leaving myself entirely out of the question, and regarding myself as a person not to be mentioned, I do not think you could find a more intelligent or diligent Board in the whole of London. I should also like to say one other word of a personal character, and that is, that I feel we are all very much indebted to Mr. Eddison for the hard personal labour which he imported into the business at a very critical period, before we obtained the manager we now have. Gentlemen, I do not think I can add anything more to what I have said which would be of interest to you. The business is a very important one, and I hope and believe, though I am a man very jealous of making promises or of expressing confident anticipations (because I know the uncertainty in all business, from long experience), I do believe that this will be a most important, and, in the end, very profitable business. I think it is a business of great interest. It is a very singular and curious business, you may say, but I think it is a business which has in it the elements of a great success, and certainly it is one which is of a very interesting character. I do not think there is anything more I can add, and I can only say that if any gentleman wishes me to give him any further particulars beyond what I have furnished, or which are not mentioned in the report, I shall be very happy to give them to the best of my ability. I now beg to propose the motion which I have submitted already.

The Hon. J. S. GATHORNE-HARDY, M.P.: I beg to second that.

The CHAIRMAN: If no gentleman has any question to ask on the motion I have put to you, you have heard it, and those who are in favour of it will please to signify the same in the usual manner. On the contrary. That is carried unanimously.

On the motion of Mr. E. J. VAUGHAN, seconded by Sir HENRY EDWARDS, the auditors, Messrs. Cooper Brothers and Co. were reappointed.

The CHAIRMAN stated, in answer to Sir Henry Edwards, who thought the auditors' remuneration too large (50 guineas), that the matter should be considered. The Chairman afterwards observed that some of his colleagues thought he ought to say that while they most cheerfully waived their fees on the present occasion, the shareholders might be inclined—supposing, as he hoped, the Company had a "rattling good year" next year—to award the Directors some remuneration for the past as well as for the current year. This, however, was a matter entirely in the hands of another meeting.

Mr. VAUGHAN intimated that at a future meeting he would feel it his duty to suggest for the consideration of the Board whether so many as seven Directors were required, seeing that they had an experienced manager.

The CHAIRMAN replied that the remuneration of the Directors was settled by the Articles of Association, and the shareholders could not alter it unless the Directors chose to waive it, or part of it. He did not think, therefore, that reducing the number of the Directors would reduce their remuneration, and, as far as he was concerned, as Chairman of the Company, he did not know which of the Directors he desired to get rid of. This question, however, was not before them now, the business of the day being concluded.

Mr. VAUGHAN said he thought they had a most capable Board, and it would be a very invidious task for him, or any one, to select any member of it whom they could dispense with. He hoped, however, that the Directors would consider his suggestion, and would not ask for the re-election of absolutely every member of the Board.

The CHAIRMAN observed that there might be legal difficulties about the point; but he thought, from the way in which the Board had acted that day, that the shareholders might rely on the Directors dealing with the question in a liberal spirit.

Mr. WELLBORE ELLIS proposed a vote of thanks to the Directors for the way in which they had managed the Company's business, and to Mr. Eddison for his services. He thought they ought not to say that they required fewer Directors, for he felt sure that all these gentlemen would more or less bring the Company business.

Mr. SMART seconded the motion, which was carried unanimously.

The CHAIRMAN, in acknowledging the vote, assured them that the one desire of the Directors was to make the Company, not only a success, but a great success, and he believed they would do so.

The proceedings then terminated.

## Electric Construction Corporation (Limited).

The first ordinary general meeting of this Corporation was held on the 8th inst., at Worcester House, Walbrook, under the presidency of Sir Henry C. Mance.

The SECRETARY (Mr. F. Walton) read the notice convening the meeting, and the auditors' report, dated November 24th, as follows:—

"To the Members of the Electric Construction Corporation (Limited).

"Gentlemen,—We have audited the accounts from the commencement of the Company, viz., June 7, 1889, up to September 30, 1890, and have examined the profit and loss account and balance-sheet with the books, vouchers, and accounts.

"The sum of £121,963. 12s. 5d. on the credit side of the profit and loss account is represented to a great extent by shares which stand in the balance-sheet at par. It is impossible to say what is the exact amount that ought to be carried to capital account in respect of the cost of patents sold and depreciation caused by the licences granted, but we think the round sum of £100,000 should be ample. In connection with these financial transactions there is a contingent liability for uncalled capital, about

Digitized by Google

£90,000, but any payment in respect of this liability should increase the assets of the Corporation.

"We are informed by the managers of the works at Wolverhampton and Millwall that the plant and machinery have been fully kept up out of revenue, but we think it advisable that a considerable sum should be placed as a reserve for depreciation, and beg to suggest that the Directors' recommendation of placing £15,000 as such reserve should be adopted.

"One of the subsidiary sets of books do not balance by the sum of £1. 18s. 5d., and so much time has been occupied in endeavouring to find this difference that the completion of the audit has been delayed.

"We believe sufficient reserves have been made to meet any error affecting profit and loss account.—Yours faithfully,

"(Signed) BROADS, PATERSON AND CO."

The CHAIRMAN: Gentlemen, I have now the pleasure of presenting to you the reports and accounts of the Company for the period ending September 30th this year, and I presume that in accordance with the usual custom you will prefer to take them as read. That being the case, I will proceed without further delay to go through the accounts, and just touch on a few of the items that seem to me to require a little extra explanation. Now, commencing at once on the credit side of the profit and loss account, the first item is £4,061, on account of the apportionment of profit. I may explain that this represents the amount which, after liberal deductions for depreciation, cost of experiments, &c., the auditors certify as profit not belonging to capital. Although we took over the benefits of the working of the Elwell-Parker Company from September, 1888, we are not allowed to count towards revenue any profits that we made before the date of the incorporation of this Company. These profits go, therefore, to increase the capital value, and do not appear in our profit and loss account. There is some little difficulty in apportioning the exact amount of the earnings for the period mentioned; but you may take it that it is roughly approximate. Probably it has been put too low, but you will understand that if you have not these earnings set out as profits, you have them in the increased value of the business which we acquired. It is simply a matter of account. The items work, sales, and expenses speak for themselves, and I have only this remark to offer—that in considering the net trading profits it would be fair to include a considerable portion of the item that follows of £14,000 charged against head office expenses. This should be deducted to arrive at the net trade results. I may also point out that the head office expenses are for a period of nearly sixteen months, not twelve months. In connection with the item of interest on temporary loans, it is desirable to mention that in order to complete our engagements with the vendor, it was necessary to obtain temporary advances from the bankers. A part of this item might, therefore, fairly have been charged to capital; we think, however, that it is of more importance to put the affairs of the Corporation on a sound financial basis than to present to you too glowing a balance-sheet, and the same principle has been applied here as in the item of preliminary expenses and the "other expenses" item—that is to say, the whole of the expenditure has been written off against the first year's working. Further, with respect to that item of "other expenses," you will, of course, easily understand that advertising must always be a serious cost, as, if it is worth doing at all, it ought to be done well. A considerable portion of that sum, £3,918, is made up by the estimated cost of goods which were sent to the Edinburgh Exhibition, which, practically, is another form of advertisement. In pursuance of our policy to be on the safe side if possible, and bearing in mind the fact that returned goods are often very much depreciated in value, we have written off the entire cost of these goods, and if anything is realised eventually from them, it will come into the accounts as net profits. Then we have cash and shares—£121,900. When the Corporation took over the businesses that we have acquired, there were foreign patents of undoubted but undeveloped value. The patent fees themselves were a heavy charge, while the income was nominal. These patent fees, I may mention, are included under the heading of head office expenses. The Directors have made it their business to realise these foreign patents by handing them over to a subsidiary company. To a great extent this item is represented by paper only, that is to say, so far as the purchase-money for patents is concerned, they having been paid for in shares. The result of the transfer has fairly justified the expectations of the Directors, for not only has a drain upon revenue been stayed, but the transfer of these foreign patents has resulted already in a most satisfactory development of business in the countries concerned. Upon paper these transactions show an extremely satisfactory profit, but the shareholders will, I am sure, support the policy of the Directors in their decision not to apply any profits of the sales of patents to the credit of revenue until the present patent account has been practically written off. While on the subject of patents, I may mention that both at Millwall and Wolverhampton we are always experimenting in order to keep up with the business of the day, and it sometimes happens that in working on one thing we discover others which are even of more value than the object originally sought for. When we took over the Elwell-Parker business one of the patents which, I may say, was lying dormant at the time, was a method of obtaining phosphorus by the assistance of electricity from phosphate of aluminium. I regret that the gale of wind which we had in November damaged our buildings there, and therefore the experiment is not sufficiently advanced to allow me to say anything certain to-day, but Mr. Parker and his co-inventor, Dr. Reedman, are very sanguine—as inventors usually are—and they have every hope of bringing it to a successful issue. You may remember that the aluminium business has been completely revolutionized by the application of electricity, and I see no reason why we should not be equally successful with the phosphorus. Be that as it may, we risk very little, and I am sure we shall gain most valuable experience by our electrical furnace, from which I believe that great applications of electricity will be made in the future. With this little digression, we will go on with the balance-sheet, which I hope you will consider is a very good one, remembering that it is for the first year that we have had to get custom together, and that we have not had the benefit of our new works. I do not think that there is much for comment, but I should have liked to see a much smaller amount under the heading of calls in arrear. We all of us know, however, that in the City of London we have passed through a very critical and trying time, and no doubt many gentlemen have found it very difficult to meet all the claims upon them. I trust that in next year's accounts this item will disappear altogether. The liability for trade accounts includes, I may tell you, a substantial sum for reserve without there being any apparent probability of our being called upon to use it. The capital liability of £17,555 has been considerably reduced—in fact, almost paid off since September; but there are still outstanding liabilities for the completion of our Bushbury Works, and other matters which are in course of adjustment and settlement. The loan on provisional debentures has also been materially reduced out of our current receipts. The item of contingent liabilities is one which the auditors have dealt with in their report. Our contract, as far as contract goes, for the equipment of the Rathbone-place and Manchester-square stations of the Metropolitan Electric Supply Company are now almost completed, although there is a responsibility attached to the running of the machinery which does not expire for some time. With regard to the liability on shares partly paid up, there is not much probability of the contingent liabilities for calls becoming actual liabilities to any great extent. The matter is practically in our own hands, and calls of this nature upon our resources would arise only in the event of such a development of business on the part of the subsidiary companies as would be a matter of congratulation for all of us. As I have already mentioned, the whole of the preliminary expenses have been written off, and will not appear again. Now turning to the credit side of the account, you will notice that the purchase-money of £397,300 has been reduced by the value of stock and book debts. This is a matter of book-keeping only—the items reappear below. But you will also observe that the purchase cost of our businesses has been reduced by the further item of £100,000 for licences and patents sold, and this, you will agree with me, is not a mere matter of book-keeping, but a matter of considerable satisfaction and congratulation, and I hope this policy and our ability to adopt it will continue in future accounts. Our capital expenditure since the acquisition of the businesses has practically been limited to the new Bushbury Works. The cost of these works has been great, much greater than was originally contemplated; but we have felt ourselves bound to meet requirements, and our action will, I am sure, be justified by the increased capacity which it gives us for turning out work. I think this policy will commend itself to the shareholders—that although it is very good to make profits by means of subsidiary companies, still we must bear in mind that we must look to the payment of our future dividends to our manufacturing profits. It is, therefore, our duty to put this Company in the foremost rank of manufacturing companies. We have endeavoured to do that. It is not enough that we should have a character for turning out good work, we have that; but you must have a reputation for turning it out promptly, punctually, and with despatch. You must be able to turn out a large amount of work in a short time. We have had to refuse orders in the past year because we could not guarantee quick delivery. I hope that that will never occur again; and I believe that we have put at your disposal a factory which can be extended so as to meet all requirements that are likely to be made upon you in the future. I think when you see these works—and we had hoped to meet you there to-day—you will agree with us that your money has been very well spent. It is, in my opinion, the finest manufactory in the world as far as I know. The freehold ground on which the Bushbury works stand has an area of 21 acres. The works themselves occupy a space of over six acres. There is access to the London and North-Western Railway adjoining by means of a siding. The canal is close to one end of the place. There is excellent water on the property, and every facility for extending the works, and I think we could dispose at a profit of ground which we are not able to use for some years, or we might utilise such part of the property for the building of workmens' cottages. The item of book debts, amounting to £104,882, includes a claim upon the vendor for liabilities of the business purchased paid by the Corporation amounting to £12,091 odd. You must not assume this to be a case of over payment to the vendor. The amount which we paid to the vendors for the business was exactly the sum which we contracted to pay, but the conditions under which the vendor acquired the business of the Electrical Power Storage Company (Limited), and the conditions upon which we acquired the business from the vendor were a little different, and that leads to this result, which is satisfactory to us if not to the vendor. The vendor purchased the business at a price sufficient to pay all liabilities and a certain sum to the shareholders, and the calculation was apparently based upon the accounts as they stood at the previous stock-taking. We purchased the property from the vendor at a fixed sum, free from liabilities. Now it happened that between the period of the stock-taking and the purchase there had been an augmentation of business, which is not always usual in the case of businesses handed over to companies, and the result is that the assets and the liabilities in respect to those assets were alike increased. We took over the assets in accordance with our contract, and it was the duty of the vendor to discharge all the liabilities. Having regard to the difficulties of such a course in a current business, provision was made in our contract that in the event of our discharging any of the liabilities the vendor would recoup us the amount. Probably the vendor may have been surprised that the amount was so large; but the matter was gone into and equitably settled, and since the date of our report the claim has been settled. I do not think I have any further remarks to make about the accounts. Looking at the numerous applications which will be made for provisional orders in the future, and seeing the steady progress that has already been made by different supply companies, I do not think we can have any doubt as to the future of the electric light; but great as the field is in this

Digitized by Google

respect, I think it is likely to be eclipsed by the demand which will be made for electricity for other purposes. There are not wanting signs in this and other countries of activity in many branches to which electricity can be applied. In America the motor industry is even greater than that of the electric light. The electric light is said to be a luxury, but the time will come when it will be considered an absolute necessity ; and in the case of electric power, we are not only better than anyone else, but also cheaper. We then come to business men who do not spend a penny without expecting to get back for it a penny farthing. That is where I have great belief in the transmission of power by electricity. I was shown over a factory the other day, and the manager said to me that every new machine he laid down he would apply electricity to. At the Bushbury Works we use electricity for the cranes, saws, lathes, and heavy machinery. There is one point on which the Directors have been a little disappointed, that is in connection with train lighting. With my failing sight I speak very feelingly on this matter. Anyone going by the 5 o'clock train from St. Pancras must be convinced at once of the beauty and superiority of this method of illuminating the trains. In dealing with directors of railway companies however, you are dealing with a very conservative body of men, who are more inclined to look at first cost than the convenience of their passengers ; but I hope if any of you are shareholders in railway companies you will at their next meeting impress upon them the desirability of introducing this beautiful illuminant into their service. We have been more fortunate with electric traction. By the assistance of Mr. Smith—than whom, perhaps, there is no greater authority on this matter—we have been able to introduce electrical tramcars at Birmingham, where they are now working, and, I believe, in a very satisfactory manner. I hope this is only the first of a long series of similar installations. Seeing that we have these developments in electricity going on, that we have important contracts, and that we have incurred a large expenditure on new works, we think the time has come when we should ask you for more capital. We should have asked for this before, but the time has not been propitious, and acting on the advice of our financial advisers we have put it off. In order to enable us to secure the full advantage of the great boon, as I believe it will prove, in electric lighting and traction, we propose to issue £150,000 in 6 per cent. debentures. We have postponed this as long as possible, but we think we should now be neglecting your interests if we did not make the issue early next year at least. We hope these debentures will be to a large extent taken up by the shareholders, and I can assure you that the Directors will be quite prepared to take more than their share if necessary. There will, of course, be a public issue, so as to enable us to obtain a Stock Exchange quotation later on for them, but our own shareholders will receive the preference. I suppose all our shareholders are aware that we have a Stock Exchange quotation for our shares. That is all I have to say, and, after hearing any questions which shareholders may have to ask, I shall put the motion for the adoption of the report and accounts.

Mr. J. SPENCER BALFOUR, M.P. (the vice-chairman), seconded the motion.

Mr. MANDER spoke of the large interest which he and his friends had taken in the Company on account of their faith in the future of electricity. He regretted, however, to see that the Directors had been promoting companies instead of confining themselves to the manufacturing business.

Dr. DRYSDALE spoke of the great use of electricity for traction purposes in America, and asked whether the Directors thought it probable that electricity would be shortly used in London as the motive power for tramcars.

Mr. HANCOCK considered that the Board ought to place more to the reserve, in order to meet the expiration of the patents. He also urged the Directors to confine their attention to manufacturing instead of to the formation of companies.

Mr. JUDD thought that the Directors ought to be congratulated on the result of the sixteen months' working, seeing that the application of electricity to many purposes was still in its infancy. He thought that the Board, in forming subsidiary companies, had had in view the object upon which the previous speakers had laid stress, of enabling them the better to confine themselves to manufacturing.

Mr. BALFOUR: There are one or two questions which have been asked that I might probably reply to more easily, as I have been Chairman of the Finance Committee of the Corporation almost since its establishment. A suggestion was made by Mr. Mander, which I am disposed to view with considerable favour—that is as regards the Millwall depot, and I hope the time will come when we shall be able to concentrate the whole of the works of the Corporation—I cannot say under one roof, but in one spot in Wolverhampton. I quite agree that that would be desirable. It is so obvious a course, that Mr. Mander ought to give the Board credit for having thought of it at first. But the displacement of a large amount of machinery, a large staff, and the transfer of works such as ours, is a serious and somewhat expensive task, and the Board have had to proceed with caution in that respect. The works, as the Chairman reminds me, have only just been finished, and I think we are indebted to everyone for the success with which we have been able to shift over from one place in Wolverhampton to another without undertaking the more serious task at present in connection with the transfer of the Millwall works. I think there has been some misapprehension about the formation of subsidiary companies, and I thank Mr. Judd for the way he put that matter, and which is the correct way exactly. We have some patents which the Board are advised are of enormous value. Patents of that sort require development. In some cases, hostile interests have to be conciliated; in other cases inventors have to be brought in to assist, and in those cases it would be absolutely impossibly for the Company to go on with its ordinary work of manufacturing if it had to run these patents too. In such cases only have the Company sought to encourage the sale of patents to any sub-company, and in all such cases the sale has been made on such terms as will secure to the Corporation a very large share—certainly its full share—of the value of these patents until they are developed. It would be impossible for us ; how can we do manufacturing simply if at the same time our attention is taken up by sending people, say to Madrid, Constantinople or Rome, to deal with our foreign patents ? These matters must be dealt with by foreign companies, and the Board is under very great obligations to Mr. Courtenay—if the remark in question is meant to apply to that gentleman—for bringing his extensive knowledge, which is probably unrivalled in Europe on questions of electricity, and putting it at the disposal of the Company. As to our hour of meeting, it is difficult to please everyone. The Chairman says he had to get up at six to attend this meeting.

Another DIRECTOR: So did I.

Mr. BALFOUR: The Board would be very glad to hold the meetings of this Company at any time that was most convenient to the shareholders, but I do not myself think that there is much grievance in our meeting at twelve o'clock. With reference to the head office expenses, I expected the criticism. As the Chairman, however, has said, the head office expenses are for sixteen and the profits for only twelve months, so the same amount of expenses will not arise again. I have urged the Board—and I am sure they will do so now—that they should have more time at their disposal to overhaul the head office expenses, to see whether economies can be effected. It is, however, extremely difficult for us to cut our expenses down to the level of those of an ordinary business. We are asked for the price of equipping a local tramway, or of a large installation in some part of the country. The man whom we send down to report on such a thing as that—who has to get out the figures, arrange the drawings, and to meet the various local authorities ; the man, in fact, who has to secure the business, must be in manner, bearing, and address a gentleman. He must be highly paid, or he would be open to bribery and so on. These expenses must be large if we are to retain some of the most profitable work that we have. I shall, however, watch the expenses. The whole business of my life is to put down expenses whenever I can, and my services are at the hands of the Corporation to secure that end here. With respect to the remarks of Mr. Hancock, I do not think that he should really have put it that we have any cause for disappointment for these figures, or the dividend which is proposed to be paid. Remember these accounts have not been got out or put together, or "cooked" by the Directors. We have made it a *sine quâ non* from the first that our accountants should give us a continual audit, that our accounts should be under supervision from week to week and day to day, and that they should be under the supervision of a firm of high standing in London. Our auditors are coming in at every moment. They see our growth, and they know every item of the business ; and I venture to say that if we had not had the restraining influence of the auditors, and did not wish ourselves to pay only a moderate dividend, we could have shown a much more favourable result. Our policy, however, has been to over-estimate expenses, and to under-estimate profits, so that we might produce accounts which we would all stand by. One or two questions were asked which I do not think we need say anything more about after what I have said about company-mongering. With respect to the issue of Debentures at 6 per cent., we should all agree that 6 per cent. is a good rate to pay on Debentures ; but I think shareholders will realise, if they watch the market, that most industrial companies of this kind have still to pay 6 per cent. on their Debentures. We can, however, make the rate 5 per cent. as easily as possible if the shareholders will only take up the Debentures and only accept 5 per cent. We should be perfectly ready to issue them at that price. I am quite prepared, and so are the other Directors, to take their proportion of Debentures bearing 5 per cent., and if the shareholders will only do the same, we can issue them at once at this lower rate. We have, however, to study the market, and to remember that electrical companies are still viewed with disfavour, a feeling which I believe that this report will do much to dissipate. As to electrical traction for tramways, I was a few days ago in the north of England, and one of the most eminent engineers of the day volunteered a very interesting statement to me. He said he had been to Birmingham, and speaking about the working portion of the tramways there, the motive power for which is electricity, he said he considered that the question was solved, and solved in the direction they were wishing. He also said that he regarded the work there as of the utmost importance, and redounding to the credit of this Corporation and everyone connected with it. We have seen nothing to cause us to doubt of its ultimate success, and, as far as the report is concerned, we have taken pains to present you with an honest, trustworthy, and faithful statement.

The CHAIRMAN said he thought that the whole of the questions that had been put had been answered by the Deputy-Chairman, and therefore he put the motion for the adoption of the report and accounts.

The resolution was carried unanimously.

The CHAIRMAN next proposed the declaration of the dividend recommended.

Mr. BALFOUR seconded the resolution, which was carried.

On the motion of the CHAIRMAN, seconded by Dr. DRYSDALE, the retiring Directors, Sir Daniel Cooper, Mr. Balfour, Mr. Courtenay, and Mr. Dibley, were re-elected to their seats at the Board.

Sir DANIEL COOPER, in acknowledging the re-election of himself and colleagues, stated that he was connected with the old E. P. S. Company for seven years, and he could bear out what the Deputy-Chairman had stated as to the difficulty of managing the foreign portion of their patents. Mr. Courtenay and himself were both Directors of the old E. P. S. Company, and that part of their duties, which occupied most of their time and attention, and which gave them most annoyance and dissatisfaction, was the foreign portion of the patents. The idea of persons in London working patents on the Continent was a mere delusion, and, therefore, the forming of their subsidiary companies had been almost a matter of necessity. It was better to throw the foreign patents away altogether than to try and attempt to work them from

Digitized by Google

London, and, therefore, anything which they got at all out of these patents would be so much profit. This could only be done through subsidiary companies. It was impossible to get a profit in any other way. What had been done in the case of this Corporation in forming subsidiary undertakings had had nothing whatever to do with company-mongering.

Mr. MANDER suggested the appointment of Mr. Parker to fill the vacancy on the Board.

The suggestion gave rise to some discussion, it being considered that the appointment of that gentleman as a Director would be incompatible to his present position as an executive officer of the Company. Eventually the proposal was withdrawn.

The retiring Directors were reappointed, and a vote of thanks to the Chairman and Directors brought the proceedings to a close.

## Reuter's Telegram Company (Limited).

A special meeting of this Company was held at 24, Old Jewry, on the 6th inst., when resolutions were submitted for increasing the capital and extending the business of the Company. Admiral the Right Hon. Sir J. C. Dalrymple Hay, Bart., K.C.B., presided, and Mr. John Hart, of 22, Great Winchester-street, the solicitor, was in attendance.

The SECRETARY (Mr. Walter F. Bradshaw) having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen, you will observe that the two resolutions which are to be submitted to you are interdependent. I shall, therefore, speak to both resolutions in the few words which I shall have the honour of addressing to you. The resolutions will eventually have to be moved separately, but unless both were carried they would be inoperative. Before moving the adoption of the resolutions which have just been read by the Secretary, I will briefly explain to the meeting the objects we have in view is asking an extension of the powers of the Company and an increase of its capital. At the outset, let me remove from your minds any idea you may entertain that our present capital is found insufficient for our existing business. It is true that we have to incur considerable expense in keeping abreast with the growing demands for telegraphic intelligence, but at present our capital is adequate for all purposes connected with that branch of business so far as it is necessary to provide agents and correspondents with funds. It may be found advisable, in the interest of our subscribers, to supplement existing services with special accounts of remarkable events, trials, fires, &c., on a larger scale than has hitherto been considered necessary, or within the scope of our general service. These, however, would be the subject of further consideration in conjunction with the newspapers themselves, and would, doubtless, be met by contributions which would recoup our outlay. The primary object of the proposed alteration of our Memorandum of Association and the increase of our capital is to enable us to undertake a class of business for which our organisation seems particularly adapted, namely, the collection of advertisements for the newspapers who are our supporters. The idea has long been entertained by our Managing Director, who has not failed to notice the great expansion of advertising of late years. The most conservative and old-fashioned firms now find it necessary to resort to this mode of attracting public attention. Until recently the law regarded a Memorandum of Association as unalterable; consequently, to carry out the project in the past it would have been necessary either to dissolve the Company and found a new one, or to form a subsidiary Company, both courses obviously open to grave objections. Fortunately during last Session of Parliament an Act was passed empowering Companies, under the sanction of the High Court, to enlarge the sphere of their operations, and we have decided to avail ourselves of this power with your approval. I will read the section of the Act which is applicable to our case:—"1.—(1.) Subject to the provisions of this Act, a company registered under the Companies Acts, 1862 to 1886, may, by special resolution, alter the provisions of its memorandum of association or deed of settlement with respect to the objects of the company, so far as may be required for any of the purposes hereinafter specified. (d.) To carry on some business or businesses which under existing circumstances may conveniently or advantageously be combined with the business of the company." It must be obvious that with agencies in all the capitals of the world, who are brought into direct communication with the newspapers, this Company has exceptional means of establishing an international advertising business on a large scale, with, we believe, immense advantage to our subscribers. We, in fact, seek to create a new business for the newspapers as well as for ourselves. Some apprehension has been expressed in certain quarters that the working of an advertisement business may prove detrimental to the telegraphic service, inasmuch as the latter has to deal with financial affairs and many things that advertisers might influence. Upon this matter, we can only point to our reputation and ask if it is likely that your Directors would commit the suicidal folly of allowing any advertiser to influence the impartiality, which, we may say without boasting, has been the characteristic of our service since its creation. Indeed, it has been made a ground of reproach that our impartiality has been carried to such a length, that we too drily chronicle events. As a safeguard, however, it is proposed to keep the telegrams strictly apart from the advertising branch, and a separate staff will manage the latter in separate offices. Our editors will no more be brought in contact with the advertising branch than are the editors of the London papers with the advertisements which appear in their columns. We are sanguine that the new business will be found a good source of revenue, but we must warn shareholders against looking for increased dividends at the commencement. The organisation of an international business takes time, and can only be accomplished after much negotiation. We have, however, taken preliminary steps abroad in conjunction with the largest advertising agency on the Continent, and as soon as we shall have obtained your approval of the resolutions now submitted to you and the sanction of the High Court, as enjoined by the Act, we shall be ready to start the new machinery. In addition to advertisement business, we believe it may be found profitable to undertake telephonic and other services, which would become feeders, as it were, of our trunk system. In short, the enlarged powers we seek to obtain will enable us to extend our business in many directions that are now barred by our restricted Memorandum of Association. With these few words I now propose the first resolution, which you have in your hands as follows:—

"*That the capital of the Company be increased to £100,000 by the creation of 2,500 new shares of £8 each, and that the Directors be forthwith authorised, under the provisions of Clause 26 of the Articles of Association of the Company, to issue such shares.*"

Baron DE REUTER briefly seconded the resolution, observing that he had nothing to add to what had been said by the Chairman, who had explained everything so ably that he believed that what was proposed would be thoroughly understood.

The CHAIRMAN put the motion to the meeting in the usual manner, and declared it carried unanimously. Continuing, he said: The second resolution is as follows:—

"*That subject to the provisions of the Companies (Memorandum of Association) Act, 1890, the provisions of the Memorandum of Association of the Company with respect to the objects of the Company may be altered as follows, that is to say, by expunging sub-sections 2 and 3 of Clause 3 of the Memorandum of Association and by inserting in lieu of the sub-sections so expunged the following sections:—*

"*(2) To carry on and extend the said business and generally to carry on, acquire, obtain, and supply telegraphic, telephonic, or other news and intelligence and to issue, publish, and circulate, and otherwise utilise, with a view to the profit or advantage of the Company, the same news and intelligence.*

"*(3) To carry on in the United Kingdom, and in any part of the world,*


PATENT

# SILICIUM BRONZE AND SILICIUM COPPER WIRE.

## The best for overhead Telephone and Telegraph Lines, AND ALL ELECTRICAL PURPOSES.

Hard Drawn High Conductivity Copper Wire.

ROLLED AND DRAWN PHOSPHOR BRONZE.

PHOSPHOR BRONZE VULCAN PHOSPHOR DURO METAL

PHOSPHOR BRONZE BEARINGS, BUSHES, AND OTHER PARTS OF ELECTRICAL MACHINERY.

*SOLE PROPRIETORS of the British, Indian and Colonial Patents,*

## THE PHOSPHOR BRONZE COMPANY (Limited),

*87, Sumner Street, Southwark, London, S.E.*

WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.


Digitized by Google

*the business of general advertisement contractors and advertising agents in all its branches.*

"*(3a) To construct, purchase, hire, or otherwise acquire, or work telegraphs and telephones for any of the purposes hereinbefore mentioned.*"

I propose that the resolution be passed.

Baron DE REUTER seconded the motion, which was unanimously adopted.

The CHAIRMAN: The business upon which we are assembled is now completed. I may, perhaps, mention that I hold in my hand proxies for 496 votes of shareholders, so I think that our proposals are very generally acceptable to our shareholders. On the 23rd inst. there will be a meeting, according to the Act, to confirm the resolutions passed to-day. I thank you for your attendance.

The meeting then separated.

## The Gulcher (New) Electric Light and Power Company (Limited).

The following is the report of the Directors of the Company for the twelve months ended June 30th last, to be presented to the third ordinary general meeting to be held at Winchester House, E.C., on Thursday, the 18th inst., at 12 o'clock.

The Preference capital of the Company, which on June 30, 1889, consisted of 12,277 Preference shares, having £12,241. 1s. 4d. paid up, consisted on June 30, 1890, of 50,000 Preference shares, having £30,797. 8s. paid up. The £10 per cent. Second Debentures, which, on June 30, 1889, amounted to £8,862. 10s., and, which, at the date of the last report had increased to £16,000, were on June 30, 1890, reduced to £400. This satisfactory alteration of the capital account is mainly due to the response made by a limited number of shareholders to the prospectus issued on January 1st last, inviting subscriptions for the then un-issued Preference shares. The central stations for the public lighting of Wellington, New Zealand, upon which on June 30, 1889, the Company had expended £9,598. 18s. 8d. were shortly afterwards completed. On June 30, 1890, this important installation stood as a debtor in the Company's books for £13,486. 13s. 3d., since which time the amount has not been increased.

The Directors, in their last report, pointed out to the shareholders that the commercial success of this undertaking would depend entirely upon the provision of further capital for private lighting. They concluded, however, after careful consideration, not to lock up so large a portion of the newly subscribed capital as would be necessary to enable the Company exclusively to provide for this private lighting. A well-supported Syndicate has accordingly been formed, which will not only provide for the private supply of the town, but will ultimately take over this Company's business in New Zealand, together with the benefit of the contract for the public lighting, entered into between this Company and the Mayor and Corporation of Wellington.

The particulars of the contract between the New Zealand Electrical Syndicate and this Company, and of other contracts undertaken and carried out during the past year, will be supplied at the general meeting, when a detailed profit and loss account will also be submitted to the shareholders.

In the autumn of last year this Company contributed towards the registration of the South-Western District and Thames Valley Electricity Supply Company (Limited), from which the Directors have reason to anticipate good results.

The gross manufacturing profits for the year ended June 30, 1890, amounted to £3,097. 2s. 4d., which, compared with the manufacturing loss of £1,417. 6s. 6d. in the preceding year, must be regarded with satisfaction. The heavy interest payable on the Second Mortgage Debentures (nearly all of which, however, have now been paid off) has alone prevented the declaration of a dividend.

Since the last general meeting, Mr. Binswanger has resigned his seat at the Board. The Directors, under the powers conferred on them by the Articles of Association, recently elected Mr. C. S. B. Hilton, a large shareholder, to assist in the direction of he Company. Mr. De Castro and Mr. Hilton retire from the Board, but being eligible, offer themselves for re-election. Mr. Russell Day, the auditor appointed at the last general meeting, also retires, but offers himself for re-election.

## NEW COMPANIES REGISTERED.

**MARINE AND GENERAL AUTOMATIC COMPANY (LIMITED).**—Registered by Andrew, Wood, and Co., 8, Great James-street, Bedford-row, with a capital of £20,040, in 4,000 ordinary shares of £5, and 40 Founders' shares of £1 each. Object: to acquire certain patents for the invention of improvements in automatic electrical tell-tale apparatus, in accordance with an agreement made August 26 between W. T. W. Thackeray, J. Huer, and J. Davies, as vendors, of the one part, and J. Knowles, as purchaser on behalf of the Company, of the other part.

**NEW COMPANIES IN NOVEMBER.**—The following is a list of the new electrical and engineering companies registered in November:—

| | |
|---|---|
| Anglo-Mexican Saw-Mills Company, in £1 shares | £5,000 |
| Chagford and Devon Electric Light Company, in £1 shares | 2,000 |
| Deflector Safety Lamp and Miners' Appliance Company, in £5 shares | 20,000 |
| Electricity and Electrical Engineering Newspaper Company, in £10 shares | 500 |
| Electrolytic Syndicate, in £1 shares | 100,000 |
| Ernest Scott and Mountain, in £10 shares | 70,000 |
| Financial Exchange and Bureau, in £100 and £2 shares | 10,000 |
| Heyford Iron Company, in £10 shares | 20,000 |
| Holmes and Sons, in £5 shares | 14,000 |
| Horsham Ironworks, in £5 shares | 5,000 |
| Plenty and Son, in £10 shares | 25,000 |
| Sleeman Controlled Torpedo Syndicate, in £1 shares | 12,000 |
| South Indian Railway Company, in £10 shares | 1,000,000 |
| South Molton Shirt and Collar Manufacturing Company, in £10 shares | 5,000 |
| United Alkali Company, in £10 shares | 6,000,000 |
| Weymersch Electric Battery Syndicate, in £5 shares | 20,000 |

**PLENTY AND SON (LIMITED).**—Registered by R. Jordan, 120, Chancery-lane, with a capital of £25,000 in £10 shares. Objects: To acquire the business of marine, general, and mechanical engineers carried on by Plenty and Son, at the Eagle Ironworks, Newbury. The first Directors are:—Earl Russell, E. P. Plenty, and H. Wethered.

**STEAM LOOP COMPANY (LIMITED).**—Registered by Slaughter and May, 21, Great Winchester-Street, E.C., with a capital of £70,720 in £1 shares. Object: to carry into effect an agreement made between John Gillespie and the Company to carry on the business of mechanical and general engineers, machine and engineering tool makers, iron and brass founders, metal workers, and steel converters, &c.

## CITY NOTES, &c.

**BRAZILIAN SUBMARINE TELEGRAPH COMPANY.**—The receipts of this Company for the week ending December 5th amounted to £5,955.

**DIRECT SPANISH TELEGRAPH COMPANY.**—The traffic receipts of this Company for the month of November amount to £2,722, as against £2,497 for the corresponding period last year.

**RICHARD HORNSBY AND SONS (LIMITED).**—At the annual meeting, held on Wednesday, a resolution declaring a dividend of 6 per cent. was carried.

**NATIONAL TELEPHONE COMPANY.**—This Company has declared an interim dividend at the rate of 5 per cent. per annum for the six months to October 31st last, payable on the 20th Inst.

**STOCK EXCHANGE.**—The Committee have ordered the following security to be entered in the official list:—Eastern and South African Telegraph Company (Limited), £201,000 Four per Cent. Mortgage Debentures Nos. 1 to 2,016.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY.**—The traffic receipts of this Company for the week ending December 5, 1890, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £4,667.


# THE NON-CONDUCTOR OF ELECTRICITY.

**VULCANISED FIBRE,**

PATENTED.

**This new material is supplied in two qualities, Flexible and Hard.**

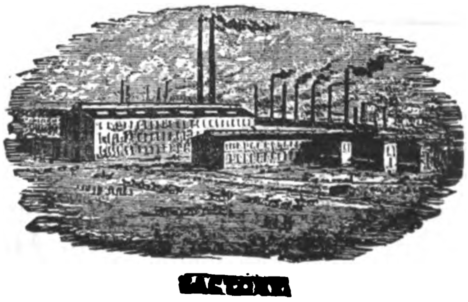
**The FLEXIBLE is a substitute for Leather, Rubber, Gutta Percha, &c., and is extensively used by Brass Founders, Axle Makers, Hydraulic, Sanitary, and other Engineers, Pump Makers, Carriage Builders, &c.**

**It makes the best Hot and Cold Water Packings, and for Axle Washers of all kinds it is unequalled.**

**The HARD is a substitute for Metals, Hard Wood, Ivory, Vulcanite, Ebonite, &c., and is a good Insulator.**

**Sold in sheets, 5ft. 6in. by 3ft. 6in., varying in thickness from 1-50in. to 1in.**

**FLEXIBLE, 2/- per lb.; HARD, 2/3 per lb.**



**MOSSES & MITCHELL, 70, Chiswell-st., London, E.C.**


Digitized by Google

## COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name. | Previous Week's Price, Dec. 3. | | Price Wednesday, Dec. 10. | | Rate per Cent. Yielded. | Dividend Due. | Business Done During Week Ending Dec. 10. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **TELEGRAPHS.** | | | | | £ s. d. | | | |
| £1,381,380 | Stock | 15/0 | Anglo-American | 48½ | 49½ | 48¾ | 49½ | 5 16 2 | Jan., Apr., July, Oct. | 48¾ | .. |
| £2,809,310 | Stock | 30/0 | Do. Preferred | 85 | 86 | 85½ | 86½ | 6 12 11 | " " | 86 | 85½ |
| £2,809,310 | Stock | .. | Do. Deferred | 13½ | 14 | 13¼ | 13¾ | .. | .. | 13⅝ | 13½ |
| £250,000 | £100 | 4% | African Direct, 4 per Cent. Debentures | 98 | 101 | 98 | 101 | 3 19 3 | January and July .. | .. | .. |
| £130,000 | 10 | 6/0 | Brazilian Submarine | 11¼ | 11¾ | 11¼ | 11¾ | 6 7 8 | Mar., June, Oct., Dec. | 11⅝ | 10⅞ |
| £84,500 | 100 | 5% | Do. 5 per Cent. Bonds | 101 | 103 | 101 | 103 | 4 17 1 | January and July .. | .. | .. |
| £75,000 | 100 | 5% | Do. 5 per Cent. Bonds (2nd Series, 1906) | 104 | 108 | 104 | 108 | 4 12 7 | June and December | .. | .. |
| $7,216,000 | $100 | 8½ | Commercial Cables | 102 | 104 | 102 | 104 | 5 15 5 | April and October .. | 104½ | .. |
| £16,000 | £10 | 8/0 | Cuba Submarine | 11½ | 12 | 11½ | 12 | 7 1 8 | February and August | .. | .. |
| £6,000 | 10 | 10% | Do. Preference 10% | 17 | 18 | 17 | 18 | 5 11 1 | " " | 17¼ | 17 |
| £12,931 | 5 | 2/4½ | Direct Spanish (£4 paid) | 3¾ | 4¼ | 3¾ | 4¼ | 5 12 11 | April and October .. | .. | .. |
| £6,000 | 5 | 10% | Do. Preference 10% | 9 | 10 | 9 | 10 | 5 0 0 | " " | .. | .. |
| £60,710 | 20 | 3/6 | Direct United States | 10½ | 10¾ | 10⅛ | 10⅝ | 6 15 0 | Jan., Apr., July, Oct. | 10¾ | 10⅛ |
| £100,000 | 10 | 2/6 | Eastern | 13¾ | 14 | 13⅞ | 14⅛ | 4 12 0 | " " | 14$\frac{1}{16}$ | 13$\frac{13}{16}$ |
| £70,000 | 10 | 6% | Do. 6 per Cent. Preference | 14½ | 15 | 14¾ | 15¼ | 3 18 8 | " " | 15⅛ | 13¾ |
| £1,200,000 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock | 103 | 106 | 104 | 107 | 3 14 9 | May and November | 105¾ | 105 |
| £200,000 | £100 | 5% | Do. 5 per Cent Debentures, 1899 | 106 | 109 | 106 | 109 | 4 11 9 | February & August | 108½ | .. |
| £250,000 | 10 | 2/6 | Eastern Extension | 13¾ | 14 | 13⅞ | 14⅛ | 4 19 1 | Jan., Apr., July, Oct. | 14⅛ | 13$\frac{15}{16}$ |
| £320,000 | 100 | 6% | Do. 6 per Cent. Debentures, 1891 | 101 | 103 | 101 | 103 | 5 16 6 | February & August | .. | .. |
| £91,800 | 100 | 5% | Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900 | 102 | 105 | 102 | 106 | 4 15 3 | January and July .. | .. | .. |
| £145,300 | 100 | 5% | Eastern & S. African 5 per Cent. Mor. Deb., 1900 | 101 | 104 | 101 | 104 | 4 16 2 | " " | .. | .. |
| £180,227 | 10 | 1/9 | Globe Telegraph and Trust | 8¾ | 9 | 8¾ | 9 | 5 8 4 | Jan., Apr., July, Oct. | 8$\frac{15}{16}$ | 8¾ |
| £180,042 | 10 | 6% | Do. 6 per Cent. Preference | 14½ | 14¾ | 14½ | 14¾ | 4 1 4 | " " | 14$\frac{15}{16}$ | 14$\frac{7}{16}$ |
| £150,000 | 10 | 5/0 | Great Northern | 15¾ | 16¼ | 15¾ | 16¼ | 4 12 4 | Jan., April, and July | 16¼ | 16 |
| £15,000 | 100 | 5% | Do. 5 per Cent. Debentures, 1881 | 101 | 104 | 101 | 104 | 4 16 2 | January and July .. | .. | .. |
| £230,000 | 100 | 5% | Do. 5 per Cent. Debentures, 1883 | 104 | 107 | 104 | 107 | 4 13 6 | March & September | .. | .. |
| £17,000 | 25 | 12/6 | Indo-European | 35 | 37 | 36 | 37 | 6 15 2 | May and November | 35½ | .. |
| £38,348 | 10 | 4/0 | London Platino-Brazilian | 6 | 7 | 6 | 7 | 5 14 4 | " " | .. | .. |
| £100,000 | 100 | 6% | Do. 6 per Cent. Debentures | 106 | 109 | 106 | 109 | 5 10 1 | March & September | .. | .. |
| £9,000 | 8 | 4/0 | Reuter's | 8½ | 9 | 8½ | 9 | 5 11 1 | April and October .. | 8¾ | .. |
| £3,381 | £100 Cert. | 6% | Submarine Cables Trust | 108 | 112 | 108 | 112 | 5 7 2 | " " | 109½ | 109 |
| £15,609 | £10 | 6/6 | West African | 8½ | 9½ | 8½ | 9½ | 5 5 3 | January and July .. | .. | .. |
| £290,000 | 100 | 5% | Do. 5 per Cent. Debentures | 98 | 101 | 98 | 101 | 4 19 0 | March & September | .. | .. |
| £30,000 | 10 | 3/0 | West Coast of America | 3½ | 4½ | 2 | 4 | .. | January and July .. | .. | .. |
| £150,000 | 100 | 8% | Do. Debentures 8% | 102 | 107 | 101 | 106 | 7 10 11 | June and December | .. | .. |
| £38,321 | 10 | Nil. | West India and Panama | 2⅞ | 3 | 2¾ | 3⅛ | .. | .. | 3 | .. |
| £34,563 | 10 | 6/0 | Do. 1st Preference 6% | 11¼ | 11¾ | 11¼ | 11⅝ | 5 2 2 | May and November | 11⅝ | 11⅜ |
| £4,669 | 10 | £3 | Do. 6 p. c. 2nd Pref. | 11 | 12 | 11 | 12 | 5 0 0 | " " | .. | .. |
| £34,174 | 15 | 6/0 | Western and Brazilian ....xd | 10¾ | 11¼ | 10¾ | 11¼ | 5 6 8 | " " | 11 | 10¾ |
| £27,873 | 7½ | 6/0 | Do. 5 per Cent. Cumulative Preferred ....xd | 6¼ | 6¾ | 6¼ | 6¾ | .. | — | 6⅝ | .. |
| £27,873 | 7½ | 4/6 | Do. 5 per Cent. Deferred | 4½ | 5 | 4½ | 5 | .. | .. | 4¾ | .. |
| £200,000 | 100 | 6% | Do. 6 per Cent. Debs., Series "A" | 103 | 106 | 103 | 106 | 5 13 2 | February & August | .. | .. |
| £250,000 | 100 | 6% | Do. 6 per Cent. Mort. Debs., Series "B" | 103 | 106 | 103 | 106 | 5 18 2 | " " | .. | .. |
| $1,336,000 | $1,000 | 7% | Western Union 7 per Cent. 1st Mortgage | 120 | 125 | 120 | 125 | 5 12 0 | May and November | .. | .. |
| £175,100 | £100 | 6% | Do. 6 per Cent. Sterling Bonds | 99 | 103 | 99 | 103 | 5 16 0 | March & September | .. | .. |
| | | | **TELEPHONES.** | | | | | | | | |
| £224,850 | 14/0 | 0/4½ | Consolidated Telephone Const. & Maintenance. | 1⅞ | 1⅞ | 1⅞ | 1⅞ | .. | May and November | .. | .. |
| £220,000 | £1 | 3% | Oriental (11s. paid) | ⅜ | ⅝ | ⅜ | ⅝ | 4 8 3 | Yearly | .. | .. |
| £133,984 | 5 | 3/0 | National | 4½ | 4⅝ | 4⅜ | 4⅝ | 5 18 11 | June and December | 4$\frac{11}{16}$ | 4⅜ |
| £15,000 | 10 | 6/0 | Do. 6 per Cent. Cumulative 1st Pref. | 12½ | 12¾ | 12½ | 12¾ | .. | " " | 12$\frac{9}{16}$ | .. |
| £15,000 | 10 | 4/9¾ | Do. 6 per Cent. Cumulative 2nd Pref. | 9¾ | 10¼ | 9¾ | 10¼ | 5 17 1 | " " | 10 | .. |
| £209,750 | 1 | ½% | South of England, Ordinary | ⅛ | ⅜ | ⅛ | ⅜ | .. | — | .. | .. |
| £20,000 | 5 | 2/1 | Do. 6 per Cent. Cumulative Pf. (£3 10s. pd) | 2½ | 3 | 2½ | 3 | .. | .. | .. | .. |
| £58,000 | 5 | 1/0 | United River Plate | 3 | 4 | 3 | 4 | .. | January and July .. | .. | .. |
| £146,128 | Stock | 5% | Do. 5 per Cent. Debenture Stock | 90 | 99 | 90 | 95 | 5 5 3 | .. | .. | .. |
| £3,200 | 100 | 7% | Do. 7 per Cent. Debentures | .. | | .. | | .. | — | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | | | |
| £200,000 | £5 | .. | London Electric Supply | 2 | ¼ | 2 | 2¼ | .. | — | .. | .. |
| £13,900 | 10 | .. | Metropolitan Electric Supply (£8 paid) | 6¾ | 7¼ | 7 | 7¼ | .. | — | 7¼ | 7 |
| £12,853 | 5 | .. | Westminster Electric Supply (£3 paid) | 2¼ | 2¾ | 2¼ | 2¾ | .. | — | .. | .. |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | | | |
| £33,416 | 3 | .. | Brush Electrical Engineering | 1¼ | 1¾ | 1¼ | 1¾ | .. | .. | .. | .. |
| £53,416 | 2 | 0/10 | Do. 6 per Cent. Preference | 1½ | 2 | 1½ | 2 | 6 0 0 | June and December | .. | .. |
| £20,000 | 5 | 7% | Crompton and Co., 7 per Cent. Pref. Shares | 5½ | 5¾ | 5½ | 5¾ | 6 1 9 | January and July .. | .. | .. |
| £17,139 | 5 | .. | Edison and Swan United | .. | | .. | | .. | .. | .. | .. |
| £45,000 | 10 | 6% | Electric Construction | 7¾ | 8¼ | 7¾ | 8¼ | 7 5 5 | .. | 8$\frac{3}{16}$ | 8 |
| £70,000 | 2 | 10/0 | Elmore's Patent Copper Depositing | 3½ | 4 | 3½ | 4 | .. | .. | 4 | 3$\frac{15}{16}$ |
| £20,000 | 5 | .. | Fowler-Waring Cables (£4 paid) | 2½ | 3½ | 2½ | 3½ | .. | .. | .. | .. |
| £11,600 | 10 | 10/0 | India Rubber, Gutta Percha & Telegraph Works | 18 | 19 | 18½ | 19½ | 5 2 7 | February & August | 19¼ | 18⅝ |
| £200,000 | 100 | 4½% | Do. 4½ per Cent. Debentures, 1896 | 100 | 102 | 100 | 102 | 4 8 3 | March & September | 101¼ | .. |
| £78,949 | 5 | 10% | Swan United (£3. 10s. paid) ..10% for year....xd | 4½ | 5 | 4½ | 5 | 6 19 10 | May and November | 4¾ | 4¾ |
| £37,350 | 12 | 12/0 | Telegraph Construction and Maintenance | 43 | 45 | 43 | 45 | 5 6 8 | March and July..... | 44¾ | 44⅝ |
| £150,000 | 100 | 5% | Do. 5 per Cent. Bonds, red. 1894 | 100 | 102 | 100 | 102 | 4 18 0 | January and July .. | .. | .. |



**JABLOCHKOFF'S DISTRIBUTION PATENT**

(BEING A PATENT FOR "PRODUCING AND DIVIDING ELECTRIC LIGHT," No. 1996 of 1877.)

**THE ELECTRICAL ENGINEERING CORPORATION, LIMITED,**

(STATTER'S) Are Proprietors of the above Patent, and Warn the Public against Infringement. (UNITED).

*The following are Licensees:—*

Brush Electrical Engineering Company, Limited.
Crompton & Co., Limited.
S. Z. de Ferranti.—London Electric Supply Corporation, Limited.
W. T. Goolden & Co.
Hammond & Co.
Wilson Hartnell.
Johnson & Phillips.
Laurence, Paris & Scott, Limited.
Nalder Brothers & Co.
Paterson & Cooper.
Ernest Scott & Co.
Siemens Brothers & Co., Limited.

3, PRINCE'S MANSIONS, VICTORIA STREET, WESTMINSTER.

PERCY E. SCRUTTON, *Secretary.*


Digitized by Google

# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 657.—Vol. XXVI. FRIDAY, DECEMBER 19, 1890. Price Fourpence.

## NOTES.

The City and South London Railway was opened yesterday, and a continuous service of trains ran throughout the day. We found a considerable number of passengers at the Monument Station, many of them preferring to use the stairs than the capacious but somewhat leisurely-worked lifts. The line has not been ballasted, as was suggested, the idea being that this would reduce the noise. Conversation is possible, and indeed was carried on between the passengers, but with considerably more effort than on the Metropolitan line. The carriages are lighted with glow lamps, and these, though not very important, are the least satisfactory part of the work. During our visit the dynamos were for some reason excited only by the shunt coils, though the turn of a switch would have compounded them. The result was that every time the train started from a station the illumination fell very considerably, and when one train was standing at a station while another was starting in the adjacent tunnel the same effect was visible. On climbing the steep gradient and severe curve, on the return journey, near the terminus, the lamps were merely red hot. On visiting the engine-room at Stockwell, we found two engines at work and one turning round. The needles of the ammeters on the four different feeders were moving slowly between 50 and 100 amperes. The speed of the engines was fairly regular, but the volts, as shown by Sir William Thomson's engine-room voltmeters, fluctuated from about 370 to 460.

About half of the passengers appeared to be "boná fide travellers," but that there were a number who were bent on an errand of curiosity was evinced by the attempts which were being made at Stockwell to prevent passengers from the City going across the platform to the next returning train, and thus defrauding the Company of a twopenny fare. An evening paper last night mentioned that some hitch occurred early in the day, but all was going well in the afternoon; about a thousand persons had passed the Stockwell turnstiles by mid-day, and some ten times that number were recorded at the Monument Station at seven o'clock, when the approach to the station was crowded. The time from Stockwell to the City was about 20 minutes. The atmosphere was perfectly pure, and was distinctly warmer than on the surface. We understand that some delay in opening has been caused owing to mechanical difficulties which have now been overcome. They related in no way to the electrical part, but concerned the coaches and their springs. We cordially hope that the extensions to Clapham and to Islington may result from a satisfactory working of this unique and boldly designed railway.

The general knowledge of secondary batteries has been undoubtedly advanced by the two Papers which have been presented to the Institution of Electrical Engineers and the long discussions which have followed them. It is suggested that the information, or at all events so much of it as is of importance, has been known to the manufacturers, who have kept it to themselves. The results are remarkable for their reliability, as being the outcome of a large amount of solid work, rather than for any startling novelty. The authors of the Papers are to be congratulated on having placed the accumulators under the actual conditions of ordinary work, instead of endeavouring to attempt to bring out some interesting scientific point, which might or might not throw light upon the theory, but which would be of little or no use to the engineer. The theory, as we have recently remarked, is not much advanced.

There are some chemists who would inflict elaborate formulæ upon us, and others, perhaps, who would begin at the other end, and may be inclined to follow Mr. D. G. Fitzgerald, who asks for what reasons the authors called the peroxidised plate the positive. In his brief reply Prof. Ayrton did not have time to answer this question, and we therefore take this opportunity of giving an answer of a thoroughly convincing character, and one which we venture to recommend to every student, since it is easy to remember. The *P*ositive plate of a secondary battery is properly so called because it is *P*eroxidised and *P*lum-coloured; the *N*egative plate, on the other hand, is of a *N*eutral colour, and is *N*ot oxidised.

The suggestion that the peculiar red coloration of cells which was illustrated in our last issue is due to gold is interesting. It has always been difficult to account for the huge quantities of that metal which have been spent, and we thought lost, in storage batteries during the last nine years.

An explanation of the rise of resistance of a secondary battery during discharge was put forward some years ago by Mr. Lane Fox, and is worthy of record while the subject is still before us. He suggested that a film of pure water is produced on the surface of the plate, and that this gives rise to the increase of resistance. It should not be difficult to prove this.

Digitized by Google

THERE has been a general impression for the last few years that selenium is a fraud. The experiments of WILLOUGHBY SMITH, ADAMS, TAINTER, and GRAHAM BELL led us to imagine that the now forgotten photophone was to be the immediate forerunner of an actual method of seeing by electricity, a method so easy to describe and talk about, and so difficult to carry into practice. Numerous arrangements have been suggested, and great ingenuity expended in devising receivers. Glow lamps, vacuum tubes, sparks, moving mirrors, sensitive gas flames, NEWTON's rings, and drops of fluid in a beam of polarised light have been put forward for this purpose. For the transmitter, selenium has always been used where any attempts have actually been made. Mr. LL. B. ATKINSON has made many experiments, and suggested a mixture of carbon and sulphur and bromide of silver, since he found, as all others have done, that selenium is liable to great variations in sensitiveness, and is of too small conductivity. The question of variation of sensitiveness has, however, been cleared up by Mr. SHELFORD BIDWELL, in his communication to the Physical Society last week, and his discovery of the electrolytic formation of selenide of copper removes the doubts which have existed as to the trustworthiness and durability of this material. Future experimenters will now be on their guard, and will either seek a metal which is not attacked by selenium, wherewith to make the cell, or will, at all events, protect the wire with which it is wound.

THE introduction of condensers which can be applied to alternate-current circuits may lead to a new departure in electrical engineering. Hitherto condensers have not been used outside the laboratory except for the purpose of telegraphy, and here the currents and pressure are so small that no serious troubles are met with other than may be due to ordinary insulation. But a number of difficulties arise when an attempt is made to construct a condenser which can comfortably accommodate an ampere which is being urged to and fro under two or three thousand volts. Dielectrics, whose homogeneity and elasticity were never considered when a few batteries were at work on them, are found to absorb and degrade energy into heat at a rate which is measured by horse-power. A system of distribution by means of condensers was described by Dr. DOUBRAVA in *The Electrician*, Vol. XXII., p. 676, and there he states that an area of one metre and a cost of eight shillings is sufficient for a 16-candle lamp. M. JABLOCHKOFF has experimented in this direction, and Mr. BLAKESLEY's work, of a very different order, though somewhat premature, will probably be re-read with interest, while Mr. SWINBURNE's complete paper, of which we publish an abstract this week, breaks entirely fresh ground and may lead to very important results.

THE modern electrician, if he seeks to investigate for himself the most recent developments of science, has to deal with periods which are measured in hundredths of thousandths of a second; and any means of making a contact of a well-defined, strictly calculable, and short duration, is at the present moment of considerable importance. In connection with this the following extract from a letter which we have received from Sir WILLIAM THOMSON will be read with interest, together with a further communication on the subject, which will be found in our correspondence columns.

"I should have said, but did not do so for want of time, in our conversation in the 'Physical' yesterday evening, that the method of discharge by impact of metal balls may be used to show electric oscillations in the discharge of a Leyden jar. For many years I have wished to do this, and a fortnight ago, as a preliminary, I began to work out the mathematical problem of calculating the duration of a collision between two perfectly elastic solid globes, which I had found to be invariably as the fifth root of the velocity of approach. Only last Tuesday I found that the problem had been fully solved by Boussinescq (1884) in his great book on Elasticity of Solids, and that 'Heinrich Hertz' (*Crelle's Journal* Vol. XCII., 1882) is referred to by Boussinescq with thorough and generous appreciation, as having anticipated him. Thus, from Hertz himself comes a fresh contribution to the investigation of electric oscillations quite unexpected, I believe, by any of those who last week welcomed the mark of approbation conferred on him by the Royal Society for his more recent great work on electric waves and oscillations."

ELECTRICAL engineers would do well to glance occasionally at some of the journals devoted to the gas industry. They will find an inveterate opposition to electric lighting, as may naturally be expected; but, on rare occasions, among the criticisms, which, after all, show a much more creditable knowledge of the subject than is exhibited by the daily press, they may find such an article as that which we reproduce in this issue. The ventilating power of gas, if we may use the expression, is merely that of the furnace in the upcast shaft of a mine. It depends quite as much upon the shaft as on the furnace; the former may, indeed, be said to be more essential than the latter. Practically, the desideratum is a sunlight with an ample flue. If electric light be used in the sunlight, it would be well to put a few gas-burners immediately above them, within the flue; and as their light is not wanted, and their radiant heat is objectionable, Bunsen burners would be better; in fact, a good ordinary gas fire might be used. The be-littling of the value of oxygen, or of its consumption, is carried rather too far by the writer of the article to which we have alluded. It is true that the occupants of a room need fresh air, but a gas-burner needs seven times as much. The remarks about the hall of the Society of Arts are none too strong, and for many years the ventilation of the theatre of the Royal Institution was a standing disgrace.

WE published, on page 559 of our last volume, a short article by Dr. SHELDON on the "Magneto-Optic Generation of Electricity," which described experiments attempting to show that a minute electromotive force is induced in the coils of a solenoid when its core is traversed by a beam of light, the plane of polarisation of which is rapidly changing. The article in question has been considerably criticised, and Dr. LODGE has pointed out that the experiments described cannot be accepted as conclusive owing to the neglect of certain precautions in conducting them. In the December number of the *Philosophical Magazine* Prof. ANDREW GRAY discusses the matter further, and gives reasons for supposing that the induced electromotive force can only occur when the angular velocity with which the polariser rotates is changing in magni-

Digitized by Google

tude. If this is the case a current may be produced by oscillating the polariser backwards and forwards, but cannot arise from uniformly rotating it, however rapid the rotation may be. It appears that several years ago Prof. GRAY experimented with the same object in view, using a beam of circularly-polarised light. The light passing through the solenoid was alternately cut off and restored by a rapidly rotating perforated screen. The experiments failed owing to the minuteness of the effect under examination; but the idea that a circularly-polarised beam of light produces a magnetic field is confirmed by an investigation in Prof. J. J. THOMSON's "Applications of Dynamics to Physics and Chemistry," where the magnetic field, due to a beam of strong sunlight, polarised in the manner described, is calculated numerically We would suggest that a more satisfactory method of oscillating the polarised ray would be to discharge a Leyden jar through a suitable solenoid in the manner adopted by MM. BICHAT and BLONDLOT, and Dr. OLIVER LODGE. The beam of light might be parallel, and the receiver could then be placed at a considerable distance, so that no direct electrical effect could be produced.

ONE of the most striking ways in which mathematics can be applied to help onward physical science arises from the power which it sometimes shows of deducing from a few well-known facts and principles conclusions with regard to new and apparently disconnected phenomena. The above instance is a case in point. The number which Prof. THOMSON has arrived at can be used to deduce the electromotive force caused by the new magneto-optic action in any particular case, and but very little calculation suffices to show that the effect in question is, after all, far too minute to be detected by ordinary experimental methods.

**Maidstone.**—The Town Council has decided to apply for a Provisional Order.

**A Daily Electrical Journal.**—On and after January 1st the *Elektricitäts Zeitung*, of Berlin, will be published daily.

**South Shields.**—At a recent special meeting of the Town Council, a resolution was unanimously passed to make application for a Provisional Order.

**Electrical Patents.**—Last year the number of patents granted was 19,507, of which 1,082, or 5·57 per cent., were connected with electricity, against 19,295 and 1,109 (5·7 per cent.) respectively in the corresponding period of 1888.

**Special Notice.**—We desire to call attention to the fact that *The Electrician* will be published on Wednesday, the 24th, instead of on Friday, the 26th December, so that all contributions intended for the Christmas-week issue must reach us by mid-day on Tuesday at the latest.

**Electric Lighting at the Guildhall.**—At the last meeting of the Common Council it was resolved:—"That it be referred to the City Lands Committee, to consider and report as to the desirability of fitting the Guildhall and offices with an installation of electric lighting and the probable cost thereof."

**Instruction of Electrical Engineers.**—In the Authorised Abstract of the discussion on Prof. Ayrton's Paper on "The Chemistry of Secondary Cells," the third word from the end of last sentence but one of Mr. King's remarks (*The Electrician*, December 12, p. 177) should be *circuit* instead of *surface*.

**National Telephone Electrical Society.**—On Friday, December 5th, in connection with the Midland branch of this Society, the vice-president (Mr. A. E. Cotterell) gave a very interesting and instructive paper on "A few Errant Notions on Telephonic Matters."

**Swan Patent Litigation.**—Judgment was given on Monday last in the Supreme Court of Appeal, Leipsic, in the case of the Allgemeine Elektricitäts Gesellschaft (formerly the German Edison Company), *v.* The Swan United Company, in favour of the Swan Company.

**Bristol.**—On Friday last week, the members of the Electric Lighting Committee of the Bristol Town Council visited Bath, accompanied by Mr. Preece. On Saturday the Committee held a consultation with Mr. Preece at Bristol, the outcome of which was that Mr. Preece was instructed to prepare an estimate for a central station to supply current to 60 arcs and 10,000 incandescents.

**The Electricien and the Revue Internationale de l'Electricite.**—On and after the New Year, the *Electricien* and the *Revue Internationale de l'Electricité* will be amalgamated under the title of *L'Electricien, Revue Internationale de l'Electricité et de ses Applications*. All communications, therefore, connected with subscription, rates, &c., must in future be addressed to M. Georges Carré, 58, Rue Saint-André-des-Arts, Paris. M. Hospitalier will not, we regret to hear, continue as editor of the amalgamated journal.

**Personal.**—The staff of the Technical College, Finsbury, have presented to Prof. William Robinson, their late colleague, on the occasion of his appointment to the Professorship of Engineering at University College, Nottingham, a handsome and massive dining-room clock, having the arms of the City and Guilds of London Institute engraved on it, along with an appropriate inscription.

**Spanish Cables.**—Messrs. Pirelli and Co. write us that we were in error in the note in our issue of the 5th inst., in giving their address at Turin. This, of course, should be Milan. They further inform us that the cables for which they have obtained the contract are not to be maintained during ten years at their expense, but that they have only to warrant the good working of them during the first year. The contract price is about £160 per mile.

**"Electrical, Mechanical, and Milling News."**—This journal will, on and after the New Year, be published under the title of the *Canadian Electrical News and Steam Engineering Journal*. "It will be the object of the *Electrical News* to make known as widely as possible the methods by which electricity may be made to serve the interests of mankind. . . . It will endeavour to bring about at the earliest possible date the organisation of a Canadian Electrical Association."

**The Barking-road Line.**—The accumulator cars operating on the Barking-road section of the North Metropolitan Tramway Company during the five months ending November ran 27,597½ miles out of a possible 27,833 miles, the loss of mileage from all causes amounting only, therefore, to 235½ miles, or ·844 per cent. These figures are confirmed by the North Metropolitan Tramway Company. On the 28th of last month, when there was a heavy fall of snow, the cars performed 193 miles out of a possible 213. This is a better average than was made by the horse cars.

**The Lighting of the City.**—At the meeting of the City Commission of Sewers on Tuesday last, a report from the Streets Committee was brought up relative to the tenders for lighting the western district of the City by electricity. It recommended that the proposal of the Brush Electrical Engineering Company, on similar terms to those contained in the agreement for the central district, be accepted. It also suggested, in regard to an application by that Company for the consent of the Commission to their Provisional Order, that such consent should be given subject to a contract being executed as in the case of the central district.

**The Westinghouse Company.**—During the month of November, the shipments of the Westinghouse Electric and Manufacturing Company are stated to have amounted to 40 alternators, having a total capacity of 30,000 sixteen candle-power lamps. To this must be added 1,200 alternate current meters. The Westinghouse Company has now increased the capacity of its motor department to an extent which enables them to manufacture 100 motors per month. The Company, it is further stated, has at the present time 50 new electric street railways under construction.

Digitized by Google

**Globular Lightning Experiments.**—Planté, as is well known, used a huge secondary battery in his globular lightning experiments. Herr von Lepel states that similar effects may be observed by placing a sheet of mica, ebonite, or glass between the poles of a powerful influence machine, the best results being obtained with glass or paper discs rubbed with paraffin. If the tension is not too great, little luminous red balls may be seen moving about on the discs. Herr von Lepel is of opinion that small particles of dust or liquid are the chief causes of the phenomenon. A slight puff suffices to extinguish the glow, which disappears with a hissing noise.

**The Electric Welding of Projectiles.**—At the reading of a Paper on this subject before the Boston Society of Arts, Lieut. Wood, of the United States Navy, exhibited several specimens of electrically welded shells. One of these had been fired against heavy steel armour, much heavier than a projectile of the size could be expected to perforate. It, however, penetrated 5in., and then, owing to the elasticity of the oak backing of the plate, was thrown back about 30ft., as perfect in condition as before it was fired from the gun. The experience of the Welding Company had been, said Lieut. Wood, that the metal seemed to be strengthened at the point of welding, and this certainly tended to justify the supposition.

**The Electro-Deposition of Aluminium.**—According to the *Electrical Engineer*, of New York, Mr. Jeançon employs for this purpose a saturated solution of persulphate of aluminium requiring the high temperature of about 180° to 200° Fahrenheit to prevent crystallization. The anode is of commercial aluminium having incorporated with it a separating substance affected neither by the current nor by the solution. This is prepared by melting the aluminium in a crucible, and stirring in about 30 per cent. of carbon or some other similar substance. Mr. Jeançon finds carbon to be preferable, and the union, which is probably largely mechanical, is facilitated by the presence of a small quantity of hydro-carbon. The process described is claimed to give a dense reguline deposit of aluminium.

**A Freak of Lightning.**—The usual monthly meeting of the Royal Meteorological Society was held on Wednesday evening at the Institution of Civil Engineers. Among the papers read was :—"Note on a Lightning Stroke, Presenting Some Features of Interest," by Mr. R. H. Scott, F.R.S. On January 5th a house near Ballyglass, county Mayo, was struck by lightning, and some damage done. A peculiar occurrence happened to a basket of eggs lying on the floor of one of the rooms. The shells were shattered, so that they fell off when the eggs were put in boiling water, but the inner membrane was not broken. The eggs tasted quite sound. The owner's account is that he boiled a few eggs from the top of the basket, the rest were "made into a mummy," "the lower ones all flattened, but not broken."

**A Bibliography of Recent English Electrical Literature.**—We have received from Mr. H. E. Hafferkorn, of Milwaukee, U.S.A., Part II., "Electricity and Magnetism," of his "Handy Lists of Technical Literature." This publication is a reference catalogue of books on Electricity and Magnetism printed in English from 1880-1890 inclusive, and it also contains a select list of books printed before 1880, and still purchaseable. Works are entered under their authors' names, and there are also subject headings in the same alphabetical series as the authors' names. This bibliography is well-planned, clearly printed, and contains full information as to prices, publishers, editions, &c. It appears, moreover, to fairly well cover the ground. This catalogue should prove most useful to electrical students and writers.

**French Cable Enterprises.**—The Société Française des Télégraphes Sous-Marins announces the opening to the public of the Martinique-Paramaribo cable. The cable connecting Paramaribo to Cayenne is now being manufactured, and will be laid early next year. The Cayenne-Vizeu section will then be taken in hand, and Brazil will thus be in telegraphic communication with the West Indies and North America *via* the cables of the Société Française. The announcement then concludes as follows :—"This Company proposes, with the help of the factory erected at Calais by the Société Générale des Téléphones, to render France at last independent of England in all that concerns the submarine telegraphic connections that she may desire to effect."

**Electricity in Railway Working.**—In a report to the Board of Trade on the collision which occurred on October 11th, near Gorgie station on the suburban section of the North British Railway, Major Marindin says :—"The best way to prevent the mistake of one signalman causing a collision of this kind would be by the adoption of one of the systems of interlocking the block instruments with the out-of-door signals in use upon a few lines in England. Another way which has been suggested would be by insulating a certain length of rails, as is done in places in America, and providing electrical arrangements which would lock the block instruments or the necessary signals so long as any axle were standing upon the insulated length of rails. This plan has not, however, been sufficiently experimented upon in this country to make it certain whether it is reliable, and if not reliable, it would be worse than useless.

**Serious Accident to Mr. Bernard Drake.**—Last week a temporary plant was fixed to supply the immediate requirements of the new Metropolitan Police buildings, the lighting of which was entrusted to Messrs. Drake and Gorham, and unfortunately one of the preliminary runs was attended by a serious accident to Mr. Bernard Drake. It seems that after visiting the different rooms in the premises he attempted to walk across the main courtyard of the building towards the engine-room, but unfortunately passed through an open door, immediately in front of which there was an unprotected area some 15ft. in depth. Instructions had been given that these doors were to be closed, and gas jets were provided in the area to prevent such an accident from occurring, but on this occasion the gas jets had been blown out and the doors had been left open by the painters. Mr. Drake was taken to the Westminster Hospital, which, it is hoped, he will be able to leave in about two months, unless other more serious symptoms should appear. We are glad to learn as we go to press that Mr. Drake is progressing favourably.

**Electricity in American Coal Mines.**—The introduction of electricity in the coal mines of Pennsylvania is, says the Pittsburg correspondent of the *Electrical Engineer* of New York, finding great opposition among the coal miners, who aver that the electric mining machines displace a number of men. The mine owners, however, do not pay much attention to this agitation, and mining machines are becoming more general every week. The mine owners state that the introduction of mining machines operated by electricity is the only means they have by which they can make their business pay. When the production of coal depended chiefly upon the miners, the cost of operating a mine was so large, and miners' wages were cut down so low, that no Americans could be induced to work at coal mining. In this emergency the advent of the mining machine was hailed with delight, and wherever mines are using electric power, the company not only can afford to pay its men good wages, but the business also makes a good profit.

**The Hazeltine Carbon Protector.**—In a recent issue the *Electrical World* describes an ingenious device intended to prevent the lateral waste of arc lamp carbons. The destruction of the carbon is partially due to actual waste at the point where the arc forms, and still more is produced by wasting around the sides of the poles where no proper return for the destruction is made in light received. The apparatus consists of a collar, made of fireclay or some similar refractory material, embracing the upper or positive carbon just above its point, and kept in the same position relative to the arc by an arrangement of chains. It shields the upper carbon so that the arc has no chance to disintegrate the carbon except at the immediate point where the arc is formed. The device has already been made use of by the Municipal Electric Lighting and Power Company of St. Louis, and the saving in the cost of carbons, trimming and caring for lamps is reported to be not less than 50 per cent. It is stated, too, that the effective candle-power of the lamp is increased.

**Bremen.**—According to the *Elektrotechnische Anzeiger*, the committee, consisting of Prof. Kittler, Director Salzenberg, and Herr Neukirch, report that Messrs. Siemens and Halske's

Digitized by Google

scheme for lighting the town of Bremen will involve a capital outlay of £100,000, and an annual expenditure of £4,500. This will provide for 10,000 16 candle-power glow-lamps in stalled, of which 8,000 could be run simultaneously, the mean time of burning of each lamp being 550 hours per annum. A second scheme, involving 25,000 lamps, 20,000 being run simultaneously, and the mean time of running each lamp being 500 hours per annum, is estimated to cost £135,000, with an annual expenditure of £8,500. A charge of 4·5 pfennings- (·54d.) per lamp-hour would, in the first project, bring in an annual profit of £7,875, or nearly 8 per cent. on the capital. Under the second plan, four pfennings (·48d.) per lamp-hour would bring in 12·2 per cent. on the capital outlay. The prices in various towns in Germany for a 16 candle-power lamp-hour are:—Barmen, ·48d.; Berlin, ·516d.; Darmstadt, ·48d.; Düsseldorf, ·54d.; Elberfeld, ·48d.; Hamburg, ·564d.; Königsberg, ·48d.; Lübeck, ·564d.; Mülhausen, ·48d.; Stettin, ·564d. It was recommended that £100,000 should be voted for the purpose of equipping an installation. A tender which has come to hand within the last few days from the Helios Company, of Cologne, has, however, delayed the adoption of this recommendation by the municipality.

**The Alkaline Accumulator.** — The alkaline accumulator devised by MM. Commelin, Desmazures, and Bailhache, full particulars of which are to be found in *The Electrician* of January 18, 1889, has recently undergone a small improvement in detail, which will tend to diminish the somewhat excessive loss of charge when left on open circuit, which was noticeable in the earlier types. A battery of these cells, weighing 21,650lb., is used on board the submarine boat, "Gymnote," and it has been found possible to obtain from this battery, without injury to it, no less than 345 horse-power hours, or one horse-power hour per 63lb. of dead weight. A battery of these cells was also employed to operate a Canet cannon during the Paris Exhibition last year. The Commelin-Desmazures accumulator contains, it will be remembered, compressed porous copper negatives (2 to 3 mm. thick), enclosed in an envelope of parchment cloth, and iron wire gauze positives, in a 50deg. Baumé solution of zincate of potassium. During the charge zinc is deposited upon the iron electrodes, and oxygen is absorbed by the copper electrodes. During the discharge the zinc is re-dissolved, combining again with the oxygen from the copper electrode. The average E.M.F. per cell is only ·75 volt. It was found that the parchment cloth became feebly conducting after long immersion in the electrolyte, and in consequence there was considerable loss of charge on open circuit. The cells are now constructed with the parchment cloth carefully insulated from the copper plates.

**Matthiessen's Correct Standard.**—The following is an abstract of the preliminary report of the "Standard Wiring Table" Committee of the American Institute of Electrical Engineers. After a very thorough investigation of Matthiessen's work, with a view to ascertaining what his standard really was, we consider, says the Committee, the correct Matthiessen's standard and the one in which he himself had most confidence was the "metre-gramme" standard. The Matthiessen's standard recommended is a hard-drawn copper wire one metre long, weighing one gramme ("metre-gramme") having resistance of ·1469 B. A. unit at temperature of 0°C.

*Table of Values based upon Matthiessen's Correct Standard.*

| — | B. A. Units. 0°C. | Legal ohms. 0°C. |
|---|---|---|
| Matthiessen's Standard metre gramme hard | ·1469 | ·1453 |
| Metre-gramme soft | ·1436 | ·1420 |
| Metre-millimetre hard | ·02104 | ·02080 |
| " " soft | ·02057 | ·02034 |
| Cubic centimetre hard | ·000001652 | ·000001634 |
| " " soft | ·000001616 | ·000001598 |
| Mil-foot hard | 9·940 | 9·829 |
| " soft | 9·9720 | 9·612 |

Specific resistance of hard copper (1 cub. cent.) = 1,634 C.-G.-S. units. Specific resistance of soft copper (1 cub. cent.) = 1,598 C.-G.-S, units, Matthiessen's standard specific gravity of hard copper, 8·89. Resistance of hard copper is 1·0226 times that of soft copper. Resistance of soft copper is ·9779 times that of hard copper. Legal ohm is equal to 1·0112 B. A. unit. B. A. unit is equal to ·9889 legal ohm.

**Paris.**—At a recent meeting of the Conseil Municipal two matters connected with the electrical supply companies were discussed at considerable length. The first discussion arose upon the report of the police authorities on the fire at the Grand Café. From this report it seems that the basement of the Grand Café had been converted into a battery transformer station, supplying 1,400 lights to customers in the vicinity. The report stated that the manager of the café asserted that the fire in question was at least the twentieth which had arisen from the same cause, and it concluded by attributing these mishaps to the ignition of the insulation of the leads due to excessive currents, the fuses not being properly proportioned to the carrying capacity of the leads. In the discussion which followed the reading of this report it came out that the charging current having a difference of potential of under 500 volts, nobody could interfere with such installations. It was resolved to petition the authorities to amend this regulation. The vexed question of the emission of smoke by the central stations was next debated. It was generally urged that the companies should be obliged to use coke or to consume their own smoke, and it was stated that a decree of 1854 enabled this demand to be enforced. Several members pointed out that no entirely satisfactory smoke annihilator existed, that the municipality was itself a very bad offender in this respect, that the 1854 decree had been superseded by a subsequent one. It was finally resolved to inaugurate a series of trials of smoke annihilators.—According to the *Bulletin International de l'Electricité*, the principal officials connected with the municipal station at the Halles Centrales are about to join the Compagnie Continentale Edison, and the station will, it is rumoured, be sold.

**The Central Lighting Station as an Investment.**—In a Paper on this aspect of electric lighting recently read before the Chicago Electric Club, Mr. B. E. Sunny refers to the various types of non-dividend paying central lighting stations. One type of non-dividend paying lighting station is, he remarks, the station that is well built, with good steam and electrical plant, and which starts off on its career with applause. It is a great success, and the patrons increase, until the fact is brought home to the owners that they have no more room left, and that they must add to the building. Then begins the work that ends in the central station becoming an exhibition of engineering gymnastics. Engines of various makes are crowded in spaces too small for them; high speed and low speed; big boilers and little ones, until the station takes on so many peculiarities that a change of engineers is apt to shut it down, until the new man can unravel the awful mystery. The remarkable thing about such a station is that it generally pays good dividends, for the reason that every boiler, engine, and dynamo is worked to its fullest capacity, and consequently under economical conditions. So long as the machinery stands the strain, the shareholders will have cause to rejoice. Re-building, however, means the throwing away of the old station in many instances; the selling off at a great sacrifice the smaller engines and boilers to make room for larger types. The stock representing the cost of the property abandoned continue, however, to be an obligation upon which dividends must be paid. Then during the transition period, while part of the work is being performed from the old station and part from the new, the increase in the operating expenses is very marked. It generally happens, too, that in their desire to make the new one a model station, the manager or superintendent devotes all his time and attention to *that* work, and leaves the old station to the boys to run, with the usual results. The whole secret of dividend-paying enterprises lies in their ability to run reliably, every day and every year, without subjecting the machinery to excessive and abnormal demands, and in the avoidance of rebuilding or abandoning original investments. Central stations, Mr. Sunny is of an opinion, should be planned from the commencement, with a view to meeting the growing demand, not of the next two years or so, but of the next fifteen or twenty years.

Digitized by Google

## ELECTRICAL DISTRIBUTION BY TRANSFORMERS FROM CENTRAL AND ECCENTRIC STATIONS.*

BY DR. J. A. FLEMING, M.A.

*(Continued from page 134.)*

*Systems of Distribution—Compensator System.*—This system of distribution for incandescent lighting by alternating currents is the invention of Prof. Elihu Thomson, and was introduced before the transformer system had attained much commercial expansion. The principle of the system is shown in Fig. 5.

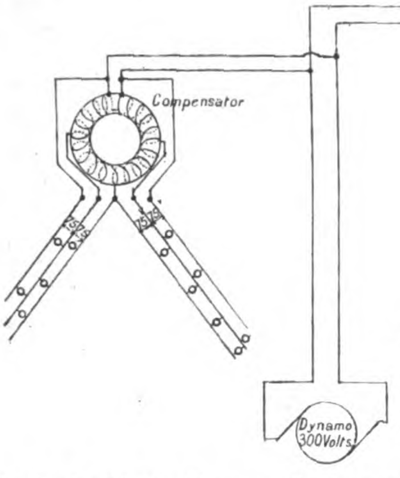



FIG. 5.—Prof. Elihu Thomson's "Compensator" System of Incandescent Lighting.

An alternating current generator usually wound for a potential of 330 volts delivers its current to the ordinary system of feeders and mains such as is employed in the direct two-wire system. At central points in the district to be lighted the compensators, or choking coils, are located—usually being placed upon poles at street intersections. A loss up to 10 per cent. of the dynamo potential, according to conditions, is allowed between the station and the lamps, and the pressure at the compensators is thus somewhat more than 300 volts.

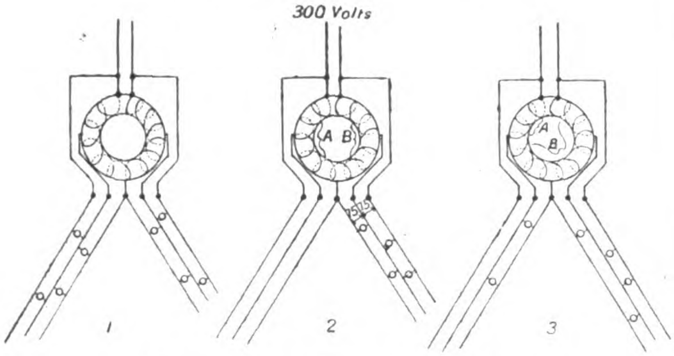



FIG. 6.—Three-wire Compensator System.

The compensator consists of a laminated core of iron as in a transformer, wound with a continuous insulated conductor, the terminals of which are connected directly to the dynamo leads.

At three points in this coil, dividing the coils equally between its terminals, wires are attached leading to binding posts on the compensator frame. The terminals of the coil are attached to similar binding posts, and from these five points are run lamp circuits, which may be two three-wire systems. The fall of potential through the compensator from one lead to the other will thus be divided into four equal parts, and the voltage in each lamp circuit will be, therefore, about 75 volts. It is evident that many variations may be made in this arrangement; the coil may be divided into any number of equal portions, and from them the circuits may be run on the 3, 4, 5, &c., wire-systems, or the various circuits may be on the simple two-wire system. We take, however, this 330 volt two 3-wire system to explain, as it was the one most used, and serves as well as any other to illustrate the principle of the arrangement.

Considering Fig. 6:—There are, at maximum load, say 8 lamps on the compensator; when they are all turned on, a very slight current traverses the coils of the compensators, the self-induction of its coils of wire wound about soft iron being so high as to practically prevent any current flow. Consider now that all the lamps on one of the three wire circuits be turned off, the conditions are as in sketch 2, Fig. 6.

The current traversing the part of the coil "A" acts as the primary of a transformer, the secondary being the part "B"; transformation from 150 volts in the primary to 150 volts in the secondary thus takes place, and one-half the current in the

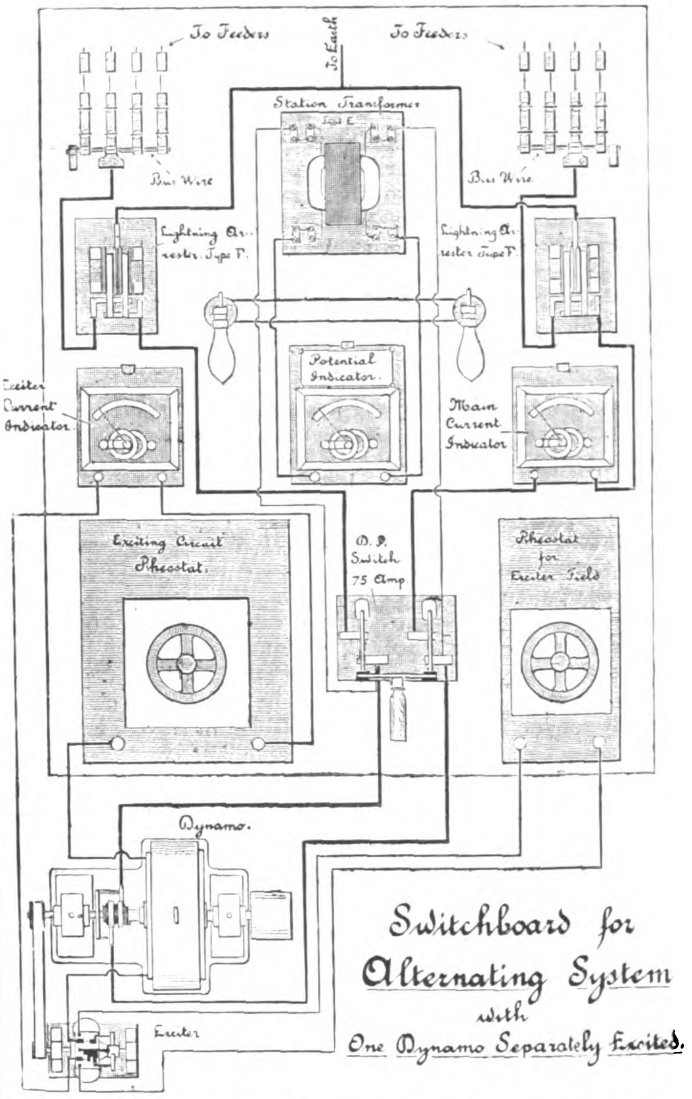



FIG. 7.—Switchboard for Thomson-Houston Transformer System.

lamp circuits is due to the dynamo current, and one-half to that part of the compensator marked "B." The part "A" thus needs to carry only sufficient current for one lamp, and the regulating capacity of the compensator is seen to be four times the carrying capacity of its wire. If the lamps be arranged as in sketch No. 3, the first part of the compensator marked "A" will carry $\frac{6}{4} = 1\frac{1}{2}$ times the current required for one lamp. The ratio of conversion in this case being 1 : 3, the part of the compensator marked "B" will supply $\frac{1 \cdot 5}{3} = \cdot 5$ times the current for one lamp.

In this way the action of the compensator for any arrangement of load may be readily deduced. In few words, its action is a combination of a transformer with a system of direct distribution.

* All rights are reserved.

Digitized by Google

The chief objection to this system is, of course, that it brings the high potential of the dynamo to the house wires.

The compensators have been manufactured in two sizes, one for 75 and the other for 150 lights. These figures, however, do not denote the maximum number of lamps which may be operated from a transformer, but merely the amount for which the compensator will regulate, *i.e.*, the maximum allowable difference in the number of lamps connected to its circuits.

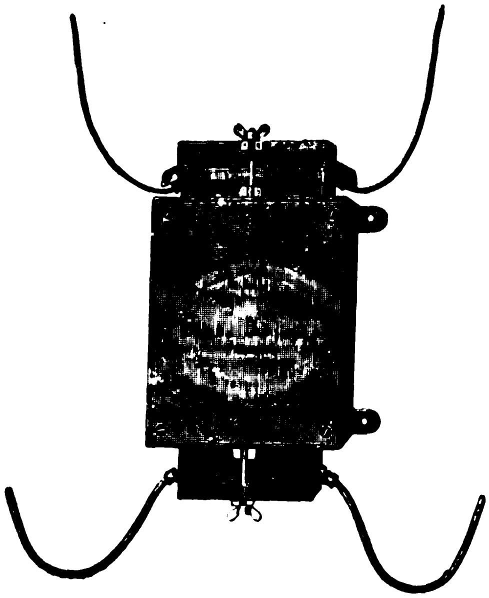


Fig. 8.—Thomson-Houston Transformer.

*Transformer System.*—The transformer system of the Thomson-Houston Electric Company is, like all other such successful systems, a constant potential one; the pressure employed being usually 1,000 volts. The dynamos are constructed to give 1,100, so that 10 per cent. may be allowed for loss in the primary and secondary circuits. As before stated, the dynamo is usually of the compound or "composite" type, the fields

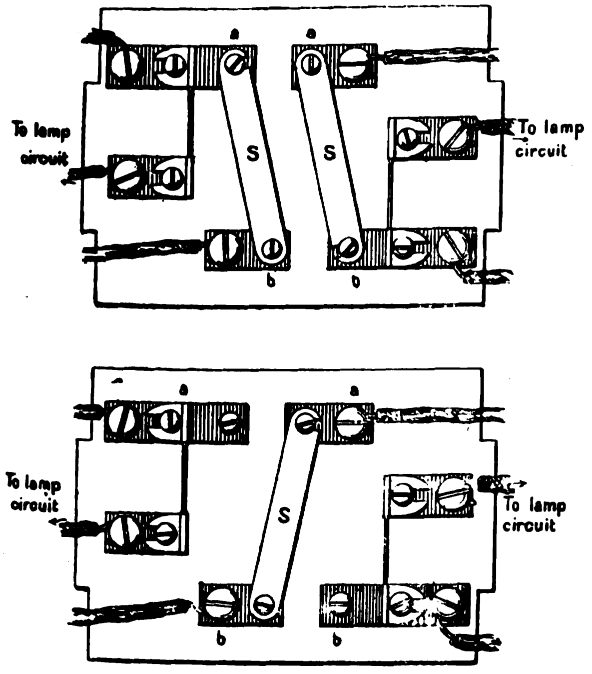



Fig. 9.—Connections on Thomson-Houston Transformer.

being excited by the rectified current from the alternator as well as by that from a small direct current dynamo.

In other respects this system is similar to other transformer systems and its principle needs no special explanation. Fig. 7 shows the form of switch-board employed. The various instruments which comprise it will be presently described. The dynamo has already been described. The standard type of alternator is the separately-excited drum armature alternator, compounded to give constant pressure for a drop of a definite number of volts in the primary line between no load and full load. This alternator is excellently designed in all its parts, and between full and no load can maintain constant potential at the end of its primary line.

*Transformers.*—The latest form of transformer manufactured by the Thomson-Houston Electric Company is shown in its box in perspective in Fig. 8. The coils are enclosed in a cast-iron box, waterproof, and stout enough to withstand ordinarily rough usage. The primary wires are seen coming out of the transformer at the top, and the secondary at the bottom, each passing through waterproof insulating bushings.

The coils are in some cases wound directly upon the cores, in others they are wound on wooden formers, which are removed when the coils are completed. In some forms the secondary winding is laid on first and the primary over it; in other forms the two are wound side by side. In either case the insulation between the two coils is very carefully made, consisting of mica, paper, and shellac. The secondary coil is wound with two equal circuits, which may be either connected in series to give 104 volts or connected in multiple arc to give 52. Fig. 9 shows the switch device by which these connections are made and the fuse wire terminals for holding the safety cut out for the secondary circuit.

*(To be continued.)*

## CAPACITY AND SELF-INDUCTION IN ALTERNATE CURRENT WORKING.—I.

BY GISBERT KAPP.

The peculiar interaction between capacity and self-induction of a circuit traversed by an alternating current has long been known to scientists, and as far back as 1884, Dr. Hopkinson gave in his Paper on "The Theory of Alternating Currents," read before the Society of Telegraph Engineers and Electricians, a practical example, in which he showed that with a certain capacity, periodic time, self-induction and resistance in circuit, the potential difference between the plates of the condenser may be 80 times the E.M.F. of the alternator. Startling as such a result must naturally appear, it failed at the time to attract much attention from practical engineers who, no doubt, pre-occupied with other problems relating to continuous-current work, were content to let such an intricate and apparently abstruse problem lie at rest until such time as its consideration should be forced upon them. This time has now come, and what in 1884 was merely an interesting laboratory experiment, having no further application than perhaps the breaking down of a condenser, is at present an intensely practical problem which the electrical engineer has to face. Phenomena arising from the effects of capacity in alternate-current circuits are forcing those who have to do with such circuits to give attention to the problems connected with these phenomena. As a case in point, I may mention that about a year ago I had to test a short underground line for a 2,000-volt alternating-current, and although the bridge test gave several hundred megohms with a steady E.M.F. of 300 volts, the line appeared to be leaky under an alternating E.M.F. of 2,000 volts. A Cardew voltmeter inserted between one of the terminals of the alternator and the corresponding main showed a small but unmistakable deflection, indicating the passage of a current. This was, of course, due to the fact that the line acted as a condenser, a small current flowing into and out of the line through the voltmeter. The capacity of the line was found to be ·037 of a microfarad, and to this corresponds at the pressure and frequency used a current of 45 milliamperes, a value quite high enough to give a slight deflection on the voltmeter. To neglect taking account of the capacity of the line would in such a case lead to a serious error in determining the insulation resistance in the manner described, whereas with a steady E.M.F. no such

Digitized by Google

error would be possible. Other problems of much more importance and on a much larger scale have since then cropped up, notably that which Mr. Ferranti has so successfully faced, of transmitting high-pressure currents from Deptford to London through a line which has considerable capacity. It is, therefore, not surprising that we find questions connected with such problems treated in the current literature.

An excellent article on the subject has been published by M. Boucherot a few weeks ago in *L'Electricien*. He considers there the following cases. (*a*) An alternate current circuit containing an inductionless resistance and a condenser placed in series; (*b*) such a circuit containing a resistance and a self-induction placed in series; and (*c*) such a circuit containing a resistance, a condenser, and a self-induction placed in series. In the latter case, he shows that with a very moderate E.M.F. impressed upon the circuit taken as a whole, the E.M.F. over the terminals of the self-induction coil and that between the plates of the condenser may, under certain circumstances, become almost infinite. The case investigated by M. Boucherot is, however, not the case we meet in practice. When the line is at work, that is to say, when more current than required to satisfy its electrostatic capacity is flowing through it, the condenser is not in series with, but forms a shunt to the lamps or whatever translating device is employed at the distant end. Under this condition M. Boucherot's solution does not apply, and I propose therefore in what follows to supplement his article by an investigation of the general case here mentioned.

Before entering into this subject it may perhaps be useful to state, for the benefit of the younger readers of *The Electrician*, what is the general aim of the investigation. The effect of self-induction and capacity combined is, broadly speaking, to produce somewhere in the circuit a pressure higher than intended, and it will easily be seen that where we already deal with high pressures such an increase may become a serious matter. It is therefore necessary to know what determines this increase of pressure, and how it can be kept within safe limits. Another effect due to the combined action of capacity and self-induction is an increase of current above the value which would suffice for working the lamps at the far end of the line if both self-induction and capacity were absent. It comes therefore to this, that if we design the alternator, whilst omitting to take account of the self-induction and capacity of the line, we shall find that we must work the machine at a lower E.M.F., and at a higher current than originally intended. Here let me draw the reader's attention to what I believe to be a popular error. An impression seems to be abroad that the effects of self-induction and capacity are only felt at one particular frequency, or, what comes to the same thing, at one particular speed of the alternator. It is supposed to be that speed at which the natural period of oscillation coincides with the period of the machine producing resonance between the machine and the circuit. This view was very clearly expressed in Mr. Swinburne's otherwise excellent Paper read at the last meeting of the Physical Society, when he said that a variation of 5 per cent. in the engine speed would at once destroy the interaction between self-induction and capacity—would in a word obviate all difficulties arising from these causes. I shall endeavour to show in this article that the difficulty exists at all speeds, but is either greater or smaller, accordingly as the speed is nearer to or farther away from that speed at which resonance obtains.

To facilitate the investigation it will be best to attack the problem piecemeal, taking first a circuit with resistance and self-induction, then a circuit with resistance and capacity, and finally a circuit having resistance, capacity, and self-induction. We assume that in all cases E.M.F. and current follow the sine law. We also assume that the coefficient of self-induction and the capacity are constants. The former assumption is not quite correct as far as relates to that part of the self-induction which is due to the armature of the alternator, since it depends to a certain extent on the relative position of the armature coils and field-magnet poles, which is constantly changing. It would, however, enormously complicate the investigation if we were to attempt to make a correction on this account, and the correction could in any case be but trifling. The second assumption regarding the constancy of the capacity would certainly be incorrect if we had to deal with an ordinary condenser consisting of tinfoil and paraffined paper. In such a condenser there is considerable electrostatic attraction between the coatings causing a compression of the paper, and consequently a diminution of distance between opposite coatings. The capacity must then increase with the potential difference on the terminals of the condenser, and cannot be a constant when, as with an alternating E.M.F. this pressure is continuously varying. When, however, the condenser takes the form of a concentric main of stout copper, or of two heavy cables drawn into a pipe, it is inconceivable that there should be any movement altering the relative position of the conductors, and we may, therefore, without error assume the capacity of such a main as constant.

The E.M.F. due to a self-induction L is

$$e = L\frac{di}{dt},$$

and since $i$ may be expressed as a simple sine function, such as $i = T \sin w t$, where $w = 2\pi\frac{1}{T}$, we can also write

$$e = L w I \cos w t.$$

This E.M.F. becomes a maximum at such times as the current passes through its zero value. Writing $E_s$ for this maximum value of the E.M.F. of self-induction, we find, therefore,

$$E_s = L w I.$$

In making measurements of current and E.M.F. we obtain, of course, not the maximum but the square root of mean squares, and it is, therefore, desirable to have a formula giving the effective value of E.M.F. Since the effective and maximum values, both as regards E.M.F. and current, are in the ratio of 1 to $\sqrt{2}$, it is obvious that the formula

$$E_s = L w I$$

will give the effective value of the E.M.F. if T be taken to represent the effective value of the current. The formula is based on C.-G.-S. units. If we wish to obtain $E_s$ in volts, we must divide the right side by $10^8$. If I is taken in amperes, we must further divide by 10, and if L is given in quadrants (or secohms) we must multiply by the ratio of the quadrant to the centimetre, namely, by $99,777 \times 10^4$. As, however, extreme accuracy is not of very great importance in treating problems, in which other and more important corrections must be neglected, we shall, for the sake of simplicity, assume that a quadrant is $100,000 \times 10^4$ centimetres, and must therefore multiply the right side of the equation by $10^9$. Hence, the equation as it stands is right for practical units, and we have

$$\left.\begin{array}{l}\text{Volts due to self-}\\ \text{induction.........}\end{array}\right\} = 2\pi \times \text{frequency} \times \text{quadrants} \times \text{amperes}$$

Thus to force a current of 10 amperes through a coil having a self-induction of ·1 quadrant with a frequency of 80 would require an E.M.F. of 500 volts.

Let the capacity of a condenser be C then an increment of E.M.F. of $d e$ will in the time $d t$ add to its charge the amount

$$C\, d e = i\, d t,$$

$i$ being the rate of current at which the additional charge $C\,de$ is supplied. Let $E_c$ be the maximum P D between the condenser plates, then $C E_c$ is the total charge, or the $\int i\, d t$ taken over a quarter period, that is, from $t = 0$ to $t = \frac{T}{4}$. Now $i\, d t = -\frac{1}{w} d(I \cos w t)$ and $C E_c = -\frac{1}{w}\left[I \cos w t\right]_{t=0}^{t=\frac{T}{4}}$ from which we obtain $I = w C E_c$.

Here, again, the values of current and E.M.F. may be taken to represent either the maxima or the effective values, whichever is more convenient. The above formula is given in C.-G.-S. units. If we want to have it in practical units we must remember that a microfarad is smaller than a C.-G.-S. unit of capacity in the ratio of $10^{15}:1$; that a volt is larger than a C.-G.-S. unit of E.M.F. in the ratio of $10^8:1$, and that an ampere is the tenth-part of a C.-G.-S. unit of current. We find thus the formula connecting capacity, volts and amperes as

$$I = C E_c w 10^{-6},$$

Digitized by Google

As an example, assume that we have a concentric cable of capacity $C=2$ microfarads, $E_c=10{,}000$ volts and $w=500$ ($n=80$) The current flowing in and out will be

$$I=2.\times 10{,}000\cdot 500\cdot 10^{-6}=10 \text{ amperes.}$$

Having thus established the fundamental relations between capacity, self-induction, current, and E.M.F., we can now proceed to show their practical application to problems of alternate current distributions, which shall be done in a subsequent article.

*(To be continued.)*

## DRUM ARMATURE WINDING.

BY F. M. WEYMOUTH.

*(Concluded from page 168.)*

A few more windings which we may touch on belong to an entirely distinct class, especially as regards their end connections. We refer to those in which the connections are made outside the circumference of the armature, instead of within. The first of these we may consider, is one patented by Messrs. Crompton and Kyle. This is based on the convolute principle, and consists of two series of convolutions running in opposite

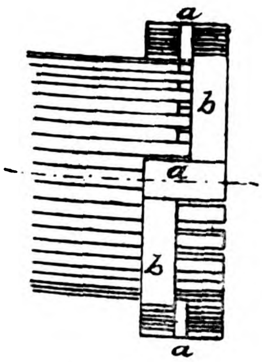



Fig. 45.—Crompton-Kyle Winding. Side View.

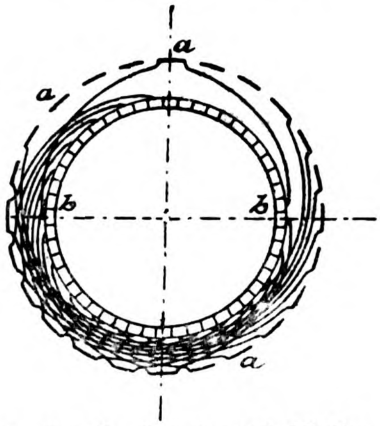



Fig. 46.—Crompton-Kyle Winding. End View.

directions outside the armature ends. Figs. 45 and 46 illustrate this arrangement, though with only a portion of the connectors shown. On the outer circumference will be observed jointing plates *a a a* parallel with the shaft. From each of these there spring two evolutes *b b* which proceed, one in each series of evolutes, to the opposing ends of a long and short bar respectively. One complete coupling *b a b* is thus shown apart in both views. Though cases may arise when this arrangement may be most suitable, yet in some respects it will not compare favourably with an inside end winding.

This form of winding plainly requires a longer coupling to unite the two ends of a diameter outside than inside the circumference. The joints, however, are all accessible after removing the commutator. But a disadvantage with this design results from the fact that an accumulation of material round the outer ends of the armature militates against the snugness of the machine as a whole. It is desirable to keep the "magnetic circuit" through the magnets as short as possible, and the field coils need to be brought close up to the pole-pieces to obtain their fullest effect. It will, therefore, be observed that designers generally bring the field coils as near the armature as possible, and, in fact, in the case of vertical machines, rest them on the horns, as shown at *a a*, Fig. 47. Thus the lines of magnetic induction generated in the magnets within the coils can pervade the pole-pieces with the least possible loss of strength, and the total magnetic resistance is kept to a minimum. In the design of end winding before us, however, the connectors would be in the way of the field coils, so that these would have to go further away from the armature, thus in some degree causing the advantage named to be sacrificed. This difficulty might, perhaps, be met by bending all the bars inward a little way toward the axis, as shown in Fig. 48. But bringing all the ends thus into a smaller circumference, unless the original spacing on the periphery of the core should be an open one, will tend to jamb them, and so necessitate their being formed to a deeper and narrower section, thereby introducing complications.

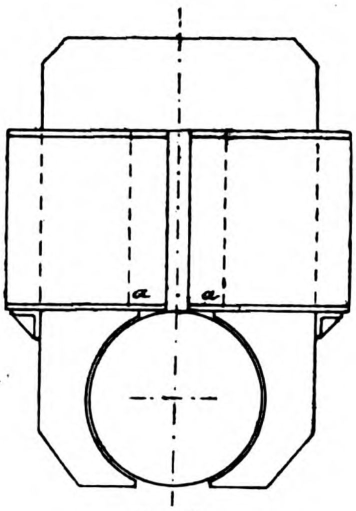



Fig. 47.

The next arrangement of outside end winding to which we may refer is one we believe was invented by a young employée formerly in the employ of Messrs. Latimer Clark, Muirhead and Co. This is shown somewhat diagrammatically in Fig. 49, and is in principle somewhat related to Siemens', Eickemeyer's, and Kapp's. With the two former it agrees in that each coil

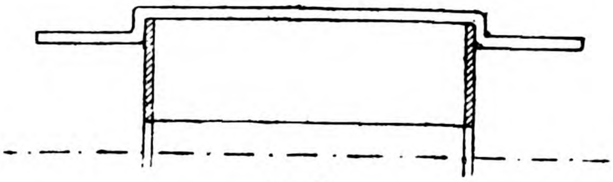


Fig. 48

consists of one wire, or group of wires, without joint from end to end; with the latter, in that the helical principle is introduced at the armature ends. Thus a coil starting, say, from a commutator lug at *a* pursues first a helical path through about a quarter circle to *b*, thence runs parallel to *c*, then down another helical path and approximate quarter circle to *d*, is here turned

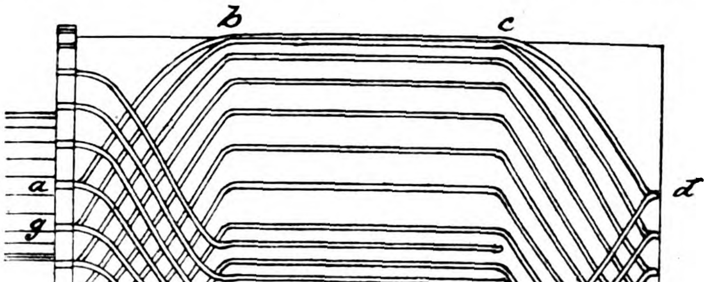



Fig. 49.—Diagram of a Suggested Form of Outside-end Winding.

back on itself, and pursues another helical path to *e*, and so on till it ends at another lug at *g*. It will be observed, however, in this winding, that the helices being in two layers, and all those from what correspond to the "long" bars crossing those from the "short" bars, the evil of the close proximity of conductors of maximum and minimum volts is in no wise

Digitized by Google

avoided; and the coils would need to be well insulated throughout. This form of winding is also neither economical in copper nor space, as compared with others that have been discussed. It is, however, well exposed to exterior ventilation; and to remove any burnt section, as in the case of the Eickemeyer arrangement, it would be necessary but to undo the connections with the commutator, and remove the exterior binding wires, to loosen the whole. It would, however, require some special cylindrical framing at the ends to carry the helical portions, the interior space of which would be more or less wasted. The armature also would be very long, necessitating a long machine.

If, however, we take this winding, and imagine all the parallel portion included within the letters *b*, *c*, *e*, *f* to be removed, so that *b f* coincides with *c e*, we shall then get approximately the last type of winding we propose to discuss, the Fritsche armature winding. The core of this armature is in fact, wound helically; the whole winding comes within the field, and it may be said that there is *no* "end winding." The pole-pieces are placed diagonally in this machine, with the corners cut off, in the manner indicated by the dotted lines in, Fig. 50. This, however, makes a bad field, as so large a proportion of the armature, as at *a a*, is uncovered by the pole-pieces; and the sectional area of the field, taken in a plane normal to its lines of force, is very much reduced compared to a field with the pole-pieces placed square in the usual manner. As regards facility for renewals, it is, of course, the same as the last described. On any armature, however, of a given diameter, it is not possible to put so many bars of a given size when laid

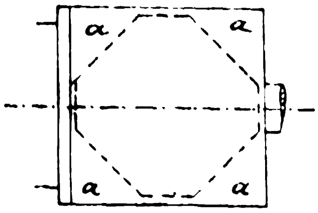


Fig. 50. - Fritsche Winding.

spirally as when laid in the ordinary manner parallel with the axis, comparing it, that is, with a parallel winding of two layers. Much care must obviously be involved in securing symmetry. An ulterior effect following on the diagonal arrangement of the pole-pieces to suit the helical winding is that, for any given output, the machine, as a whole, will need to be large and heavy as compared with others, and so will cost more. The coils, of course, have no joints, and, except those forming the inner layer, are well exposed to exterior ventilation. That the inner half should be without ventilation is a drawback. The commutator of this machine is abnormally large, as indicated. A full account of this machine was given in the *Electrician*, Vol. XXII., p. 655.

## THE ELECTRO-MAGNET.*

BY PROFESSOR SILVANUS P. THOMPSON.

(Concluded from page 18[illegible].)

### Polarised Mechanism: Uses of Permanent Magnets.

We must now turn our attention to one class of electro-magnetic mechanism which ought to be carefully distinguished from the rest. It is that class in which, in addition to the ordinary electro-magnet, a permanent magnet is employed. Such an arrangement is generally referred to as a polarised mechanism. The objects for which the permanent magnet is introduced into the mechanism appear to be in different cases quite different. I am not sure whether this is clearly recognised, or whether a clear distinction has ever been drawn between three entirely separate purposes in the use of a permanent magnet in combination with an electro-magnet. The first purpose is to secure unidirectionality of motion; the second is to increase the rapidity of action and of sensitiveness to small currents; the third to augment the mechanical action of the current.

(*a*.) [illegible] M[illegible].—In an ordinary electro-magnet it does not matter which way the current circulates; no matter whether the pole is north or south, the armature is pulled, and on reversing the current the armature is also pulled. There is a rather curious old experiment which Sturgeon and Henry showed, that if you have an electro-magnet with a big weight hanging on it, and you suddenly reverse the current, you reverse the magnetism, but it still holds the weight up; it does not drop. It has not time to drop before the magnet is charged up again with magnetic lines the other way on. Whichever way the magnetism traverses the ordinary soft iron electro-magnet, the armature is pulled. But if the armature is itself a permanent magnet of steel it will be pulled when the poles are of one sort, and pushed when the poles are reversed—that is to say, by employing *a polarised armature* you can secure unidirectionality of motion in correspondence with the current. One immediate application of this fact for telegraphic purposes is that of duplex telegraphy. You can send two messages at the same time and in the same direction to two different sets of instruments, one set having ordinary electro-magnets, with a spring behind the armature of soft iron, which will act simply independently of the direction of the current, depending only on its strength and duration; and another set having electro-magnets with polarised armatures, which will be affected not by the strength of the current, but by the direction of it. Accordingly, two completely different sets of message may be sent through that line in the same direction at the same time.

Another mode of constructing a polarised device is to attach the cores of the electro-magnet to a steel magnet, which imparts to them an initial magnetisation. Such initially-magnetised electro-magnets were used by Brett in 1848, and by Hjörth in 1850. A patent for a similar device was applied for in 1870 by Sir William Thomson, and refused by the Patent Office. In 1871 S. A. Varley patented an electro-magnet having a core of steel wires united at their ends.

Wheatstone used a polarised apparatus consisting of an electro-magnet acting on a magnetised needle. He patented, in fact, in 1845, the use of a needle permanently magnetised to be attracted one way or the other between the poles of an electro-magnet. Sturgeon had described the very same device in the *Annals of Electricity* in 1840. Gloesner claims to have invented the substitution of permanent magnets for mere armatures in 1842. In using polarised apparatus it is necessary to work, not with a simple current that is turned off and on, but with reversed-currents. Sending a current one way will make the moving part move in one direction; reversing the current makes it go over to the other side. The mechanism of that particular kind of electric bell that is used with magneto-electric calling apparatus furnishes an excellent example of a polarised construction. With these bells no battery is used; but there is a little alternate-current dynamo, worked by a crank. The alternate currents cause the pivotted armature in the bell to oscillate to right and left alternately, and so throw the little hammer to and fro between the two bells.

(*b*.) *Rapidity and Sensitiveness of Action.*—For relay work polarised relays are often employed, and have been for many years. Here on the table is one of the Post-office pattern of standard relay, having a steel magnet to give magnetism permanently to a little tongue or armature which moves between the poles of an electro-magnet that does the work of receiving the signals. In this particular case the tongue of polarised relay works between two stops, and the range of motion is made very small in order that the apparatus may respond to very small currents. At first sight it is not very apparent why putting a permanent magnet into a thing should make it any more sensitive. Why should permanent magnetism secure rapidity of working? Without knowing anything more, inventors will tell you that the presence of a permanent magnet increases the rapidity with which it will work. You might suppose that permanent magnetism is something to be avoided in the cores of your working electro-magnets, otherwise the armatures would remain stuck to the poles when once they had been attracted up. Residual magnetism would, indeed, hinder the working unless you have so arranged matters that it shall be actually helpful to you. Now for many years it was supposed that permanent magnetism in the electro-magnet was anything but a source of help. It was supposed to be an unmitigated nuisance, to be got rid of by all available means, until, in 1855, Hughes showed us how very advantageous it was to have permanent magnetism in the cores of the electro-magnet. Here (Fig. 51) is the drawing of Hughes's magnet to which I referred in Lecture III. A compound permanent magnet of horse-shoe shape is provided with coils on its pole-pieces, and there is a short armature on the top attached to a pivotted lever and a counteracting spring. The function of this arrangement is as follows. That spring is so set as to tend to detach the armature, but the permanent magnet has just enough magnetism to hold the armature on. You can, by screwing up a little screw behind the spring, adjust these two contending forces, so that they are in the nicest possible balance: the armature held on by the magnetism, and the spring just not able to pull it off. If, now, when these two actions are so nearly balanced you send an electric current round the coils of the electro

* A series of [illegible] Lectures delivered before the Society of Arts, January—February, 18[illegible]

Digitized by Google

current goes one way round, it just weakens the magnetism enough for the spring to gain the victory, and up goes the armature. This apparatus then acts by letting the armature off when the balance is upset by the electric current; and it is capable of responding to extremely small currents. Of course, the armature has to be put on again mechanically, and in Hughes's type-writing telegraph instruments it is put on mechanically between each signal and the next following one. The arrangement constitutes a distinctive piece of electro-magnetic mechanism.

(c.) *Augmenting Mechanical Action of Current.*—The third purpose of a permanent magnet to secure a greater mechanical action of the varying current is closely bound up with the preceding purpose of securing sensitiveness of action. It is for this purpose that it is used in telephone receivers; it increases the mechanical action of the current, and therefore makes the receiver more sensitive. For a long time this was not at all clear to me, indeed I made experiments to see how far it was due to any variation in the magnetic permeability of iron at different stages of magnetisation, for I found that this had something do do with it, but I was quite sure it was not all. Prof. George Forbes gave me the clue to the true explanation; it lies in the law of traction with which you are now familiar, that the pull between

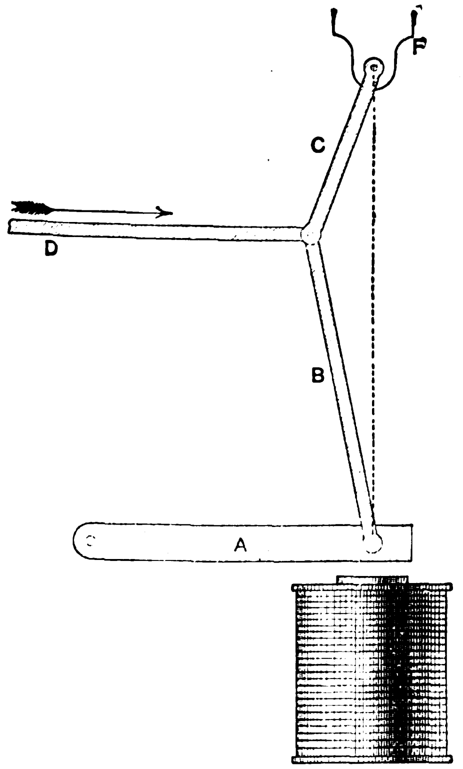



FIG. 68.—Froment's Equaliser with Stanhope Lever.

a magnet and its armature is proportional to the square of the number of magnetic lines that come into action. If we take N, the number of magnetic lines that are acting through a given area, then to the square of that the pull will be proportional. If we have a certain number of lines, N, coming permanently to the armature, the pull is proportional to $N^2$. Suppose the magnetism now to be altered—say made a little more; and the increment be called $dN$; so that the whole number is now $N + dN$. The pull will now be proportional to the square of that quantity. It is evident that the motion will be proportional to the difference between the former pull and the latter pull. So we will write out the square of $N + dN$, and the square of N, and take the difference.

Increased pull, proportional to $N^2 + 2N \cdot dN + dN^2$;
Initial pull, proportional to $N^2$;

Subtracting; difference is $2N \cdot dN + dN^2$.

We may neglect the last term, as it is small compared with the other. So we have, finally, that the change of pull is proportional to $2N \cdot dN$. The alteration of pull between the initial magnetism and the initial magnetism with the additional magnetism we have given to it, turns out to be proportional, not simply to the change of magnetism, but also to the initial number, N, that goes through it to begin with. The more powerful the pull to begin with, the greater is the change of pull when you produce a small change in the number of magnetic lines. That is why you have this greater sensitiveness of action when using Hughes's electro-magnets, and greater mechanical effect as the result of applying permanent magnetism to the electro-magnets of telephone receivers.

Here is another device for oblique approach, made by Froment. In the gap in the circuit of the magnet a sort of iron wedge is put in, which is not attracted squarely to either face, but comes in laterally between guides. Another of Froment's equalisers, or distributers, consists of a parallel motion attachment for the armature, so that oblique approach may take place, without actual contact. Here (Fig. 68) is another mechanical method of equalising devised by Froment, and used by Le Roux. You know the Stanhope lever, the object of which is to transform a weak force along a considerable range into a powerful force of short range. Here we use it backwards. The armature itself, which is attracted with a powerful force of short range, is attached to the lower end of the Stanhope lever, and the arm attached to the knee of the lever will deliver a distributed force over quite a different range. One way, not of equalising the actual motion over the range but of counterbalancing the variable attractive force, is to employ a spring instead of gravity to control the armature. So far back as 1838, Edward Davy, in one of his telegraphic patents, described the use of a spring (Fig. 69) to hold back the armature. Davy preceded Morse in the use of a spring to pull back the armature. There is a way of making a spring act against an armature more stiffly as the pull gets greater. In this method there is a spring with various set screws set up against it, and which come into action at different ranges, so as to alter the stiffness of the spring, making it virtually stiffer as the armature approaches the poles. Yet another method

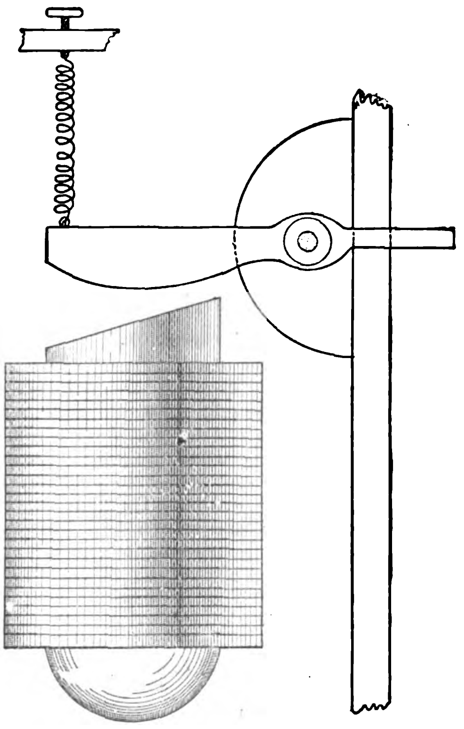


FIG. 69.—Davy's Mode of Controlling Armature by Spring

is to employ, as the famous conjuror Robert Houdin did, a rocking lever. Fig. 70 depicts one of Robert Houdin's equilisers. The pull of the electro-magnet on the armature acts on a curved lever which works against a second one; the point of application of force between the one and the other altering with their position. When the armature is far away from the pole, the leverage of the first lever on the second lever is great. When the armature gets near, the leverage of the first lever on the second is comparatively small. This employment of the *rocking lever* was adopted from Houdin by Duboscq, and put into the Duboscq arc lamp, where the regulating mechanism at the bottom of the lamp contains a rocking lever. Here upon the lecture table is a Duboscq's arc lamp. In this pattern (Fig. 71), one lever, B, which is curved, plays against another, A, which is straight. A similar mechanism is used for equalising the action in the Serrin arc lamp, where one of the springs that holds up the jointed parallellogram frame is applied at the end of a rocking lever to equalise the pull of the regulating electro-magnet. In this lamp there is also introduced the principle of oblique approach, for the armature of the electro-magnet is not allowed to travel straight towards the poles of the magnet, but is pulled up obliquely past it.

Another device for equalising the pull was used by Wheatstone in his step-by-step telegraph in 1840. A hole is pierced in the armature, and the end of the core is formed into a projecting cone which passes through the aperture of the armature, thereby securing a more equable force and a longer range. The same device has reappeared in recent years in the form of electro-magnet used in the Thomson-Houston arc lamp, and in the automatic regulator of the same firm.

Digitized by Google

### Electro-magnetic Mechanism.

There are some other kinds of electro-magnetic mechanism to which I must briefly invite your attention, as forming an important part of this great subject. Of one of these the mention of permanent magnets reminds me.

### Moving Coil in Permanent Magnetic Field.

A coil traversed by an electric current experiences mechanical forces if it lies in a magnetic field; the force being proportional to the intensity of the field. Of this principle the mechanism of Sir W. Thomson's siphon recorder is a well-known example. Also those galvanometers which have for their essential part a movable coil suspended between the poles of a permanent magnet, of which the earliest example is that of Robertson (see *Encyclopædia Britannica*, Ed. VIII., 1855), and of which Maxwell's suggestion,

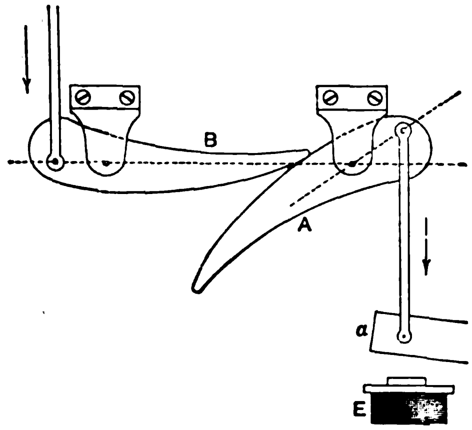



Fig. 70.—Robert Houdin's Equaliser.

afterwards realised by d'Arsonval, is the most modern. Siemens has constructed a relay on a similar plan.

### Magnetic Adherence.

There are a few curious pieces of apparatus devised for increasing adherence electro-magnetically between two things. Here is an old device of Nicklès, who thought he would make a new kind of rolling gear. Whether it was a railway wheel on a line, or whether it was going to be an ordinary wheel gearing, communication of motion was to be made from one wheel to another, not by cogs or by the mere adherence of ordinary friction, but by magnetic adherence. In Fig. 72 there are shown two iron wheels rolling on one another, with a sort of electro-magnetic jacket around them, consisting of an electric current circulating in a coil, and causing them to attract one another, and stick together with magnetic adherence. In Nicklès' little book on the subject there are a great number of devices of this kind described, including a magnetic brake for braking railway waggons, engines, and carriages, apply-

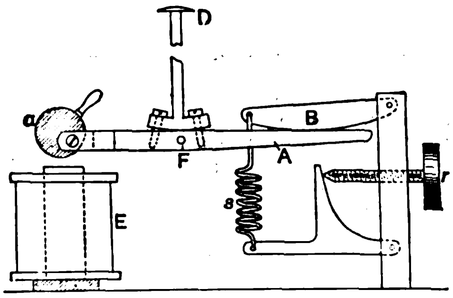



Fig. 71.—Mechanism of Duboscq's Arc Lamp.

ing electro-magnets either to the wheels or else to the line, to stop the motion whenever desired. The notion of using an electro-magnetic brake has been revived quite recently in a much better form by Prof. G. Forbes and Mr. Timmis, whose particular form of electro-magnets, shown in Fig. 73, is peculiarly interesting, being a better design than any I have ever seen for securing powerful magnetic traction for a given weight of iron and copper. The magnet is a peculiar one; it is represented here as cut away to show the internal construction. There is a sort of horseshoe made of one grooved rim, the whole circle of coil being laid embedded in the groove. The armature is a ring which is attracted down all round, so that you have an extremely compact magnetic circuit around the copper wire at every point. The magnet part is attached to the frame of the waggon or carriage, and the ring-armature is attached to the wheel or to its axis. On switching on the electric current the rim is powerfully pulled, and braked against the polar surface of the electro-magnet.

Forbes's arrangement appears to be certainly the best yet thought of for applying a magnetic brake to the wheels of a railway train.

Another, but quite distinct, piece of mechanism depending on electro-magnetic adherence is the magnetic *clutch* employed in Gülcher's arc lamp.

### Repulsion Mechanism.

Then there are a few pieces of mechanism which depend on repulsion. In 1850 a little device was patented by Brown and Williams, consisting, as shown in Fig. 74, of an electro-magnet which repelled part of itself. The coil is simply wound on a hollow tube, and inside the coil is a piece, B, of iron, bent as the segment of a cylinder to fit in, going from one end to the other. Another

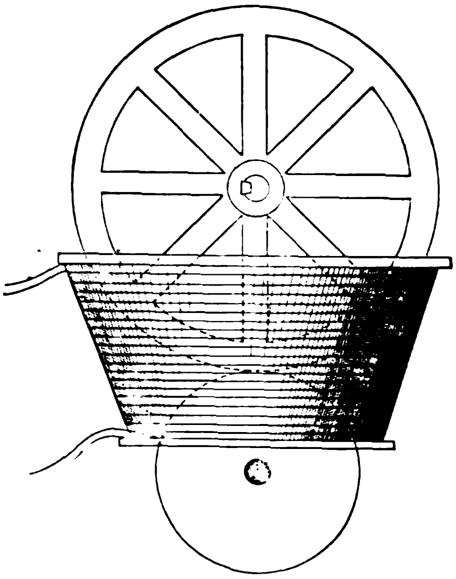


Fig. 72.—Nicklès' Magnetic Friction-Gear.

little iron piece, A, also shaped as the segment of a tube, is pivotted in the axis of the coil. When these are magnetised one tends to move away from the other, they being both of the same polarity. Of late there have been many ampere-meters and voltmeters made on this plan of producing repulsion between the parallel cores.

Here (Fig. 75) is another device of recent date, due to Maikoff and De Kabath. Two cores of iron not quite parallel, pivotted at the bottom, pass up through a tubular coil. When both are magnetised, instead of attracting one another, they open out; they tend to set themselves along the magnetic lines through that tube. The cores being wide open at the bottom tend to open also at the top.

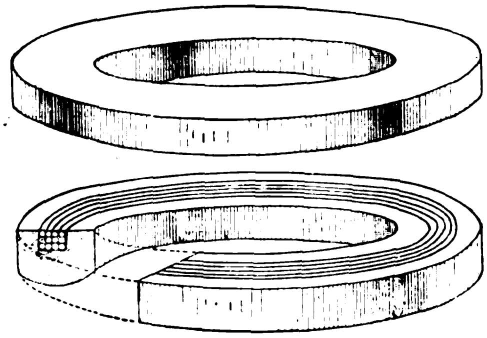


Fig. 73.—Forbes's Electro-Magnet.

### Electro-magnetic Vibrators.

Then there is a large class of mechanisms about which a whole chapter might be written, namely, those in which vibration is maintained electro-magnetically. The armature of an electro-magnet is caused to approach and recede alternately with a vibrating motion, the current being automatically cut off and turned on again by a self-acting brake. The electro-magnetic vibrator is one of the cleverest things ever devised. The first vibrating electro-magnetic mechanism ever made was exhibited here in this room in 1824 by its inventor, an Englishman named James Marsh. It consisted of a pendulum vibrating automatically between the poles of a permanent magnet. Later, a number of other vibrating devices were produced by Wagner, Neef, Froment, and others. Most important of all is the mechanism of the common electric trembling bell, invented by a man whose very name appears to be quite forgotten—John Mirand. How many of the millions of people who use electric bells know the name of the man who invented them? John Mirand, in the year 1850, put the electric

Digitized by Google

bell practically into the same form in which it has been employed from that day to this. The vibrating hammer; the similar push-button; the indicator or annunciator, are all of his devising, and may be seen depicted in the specification of his British patent just as they came from his hand.

Time alone precludes me from dealing minutely with these vibrators, and particularly with the recent work of Mercadier and that of Langdon-Davies, whose researches have put a new aspect on the possibilities of harmonic telegraphy. Langdon-Davies's rate-governor is the most recent and perfect form of electro-magnetic vibrator.

### Indicator Movements.

Upon the table here are a number of patterns of electric bells, and a number also of the electro-mechanical movements or devices employed in electric bell work, some of which form admirable illustrations of the various principles that I have been laying down. Here is an iron-clad electro-magnet; here a tripolar magnet; here a series of pendulum motions of various kinds; here is an example of oblique pull; here is Jensen's indicator, with lateral pull; here is Moseley's indicator, with a coil and plunger, iron-clad; here is a clever device in which a disc is drawn up to better the magnetic circuit. Here, again, is Thorpe's semaphore indicator, one of the neatest little pieces of apparatus, with a single central core surrounded by a coil, while a little strip of iron coming round from behind serves to complete the circuit all save a little gap. Over the gap stands that which is to be attracted, a flat disc of iron, which, when it is attracted, unlatches another disc of brass which forthwith falls down. It is an extremely effective, effective, very sensitive, and very inexpensive form of annunciator. The next two are pieces of polarised mechanism having a motion directed to one side or the other, according to the direction of the current. From the back-board projects a small straight electro-magnet. Over it is pivotted a small arched steel magnet, permanently magnetised, to which is attached a small signal lever bearing a red disc. If there is a current flowing one way, then the magnet that straddles over the pole of the electro-magnet

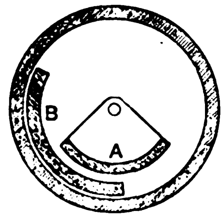



Fig. 74.—Electro-magnetic Mechanism Working by Repulsion.

will be drawn over in one direction. If I now reverse the current, the electro-magnet attracts the other pole of the curved magnet. Hence this mechanism allows of an electrical replacement, without compelling the attendant to walk up to the indicator board. The polarised apparatus for indicators has this advantage, that you can have electrical as distinguished from mechanical replacement.

### The Study of Electro-magnetic Mechanism.

The rapid survey of electro-magnetic mechanisms in general has necessarily been very hurried and imperfect. The study of it is just as important to the electrical engineer as is the study of mechanical mechanism to the mechanical engineer. Incomplete as is the present treatment of the subject, it may sufficiently indicate to other workers useful lines of progress, and so fitly be appended to these lectures on the electro-magnet. In a very few years we may expect the introduction into all large engineering shops of *electro-magnetic tools*. On a small scale, for driving dental appliances, electro-magnetic engines have long been used. Large machine tools, electro-magnetically worked, have already begun to make their appearance. Some such were shown at the Crystal Palace, in 1881, by Mr. Latimer Clark; and more recently, Mr. Rowan, of Glasgow, has devised a number of more developed forms of electro-magnetic tools.

### Suppression of Sparking.

It now remains for me to speak briefly of the suppression of sparks. There are some half-dozen different ways of trying to get rid of the sparking that occurs in the breaking of an electric circuit whenever there are electro-magnets in that circuit. Many attempts have been made to try and get rid of this evil. For instance, one inventor employs an air blast to blow out the spark just at the moment it occurs. Another causes the spark to occur under a liquid. Another wipes it out with a brush of asbestos cloth that comes immediately behind the wire and rubs out the spark. Another puts on a condenser to try and store up the energy. Another tries to put on a long thin wire or a high resistance of liquid, or something of that kind, to provide an alternate path for the spark, instead of jumping across the air and burning the contacts. There exist some half-score, at any rate, of that kind of device. But there are devices that I have thought it worth while to examine and experiment upon, because they depend merely upon the mode of construction adopted in the building of the electro-magnet, and they have each their own qualities. I have here five straight electro-magnets, all wound on bobbins the same size, for which we shall use the same iron core and the same current for all. They are all made, not only with bobbins of the same size, but their coils consist as nearly as possible of the same weight of wire. The first one is wound in the ordinary way; the second one has a sheath of copper wound round the interior of the bobbin before any wire is put on. This was a device, I believe, of the late Mr. C. F. Varley, and is also used in the field magnets of Brush dynamos. The function of the copper sheath is to allow induced currents to occur, which will retard the fall of magnetism, and damp down the tendency to spark. The third one is an attempt to carry out that principle still further. This is due to an American of the name of Paine, and has been revived of late years by Dr. Aron, of Berlin. After winding each layer of the coil, a sheath of metal foil is interposed so as to kill the induction from layer to layer. The fourth one is the best device hitherto used, namely, that of differential winding, having two coils connected so that the current goes opposite ways. When equal currents flow in both circuits there is no magnetism. If you break the circuit of either of the two wires the core at once becomes magnetised. You get magnetism on breaking, you destroy magnetism on making the circuit; it is just the inverse case to that of the ordinary electro-magnet. There the spark occurs when magnetism disappears, but here, since the magnetism disappears when you make the circuit, you do not get any spark at make, because the circuit is already made. You do not get any at break, because at break there is no magnetism. The fifth and last of these electro-magnets is wound according to a plan devised by Mr. Langdon-Davies, to which I alluded in the middle of this lecture, the bobbin being wound with a number of

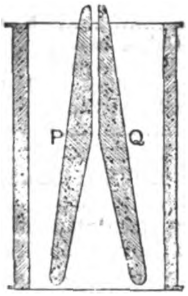



Fig. 75.—Repulsion between two Parallel Cores.

separate coils in parallel with one another, each layer being a separate wire, the separate ends of all the layers being finally joined up. In this case there are fifteen separate circuits; the time-constants of them are different, because, owing to the fact that these coils are of different diameters, the coefficient of self-induction of the outer layers is rather less, and their resistance, because of the larger size, rather greater than those of the inner layers. The result is that instead of the extra currents running out all at the same time, it runs out at different times for these fifteen coils. The total electromotive force of self-induction never rises so high, and it is unable to jump a large air-gap, or give the same bright spark as the ordinary electro-magnet would give. We will now experiment with these coils. The differential winding gives absolutely no spark at all, and second in merit comes No. 5, with the multiple-wire winding. Third in merit comes the coil with intervening layers of foil. The fourth is that with copper sheath. Last of all, the electro-magnet with ordinary winding.

### Conclusion.

Now let me conclude by returning to my starting point—the invention of the electro-magnet by William Sturgeon. Naturally you would be glad to see the counterfeit presentment of the features of so remarkable a man, of one so worthy to be remembered amongst distinguished electricians and great inventors. Your disappointment cannot be greater than mine when I tell you that all my efforts to procure a portrait of the deceased inventor have been unavailing. Only this I have been able to learn as the result of numerous inquiries: that an oil painting of him existed a few years ago in the possession of his only daughter, then resident in Manchester, whose address is now, unfortunately, unknown. But if his face must remain unknown to us, we shall none the less proudly concur in honouring the memory of one whose presence once honoured this hall wherein we are met, and whose work has won for him an imperishable name.

---

Prof. Thompson, in replying to the vote of thanks, stated that if any of those present could assist him in discovering what had become of the portrait of William Sturgeon, or in gleaning any particulars with regard to John Mirand, he should be much indebted to them if they would communicate with him.

Digitized by Google

# The Electrician.

ublished every Friday, Price Fourpence; Post Free, Fourpence Halfpenny.
Editorial, Publishing, and Printing Offices:
SALISBURY COURT, FLEET ST., LONDON, E.C.
*Telephone No. 2714. Telegrams:* "ELECTRICIAN NEWSPAPER, LONDON."

*All Letters relating to Subscriptions, Advertisements and other business matters should be addressed to the Publisher, "*THE ELECTRICIAN,*" Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to "*THE ELECTRICIAN*" Printing and Publishing Company, Limited, and be crossed "Coutts and Co." All other letters to be addressed to the Editor.*

*All letters intended for insertion in "*THE ELECTRICIAN,*" or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

"THE ELECTRICIAN" *is published every Friday morning, in time for the morning mails. Subscribers should receive their copies by the first post on Friday morning.*

"THE ELECTRICIAN" *is on sale at the railway bookstalls throughout the Kingdom on Friday morning, and can be obtained of all Booksellers and Newsvendors; or direct from the Publishing Offices as above.*

*New Volumes of* "THE ELECTRICIAN" *commence in May and November.*

## SUBSCRIPTION RATES.

The rates for Subscriptions to "THE ELECTRICIAN" are as follows :—

| | 3 months. s. d. | 6 months. s. d. | 12 months. s. d. |
|---|---|---|---|
| For the United Kingdom | 5 0 | 10 0 | 19 6 |
| For Foreign Parts and Colonies:— Within Postal Union | 6 6 | 12 6 | 24 0 |
| Aden Borneo, Ceylon, China, India, Japan, Java, Labuan, Mozambique, New Caledonia, Persia, Philippine Islands, Siam, Transvaal, and Zanzibar | 7 6 | 14 6 | 28 0 |



## TO ADVERTISERS.

"THE ELECTRICIAN" *offers exceptional advantages to Advertisers.* **It has by far the largest circulation of any English Electrical paper, and circulates all over the World.**

*Particulars relating to Advertisements will be promptly forwarded on application to the Offices as above.*

TRADE ADVERTISEMENTS *intended for the current issue must reach the Offices not later than First Post on Thursday morning. Renewals of expiring advertisement orders and alterations to standing advertisements should be in the Publisher's hands by Wednesday at latest. No alteration can be made in Wrapper advertisements after Wednesday evening.*

SMALL PREPAID ADVERTISEMENTS *(for Rates see page xvii.) are accepted up to 4 p.m. on Thursday.*

## TECHNICAL PRINTING.

"THE ELECTRICIAN" PRINTING AND PUBLISHING COMPANY (LIMITED) *inform Electricians, Electric Light Engineers, &c., that they make a specialty of Technical Printing, and have a large Staff thoroughly acquainted with Electro-Technology. They can, therefore, promise Accuracy and Despatch in the Printing of Electro-Technical Literature, &c.*

## "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. (Royal 8vo.)

*Early in each year is issued* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. *The* DIRECTORY *was established in 1883, and the 1890 Edition consisted of about 850 pages of printed matter. The names and addresses of all persons engaged in the Electrical Industries at home and abroad may be relied upon as accurate. Useful Tables and Electrical Formulæ, and information specially compiled for this work are given, together with popularly-written Biographical Notices of the leading Electricians, Electrical Engineers, &c., accompanied in many cases by Portraits.*

*Orders for the 1890 issue should be forwarded* AT ONCE *to the Publishing Offices, Salisbury-court, Fleet-street, London, E.C.*

*The 1891 Edition is now preparing, and New Names, &c., can now be received.*

## ELECTRICAL BOOKS AND PUBLICATIONS.

***All Books, Newspapers, and other publications, dealing with Electrical and kindred subjects, can be ordered direct of*** **"THE ELECTRICIAN"** ***Printing and Publishing Company, who are proprietors of the well-known*** **"ELECTRICIAN"** ***Series of Standard Electrical Works, and are agents for all the leading publishing houses at home and abroad.***


## CONTENTS OF THE CURRENT NUMBER.


NOTES ... 191
Electrical Distribution by Transformers from Central and Eccentric Stations. By Dr. J. A. Fleming, M.A. Illustrated. Continued ... 196
Capacity and Self-Induction in Alternate Current Working. By Gisbert Kapp ... 197
Drum Armature Winding. By F. M. Weymouth. Illus. Concluded. ... 199
The Electro-Magnet. By Prof. Silvanus P. Thompson, D.Sc., B.A., M.I.E.E. Illus. Con. 200
THE FERRANTI EFFECT ... 204
Electric Lighting Progress in London. By F. Bailey, Assoc. M.Inst.C.E. ... 206
Gas and Electric Light and Ventilation ... 212
Physical Society—
Some Experiments with Selenium Cells. Illustrated. 213
On Alternate Current Condensers. Illustrated ... 214
Notes on the Chemistry of Secondary Cells. By Prof. W. E. Ayrton and Messrs. C. G. Lamb, B.Sc., and E. W. Smith. *Discussion.* Illustrated. Con. 215
Experiments on the Magnetisation of Thin Plates of Steel at Right Angles to their Plane. By W. Doule ... 216
American Notes ... 216
CORRESPONDENCE—
Experiment with a Condenser at Deptford — William Thomson ... 216
Forces between Currents—James Erskine - Murray. Illustrated ... 217
Tenders for Mullingar Asylum Arthur O'Brien ... 218
Electrical Treatment of Sewage—Ed. C. de Segundo ... 218
Electricity for Heating Purposes—E. L. Fleming ... 218
Trade Notes and Notices ... 219
Books Received ... 219
PATENT RECORD ... 219
COMPANIES' MEETINGS, &c.—
The Gülcher (New) Electric Light and Power Company (Limited) ... 219
Western Counties and South Wales Telephone Company (Limited) ... 220
New Companies Registered ... 221
City Notes, &c. ... 221
Companies' Share List ... 222


## SPECIAL NOTICE.

**"THE ELECTRICIAN" will be published on Wednesday, the 24th, instead of on Friday, the 26th December, and all Contributions and Advertisements intended for the Christmas Week issue must reach the Office by mid-day on TUESDAY, at the latest.**

## THE FERRANTI EFFECT.

The discussions at the Physical Society frequently exhibit a little inertia. At meetings the President invites member after member, in vain, to offer remarks; and the author is permitted to place his own interpretation on the silence. His Paper is either so complete that nothing more can be said, and so accurate that no criticism can be raised, or its cool reception may be due to another reason, on which it is unnecessary to dwell. But occasionally the other kind of inertia is manifest, and the subject is tossed from one speaker to another until it is split into fragments, each of which is seized on by a different member, and the game is kept up with growing complication until long after the hour at which an afternoon meeting can be expected to continue, and, indeed, sometimes until the Paper itself has been well nigh forgotten. Although something of this kind took place last Friday, the most interesting Paper of Mr. SWINBURNE is not one which it is easy to forget.

Beginning with the discussion on condensers, the subject of non-homogeneous dielectrics was touched upon. This led to the brown paper of the Ferranti mains. Returning to condensers, Mr. BLAKESLEY described a split dynamometer method of measuring the power absorbed in an alternate current circuit, then quartz and various kinds of glass were discussed, a little confusion being caused by some members speaking of its resistance, others of its inductance. Then the soakage of the charge into a Leyden jar came up, and Sir WILLIAM THOMSON gave some interesting information about the instantaneous discharge of a jar by a rebounding metal ball. This led to Hertz's work on the duration of contact of colliding bodies, and it was

Digitized by Google

mentioned that two globes of steel, each the size of the earth, colliding together after approaching with a velocity of one centimetre per second would remain in contact for 27 hours. After this the meeting returned to Leyden jars, and thence to the insulation of armature coils, and to the thermal considerations of imperfect dielectrics. Then, with an "impulsive rush," the meeting went back to the increase of volts on the FERRANTI mains. Mr. SWINBURNE had practically stated that the alleged results were impossible, and that resonance could have nothing to do with it, and proceeded to offer an explanation of something which might have happened. Sir WILLIAM THOMSON gave some calculations founded on one assumed capacity, Mr. SWINBURNE taking another value, both being not far from, but on opposite sides of the true figure. Then Prof. AYRTON gave an account of what he had heard from Mr. FERRANTI, and Mr. KAPP described some experiments of his own, in which he had measured the volts by the length of the disruptive discharge. Another speaker ventured to contribute some information obtained from the inventor of the mains in question. Amid the confusion of theories and conflict of evidence, Mr. SWINBURNE pleaded that he had received his account from Mr. SPARKS, who, in the opinion of one of the most distinguished members present, should be considered as the highest authority on disruptive discharges.

A great deal of the confusion appeared to spring from the fact that the rise in volts is due to the length of the main—the longer the main the higher the volts; but yet the voltage of the main itself is practically uniform, except for the ordinary drop due to its ohmic resistance. The facts may be very simply stated, and we have the authority of Mr. FERRANTI for the accuracy of the following:—When the mains were being laid the insulation of the outer conductor was tested by the application of a pressure of 500 volts from a converter. In order to be quite sure that the pressure was on the mains, five lamps of 100 volts each were lighted on the far end. It was found as the length of main was increased that the brightness of the lamps also increased; and it was further found a little later on that another lamp had to be put in series in order that the lamps lighted across the ends should not be too bright. This effect was not altogether new to Mr. FERRANTI, as he had found practically the same thing some 18 months or two years ago when testing cables; but extreme pressure put upon him by the large quantity of work in hand, prevented his giving it that amount of attention and consideration which so interesting a phenomenon deserved. Nothing whatever happened to the dynamo, as ingeniously supposed by Mr. SWINBURNE, nor was it necessary to connect a transformer at the distant end, although, when it is done the effect is substantially the same. This heaping up of the voltage at the distant end of the line has been investigated by several mathematicians, and as we believe that it will shortly be thoroughly dealt with by far more able hands, we do not propose to go into any theoretical considerations on the present occasion. The phenomena of resonance are of two kinds, one of which has little or nothing to do with the question. Resonance is the result of a coincidence between the period of the alternate current and the natural period of oscillatory discharge of the condenser. The wave length of the Deptford current is some two thousand miles. If there be a harmonic corresponding to the eighth octave above, it might be commensurable with the length of the main, but no true resonance could arise on this account. As Mr. SWINBURNE observed when he demolished his own hypothesis of resonance, any effect of this kind must be dependent on the frequency of the alternations, and we believe that the explanation will resolve itself into a simple question of capacity and self-induction, and has not been observed before simply because the capacity has never reached so high a value on any previous conductor in which considerable alternating currents have been carried. It should be remarked that the rise in the voltage or the altered ratio of transformation does not, as has been asserted, disappear when a considerable current is passing. It has been observed when 250 horse-power was being transmitted, that the volts at Deptford were apparently 8,500, while 10,000 were found at London, nearly eight miles distant. No sooner was this discovered than it was found that no such "heaping up" is observed when the mains are supplied direct by a dynamo, so no inconvenience whatever will be felt by the London Electric Supply Company in practice.

It would seem that a difficulty will be thus placed in the way of those who have proposed to use "step up" transformers and low-pressure dynamos, thus avoiding the difficulties and dangers of high volts; and it may be that some dynamos which have high-self induction may exhibit this effect when coupled direct on to a circuit of considerable capacity. The matter will not long remain in obscurity. Mr. KAPP has set to work without delay, and the first part of his contribution upon this question will be found in another column. Prof. AYRTON promises to deal with it in a paper before the Physical Society. Dr. FLEMING has had the calculations in hand for some time past, and the author of the "Ferranti effect" is by no means leaving others to explain the strange experiment which he has conducted on so gigantic a scale.

## REVIEWS.

**Spinning Tops.** By Prof. J. Perry, F.R.S. Romance of Science Series. Society for Promoting Christian Knowledge. (London: 1890.)

This admirable little book, which has but little to do with electricity, is based upon the lecture delivered at Leeds during the last meeting of the British Association. The latter portion, it is true, contains some very interesting suggestions with regard to magnetic theories, but if they were absent we should not think it necessary to make excuse for noticing it in these columns. As a book on mechanics, it is sufficient to say that it is as clear, as original, as interesting, and as valuable as the "Practical Mechanics" of the same author. We have on several occasions imagined that we grasped the explanation of the behaviour of a gyroscope, and we must confess that on each occasion we failed to retain any tolerable conception of it for more than about twenty minutes. But no one who carefully reads and follows the arguments of this little work, aided by the excellent illustrations, can fail to gain either a thorough insight into the strange stiffness and obstinate crab-like tricks of a gyroscope, or, at all events, a tolerably clear idea of what it really tries to do, the laws which it may be said to obey, and a general knowledge of the many accompanying phenomena of top spinning, such as precession, nutation, and "going to sleep."

Some years ago we spent no little time in endeavouring to arrive at a common-sense explanation of gyroscopic action, and we searched authorities of every kind. The only writers who had anything whatever to say about it were those kind of mathematicians who address themselves to others of their own attainments, and who seem to think that to reduce their language a little nearer to the comprehension of less learned people is to lower the dignity of their subject, if not of themselves. Fortunately, Prof. Perry not only continually keeps in mind that he is addressing himself to a popular audience, but he has very decided ideas as to how much he shall put before them, how much must only be briefly alluded to, what expressions may be used without going into explanation of their precise meaning, and what ideas it is absolutely necessary to clearly define and understand. To read the book through from beginning to end, as we have done, is to

Digitized by Google

do very little with it. We are looking forward to repeating many of his experiments with his book in hand, and learning thoroughly those many features of the top and the gyroscope, which mathematicians merely use as pegs on which to hang their frightful festoons of mixed mathematics.

**Soap Bubbles, and the Forces which Mould them.** By C. V. Boys, F.R.S. (Society for the Promotion of Christian Knowledge, London, 1890.)

This book is an admirable companion to the one which we have just noticed, not that its contents have anything in common; indeed, there is a contrast. Prof. Perry's demonstrations are suggestive of noise, rapid motion, and of physical exertion, while no experiments could well be more silent and full of quiet beauty than those of Mr. Boys. Some parts of his book exhibit a dry humour of a very rare order, notably the instructions for exhibiting conic sections by the shadow of a bedroom candlestick.

We have never had the good fortune to hear Mr. Boys lecture on this subject, but have seen some of his experiments repeated by others, and have ourselves attempted a few of them. We do not think that any apology is necessary for the innovation which the author makes in devoting the concluding portion of the book to a few hints on performing the experiments. Many of them are easily done, and nearly all of them are instructive. A few, like some of Prof. Perry's, are somewhat akin to conjuring or juggling. But at this season of the year the boundary, if there be one, between scientific apparatus and toys lacks definition.

Mr. Boys' subject, like that of Prof. Perry, while it is a fascinating amusement for children, teems with mathematical mysteries of a high order of inscrutability. The forces of surface tension and kindred molecular phenomena are ever present, while the pliant bubble films in responding to them are moulded into curves and surfaces in which any geometrician may revel. The mathematics of top-spinning, on the other hand, are of a boisterous kind; moments, momentum, and moments of momentum are there, wobbling and whirling may be expressed in complex angular velocities round innumerable axes, which chase each other in various planes, and any rigidity that is to be found is due to extremely rapid motion. Mr. Boys' bubbles ask for such passive expressions as conic sections and their roulettes, and when he examines a body in motion, such as a fountain or a falling drop, he first bids it stay, and under an intermittent illumination watches the silvery beads that appear to hang at rest in the darkened lecture room. Two trifling criticisms may be offered. The diagram in Fig. 11, showing the repulsion of a wet and a non-wetted plate and the accompanying explanation are not clear, and the roulettes of the conic sections are drawn on far too small a scale. It would, perhaps, be hardly in keeping with the bedroom candle experiment to suggest that before commencing soap bubble experiments in an ordinary room, it is advisable to lay down a few newspapers on the table and floor. One fault is to be found in both of these charming books, and the publishers are probably more to blame than the authors—each page bears the title of the book instead of a head-line describing the contents below it.

## ELECTRIC LIGHTING PROGRESS IN LONDON.*

BY F. BAILEY, ASSOC. M.INST.C.E.

The last Paper on electric lighting read before the Society was by Mr. R. E. B. Crompton, in 1888, when he placed before you some of the difficulties and obstacles which were retarding the progress of electric lighting. The rapid progress made within the last eighteen months will, however, show that these difficulties have to a great extent been removed by a number of supply companies having obtained Parliamentary powers to lay mains within certain specified areas into which London has been divided. I propose, therefore, to place before you in general terms the work done and in progress by the various companies, as the time at my disposal will not permit me to give minute details of generating stations and systems.

Although the development of electric lighting has been so rapid within the last ten years, it must not be forgotten that the arc light was shown at the Royal Institution in 1809, and remained a scientific curiosity until 1848, when Staite gave a public exhibition of his arc lamp from the portico of the National Gallery in Trafalgar-square. The *Illustrated London News* of that time contains a drawing of the scene with the following remarks:—"The electric light possesses no novelty. Year after year it has been exhibited at every course of philosophical lectures since the time of Sir Humphry Davy, and therefore really its practicability forms the whole subject for consideration." The electrical energy for this light was obtained from a primary battery; and it is probable that the practicability of this method of obtaining light will continue to remain a subject for remote consideration. At this time the seed sown by Faraday's discovery, in 1831, of electro-magnetic induction had fallen on fruitful soil; and the wonderful dynamos of to-day form a suitable monument to his genius.

You will see, therefore, that electric lighting commenced its career in London, and London ought, therefore, to show the greatest progress. The incandescent lamp, in some form or another, is mentioned almost yearly from 1836 onwards, and I propose at once to jump to the period when Swan in England and Edison in America brought out the present form of lamp.

Through the kindness of Mr. J. W. Swan, I have the honour to show you the first lamp he made. It is to be hoped that this lamp will eventually come under the care of one of our great museums, in order that future ages may recognise the genius of Mr. Swan.

I have also to thank Mr. Sydney Morse for the loan of another valuable historical lamp, this being the first lamp constructed by Edison.

Time does not permit me to trace the history of the incandescent lamp, or the extraordinary development of its manufacture. Nothing could have been done practically without the mercury pump, and we ought, therefore, to place the inventor, Dr. Sprengel, in a high position on our records of pioneers.

Turning to the record of general distribution of the electric light in London, you all know that practically nothing was done under the Act of 1882, but private enterprise provided fields for encouraging the efforts of the electrical engineer, and foremost amongst these must be mentioned the Grosvenor Gallery station, which did such good service in making the capabilities of the light known, and in proving the absolute necessity that existed for it; for however defective the supply may have been towards the close of the existence of the station (owing to the plant being overloaded), we owe a debt of gratitude to Lord Crawford for his energetic support to this enterprise, and to those who worked so hard to bring it to perfection. Mr. Ferranti, and those who worked with him at the Grosvenor, laid the foundation-stone of a satisfactory transformer system, and as they had no Parliamentary powers to lay down underground mains, overhead lines were run in all directions. The perfection to which they brought the details of overhead construction is so fully proved by the absence of accidents that it is much to be regretted that the overhead conductors in the United States were allowed to have been put up with no regard to common sense or safety.

It is frequently stated that the Electric Lighting Act of 1882 did much towards stifling inordinate speculation, but in attempting to make people wise by this Act of Parliament, a very serious check was placed upon the development of electrical progress.

The enormous strides which have been made under the more encouraging Electric Lighting Act of 1888 will convince everyone that it was urgently required, and electrical engineers fully realise what they owe to Sir Frederick Bramwell for his share in framing this Act. One of the consequences of this Act was a deluge of applications for Provisional Orders. A court of inquiry was therefore ordered by the Board of Trade, who appointed Major Marindin as their inspector for this purpose.

If you carefully read the eighteen days' evidence given, you will probably be convinced that every system was the best. The inquiry lasted several days, and resulted in the granting of Provisional Orders, confirmed by Parliament in August, 1889, to the companies mentioned in the summary on opposite page, which also includes other information.

I must here gratefully acknowledge the very cordial assistance which the engineers of the various companies have given me.

We will now very briefly go round the stations of the companies, commencing with

### *The Kensington and Knightsbridge Electric Light Company.*

This Company commenced work under the name of the Kensington Court Electric Light Company in the autumn of 1886, and under Mr. Crompton's able guidance made such rapid progress that they commenced to supply current in January, 1887, using underground mains and running their plant in a temporary building. The Board of Trade license under which the work commenced being incorporated in the company's Provisional Order of 1889, which authorises them to supply a portion of the parish of Kensington, St. Mary Abbott, and the detached portion of the parish of St. Margaret, Westminster.

* Paper read before the Society of Arts, December 10, 1890.

Digitized by Google

## ELECTRIC LIGHTING COMPANIES IN LONDON.

| Name of Company. | Capital (Nominal) £ | Number of years in existence. | Stations. | Total Indicated Horse-power Engines. | Number of Lamps equivalent to 32 Watt Lamps now connected. | System. | Length of conduit pipe, or single run of main. | Lamps per mile. | Meters. No. | Meters. Type. | Districts. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| London Electric Supply Corporation, Limited. | 1,250,000 | 5 | Deptford Converting Statns. | 4,500 | 38,000 | Alternate-current transformers (Ferranti). | | | 136<br>174<br>14 | Ferranti-Mercury.<br>Ferranti-Wright.<br>Frager. | Parishes of St. James, St. George, Chelsea, Rotherhithe, Bermondsey, Clerkenwell, St. Mary, Newington, Lambeth (part of), St. Martin (part of), St. Margaret and St John, Westminster.<br>Greenwich district, St. Olave district, St. Saviour's district. |
| Metropolitan Electric Supply Co., Ltd. | 500,000 | * 2½ | Whitehall.<br>Sardinia-st.<br>Rathbone-pl.<br>Manchester-sq. | 600<br>3,000<br>1,200<br>2,000 | 44,598 | Direct current and batteries.<br>Alternate current trans. (Westinghouse).<br>Do. (Parker). | 30 miles. | 1,486 | 25<br>378 | Aron.<br>Westinghouse. | Parishes of St. Martin's-in-the-Fields (part of) Bill, 1889, Mid-London Order; the Board of Works of St Giles' district, Holborn district, Strand district, 1889; West London order, parish of St. Marylebone, 1889; Paddington Order, parish of Paddington, 1890. |
| House-to-House Electric Supply Co., Ltd. | 350,000 | 2 | West Brompton | 600 | 12,898 | Transformers (Lowrie-Hall). | 8½ miles. | 1 517 | 71<br>168 | Lowrie-Hall<br>Westinghouse. | Parish of St. Mary Abbott, Kensington (two portions of). |
| Westminster Electric Supply Co., Ltd. | 214,765 | 2 | Millbank-st.<br>Dacre-st.*<br>Eccleston-pl.†<br>Davies-st.† | | 7,540 | Direct current and batteries.<br>" " " | | | 93 | Aron. | Parishes of Westminster, Belgravia, and Mayfair. |
| Kensington and Knightsbridge Electric Supply Co., Ltd. | 300,000 | 4 | Kensington-ct.<br>Chapel-pl. | 1560, and Howell batteries | 24,850 | " " "<br>Direct current and batteries (Crompton). | 10½ miles. | 2,366 | 200<br>90<br>34 | Aron.<br>Hookham.<br>Aubert. | Central Kensington and Knightsbridge. |
| Chelsea Electric Supply Co. | 108,000 | 6 | Draycott-pl. and three distributing stns | Batteries E.P.S. | 19,500 | Direct current and batteries (King).§ | | | | | Parish of St. Mary Abbott, Kensington (portion of). |
| Notting-hill Electric Supply Co. | 100,000 | 1 | High-st.‡ | | | | | | | | Parish of St. Mary Abbott, Kensington (portion of). |
| St. James and Pall Mall Electric Supply Co. | 100,000 | 2½ | Duke-st. | 1,960 | 23,174 | Direct current. | 4½ miles. | 5,452 | 190 | Aron. | Parish of St. James. |
| St. Pancras Vestry. | | | Stanhope-st.† | | | Direct current. | | | | | Parish of St. Pancras. |
| The Electricity Supply Corporation, Ltd. (formerly Messrs. Gatti). | | | Strand. | 600 | 8,500 | Direct current. | | | | Frager. | Parish of St. Martin's-in-the-Fields. |
| | | | | Total ...... | 179,060 | Lamps equivalent to 8 c.p. each. | | Total.. | 1,573 | | |

* Temporary station. † Now in progress. ‡ Nearly complete, and another station not yet commenced. § As published in the *Engineer*, 24th October, 1890.

The direct current is employed in conjunction with "Howell" secondary batteries, the pressure being 200 volts on the 3-wire system, with 100 volts in the houses.

The batteries are charged at any convenient time when the engines have power to spare, and not only act as a sponge, which can be squeezed when the engine plant requires assistance, but also act as regulators, as well as maintaining the supply during the hours of minimum demand. The satisfactory use of secondary batteries in this manner has attained its present development mainly through the indefatigable labours of Mr. J. C. Howell.

Two generating stations are erected, one at Kensington-court, (*The Electrician*, Vol. XXV., p. 381), and the other at Chapel-place, Knightsbridge, the plant consisting of "Babcock and Wilcox" boilers and exhaust steam feed water heaters, "Willans" compound engines combined direct with Crompton dynamos and "Howell" batteries in both stations. There is also a battery station situated near the centre of the Kensington district at Queen's-terrace-mews, where two large "Howell" batteries are placed. In all cases ample space is provided for the future extension of the plant when required. Arrangements are provided on the Kensington-court station switchboards to enable any dynamo to be used for charging the distant battery station to which a pair of charging mains are laid. Mr. Crompton also designed for this company a system of mains of considerable novelty which was severely criticised at the time but has since proved most satisfactory.

Culverts constructed with concrete or brickwork are laid under the pavements, and bare copper conductors, supported at intervals by glass insulators, are placed in these culverts. The conductors are composed of copper strips, 1 inch by ¼ inch, laid one over the other so as to make up the total section required. In cases where there is no room under the pavement in which to build up the culvert, wrought-iron gas tubing is used, and cables insulated with thick vulcanised rubber are drawn through and connected to the bare conductors. Numerous service boxes are fixed in the pavements to enable houses to be connected without opening the ground. Four and a-half miles of pipes with cables have been laid. (*The Electrician*, Vol. XXIV., p. 343.

On December 1st lamps were connected to an equivalent of 24,850 32-watt lamps, and Mr. W. H. Miller, the company's engineer, to whom I am indebted for these particulars, informs me that the lamp supply, or maximum number of lamps in use at one moment, is between 30 and 40 per cent. of the lamp connection.

### *The House-to-House Electric Light Supply Company.*

This company, as you see on the map on the wall, covers a large area, which consists of two detached districts, practically North Kensington and West Brompton. The generating station is situated off the Richmond road, West Brompton, and contains space for a very large plant. (*The Electrician*, Vol. XXVI., p. 42.)

The Lowrie-Hall alternating current transformer system is adopted, with 2,000 volts on the mains. Four principal mains at present carry the current from the station, the transformers being connected to these mains where required. Cast-iron pipes are laid to form a conduit into which vulcanised india-rubber "Silvertown" cables are drawn; suitable manholes, covers, and junction-boxes being provided.

At present the demand for light is supplied from a plant consisting of :—

Digitized by Google

Three "Babcock and Wilcox" boilers, working at 150lbs per square inch.

Three "Fowler" compound horizontal engines, each of 200 indicated horse-power.

Three "Lowrie-Hall" alternators, each of 100 units 2,000 volts.

Three "Elwell--Parker" exciters, each of 3 units.

The engines work at a speed of 88 revolutions per minute, each engine driving 1 alternator by 7 cotton ropes, the exciter for each alternator being driven by cotton ropes from the alternator pulley.

The Lowrie-Hall pressure regulator and recording instruments are also used. Mr. Hall, the Company's manager, has kindly given me this information, and states that on their lamp connections, equivalent to 12,898 lamps of 8 candle-power, the maximum lamp supply is equivalent to 5,430 lamps of 8 candle-power—say 42 per cent.

*St. James's and Pall Mall Electric Lighting Company.*

This Company was formed for the purpose of supplying the whole of the parish of St. James's, Westminster, and commenced to supply current under their provisional orders from their station in Mason's-yard, Duke-street, on April 4, 1889.

The direct current is employed without batteries.

At present the above station supplies the southern half of the district, the total plant consisting of :—

Five "Davy-Paxman" boilers, working at 150lb. per square inch.

Two large Berryman feed water heaters.

Ten Willans' compound engines, each of 200 indicated horse-power.

Two Willans' compound engines, each of 80 indicated horse-power.

Twelve dynamos, "Latimer Clark, Muirhead and Co.," and "Siemens," driven direct from the engines.

The whole of this plant is neatly arranged, so as to occupy the least space.

The mains consist of a network of conductors on the three-wire system, supplied at about 100 volts at the station by suitable feeders. A cast-iron trough or culvert is laid under the surface of the pavement, and three conductors, each consisting of a number of strips of bare copper, which can be added to at any time, are carried by porcelain bridges, placed at suitable intervals apart. To avoid any risk of the mains touching each other, porcelain distance-pieces are placed over the mains. A cast-iron lid, with water-tight joint, covers the trough. Connection to customers' houses is made by drawing well insulated cable through gas-tubing, which is screwed into the trough. (*The Electrician*, Vol. XXIV. p. 369).

On the 5th December, a total, equivalent to 23,174 lamps of 8 candle-power, were connected. Mr. Dobson, the Company's engineer, kindly informed me that the maximum lamp supply is equal to about 13,222 lamps of 8 candle-power—say 57 per cent.

*The Westminster Electric Supply Corporation.*

The district in which this Corporation is authorised to supply electricity by its Provisional Order comprises that portion of the united parishes of St. Margaret and St. John, Westminster, which lies to the south of the centre line of the Metropolitan District Railway, and the portion of the parish of St. George, Hanover-square, covering Belgravia and Mayfair.

The system adopted is similar to that of the Kensington and Knightsbridge Company, direct current in conjunction with batteries used as regulators, and also for supply during hours of minimum demand.

Three stations are being erected, one at Millbank-street, one at Eccleston-place, and one in Davies-street. (*The Electrician*, Vol. XXV. p. 741).

Current is now being supplied from the Millbank-street station and from a small temporary station in Dacre-street. The other two are being pushed forward as fast as possible, in order to supply from all stations early in the year.

Mains are being laid for a three-wire distribution, Messrs. Crompton being the contractors for the Westminster district, where the system adopted is similar to that put down by Mr. Crompton for the Kensington and Knightsbridge Company.

For other parts of the district Prof. Kennedy, the engineer to the Company, has devised the arrangement shown in the plan on the wall ; bare copper strip rests on stoneware insulators placed from six to eight feet apart, and bedded in the concrete culvert as shown. The copper is stretched by a special tool before being pulled in, and this process gives it sufficient stiffness not to sag perceptibly between the insulators. The total sectional area of the conductors can be increased when required by the addition of more copper strip. Feeders are used in a most systematic manner, and Prof. Kennedy is to be congratulated on the favourable prospects of this Company's work. There is a large demand for light in the district, and the rapid progress of this Company justifies the expectation of a speedy supply from the stations now in progress.

*The London Electric Supply Corporation.*

The Parliamentary powers possessed by this Company cover a large area, comprising the district bordering the south side of the Thames from Westminster-bridge to Greenwich, Mayfair, Belgravia, St. James and Pall Mall, St. Martin's-in-the-Fields, part of Westminster, Chelsea, and two isolated areas, namely, Newington and Clerkenwell.

The Ferranti system is employed throughout, alternating current being generated at an extra high pressure and transmitted to converting stations, from which it is distributed at high pressure to the service converters.

The Corporation has erected a large station at Deptford, which has been admirably designed for the purpose, having road-frontage, wharfage, and coaling dock. The plant consists of 24 "Babcock and Wilcox" boilers, 4 compound vertical engines by Hick and Hargreaves, two of which are 1,500 indicated horse-power each, and two of 750 indicated horse-power each. There is almost unlimited room for future extension.

Each of these engines drives a Ferranti dynamo by cotton ropes, the exciters being driven direct from independent engines.

In order to convey the high pressure from Deptford to London, Mr. Ferranti devised a special form of main for this purpose, which has been frequently described.

About 28 miles of these mains have been laid, the distributing mains from the converting stations being of various kinds. This Company's Grosvenor Gallery station having lately been closed, a hurried change has had to be made in order to enable the Corporation to supply from Deptford.

*Chelsea Electricity Supply Company.*

This Company's Provisional Order covers the whole parish of Chelsea, a portion of which the Company is now supplying.

Direct current is employed with accumulators, but, unlike the other companies in London, in this case the accumulators are charged with a high pressure current, and discharge direct at low pressure into the mains. I am not in possession of any information of this Company's progress. From published descriptions you will doubtless be aware that the generating station is situated at Draycott-place, with battery stations at Clabon-mews, Egerton-mews and Pavilion-road.

*The Electricity Supply Corporation.*

This Company obtained a Provisional Order in 1889 for supplying the whole of the parish of St. Martin's-in-the-Fields. Direct current, without batteries. The station is placed just off the Strand, and was laid down, some years ago, by Messrs. Gatti to supply the Adelaide Gallery and the Adelphi Theatre ; it is now being extended. At present the plant consists of :—

Four "Babcock and Wilcox" boilers.

Five Willans' engines, amounting to 600 indicated horse-power.

Five "Edison-Hopkinson" dynamos, each being driven direct from one engine. Callender mains are laid down in Callender-Webber casing.

*St. Pancras Vestry.*

The Vestry have decided to carry out the electric lighting of the parish themselves, and have secured the able services of Professor Robinson as their engineer. The direct current system will be adopted, and a station is now being erected in Stanhope-street, Euston-road, for the supply of the south-west portion of the parish.

*Notting-hill Electric Lighting Company.*

The Provisional Order granted to this Company includes the district of Notting-hill, which comes within part of the parish of Kensington, St. Mary Abbott.

The system is similar to that adopted by the Kensington and Knightsbridge Company.

The first generating station, situated off High-street, Kensington, is now approaching completion, the plant consisting of Babcock and Wilcox boilers, Willans engines, Crompton dynamos, and Howell batteries ; Crompton's mains are also laid as shown in the map on the wall.

*The Metropolitan Electric Supply Company.*

The Parliamentary powers of this Company include the large and important districts of Paddington and Marylebone parishes, with part of St. Martin's-in-the-Fields, the Holborn and Strand district, and St. Giles' Board of Works.

Various systems are employed by this Company, both the alternating and direct current systems being adopted.

The Company is at present supplying from four stations, and it may perhaps be better to describe them separately.

The Whitehall station, situated in Whitehall-avenue, is a direct current station which possesses no novelty, and supplies the surrounding locality, the plant consisting of Hick-Hargreaves boilers, Willans engines, and Siemens dynamos. Callender mains are laid down the Northumberland-avenue subway and elsewhere.

Digitized by Google

The Sardinia-street station (*The Electrician*, Vol. XXV., p. 703), contains a complete plant on the Westinghouse alternating current system, consisting of twelve Babcock and Wilcox boilers, working at 150lb. per square inch; twelve Westinghouse alternators, each being belt-driven by a Westinghouse compound engine. There are also three exciters, each being belt-driven by its own engine.

The Manchester-square station (*The Electrician*, Vol. XXVI,, p. 69), contains nine Babcock and Wilcox boilers, ten Parker alternators, each driven direct by a 200 horse-power Willans engine, as shown in the sketch of the engine-house placed on the wall. There are also four exciters, each being driven direct by a Willans engine. The steam piping is arranged on a method devised by Mr. J. H. Rosenthal, the London manager of the Babcock and Wilcox Boiler Company, and possesses many advantages.

The Rathbone-place station (*The Electrician*, Vol. XXVI., p. 109), contains plant of a similar kind, there being five boilers, six alternators and engines, two exciters and engines.

The system of distribution from the three latter alternating current stations is of a simple description—cast-iron pipes laid underground form conduits, into which "Silvertown" vulcanised rubber cables have been drawn when required. Split T-pieces are inserted in the pipes for connection to customers' premises. These mains are looped from house to house, returning to the station, so as to form complete rings. Each customer has, therefore, a duplicate supply, thus enabling new customers to be connected to the system without interrupting the supply on the circuit.

All these three stations are connected together by trunk mains, which enable one station to assist another, or take the whole load of the district during the hours of least demand. The current leaves each of these stations at a pressure of 1,000 volts, this moderate pressure being adopted as the number of supply stations reduces the distance to which each cable has to be laid to meet the demand. The whole supply is distributed by a number of small cables, which can be easily replaced when required.

The demand for light has been very encouraging; and, as you will see from the Table, the progress of the lamp connection to these stations has been very rapid. I regret, however, to say that, although this Company at present supplies light to twelve public-houses, only four churches are, so far, connected with the system.

Having now completed our tour of the stations of the various companies, we have seen how the streets of London have lately been disturbed in order to lay all these mains; no doubt a certain amount of inconvenience has unavoidably been caused to traffic, but it has revealed the wonderful system of organisation by which London is governed; and the vestry surveyors, whose labours have been much increased, have not only afforded every facility for carrying out the work, but have rapidly re-instated the pavements at, of course, the cost of the respective electric light companies. The public, therefore, though for a short time inconvenienced, have in reality secured new pavements for old.

Summarising the plants adopted by the various supply companies, it is interesting to notice how the peculiar conditions of electrical supply in the very limited space usually available have been provided for by manufacturers. As an instance of this, it may be noted that "Willans" engines, amounting to about 9,000 horse-power, are used by the public supply companies in London, and similar engines, aggregating more than 2,000 indicated horse-power, for private plants in the metropolis. The Babcox and Wilcox boiler having also been so universally adopted, it may be of interest to state that 78 boilers of this type, supplying 14,230 indicated horse-power, are now at work in London.

*Private Plants.*

One result of the Act of 1882 has undoubtedly been to cause a large number of private installations to be erected, but so many of our leading electric light contractors have laid down thoroughly efficient plants that there is perhaps no cause for regret. Most of the large terminal London railway stations work their own electric light machinery, the largest installation being at Paddington, (*The Electrician*, Vol. XVII., p. 51), where the Great Western Railway Company have machinery of 1,500 horse-power for this purpose. For residences, gas-engines provide the motive-power for driving dynamos supplying about 18,000 lamps of 32 watts each, the remainder being steam-driven.

It may be of interest to note that the Crossley "Otto" gas-engine, which was awarded a gold medal at this Society's recent motor competition, is being employed for this purpose, amongst others, by Messrs. Laing, Wharton and Down. This total may appear large, but it must be remembered that many of the large hotels having their own steam plant for working lifts, warming and cooking, have added electric lighting machinery; the total also includes the lamps at D'Oyly Carte's new theatre, where Messrs. Verity have erected a plant so complete that it may almost be considered as a small central station.

*Number of Incandescent Lamps now in Use in London.*

With the kind assistance of the electric light contractors, particularly Messrs. Verity, Laing, Wharton and Down, Phipps and Dawson, Drake and Gorham, Sharp and Kent, and many others, and the public supply companies, I have been able to collect data that the total equivalent number of 32 watt lamps now in use in London is approximately as follows :—

| | |
|---|---|
| Public Supply Companies ................................ | 179,060 |
| Private Plants.................................................. | 85,000 |
| Total............................ | 264,060 |

At the present rate of increase a very moderate estimate gives an addition of at least 4,000 lamps per week, and there is little doubt that this number will be greatly exceeded at no distant date. All these incandescent lamps have been calculated on a basis of 32 watts or 8 candle-power lamps, as experience has shown that this is a size much used in London, and, by taking the smallest lamp, we avoid dealing with half lamps.

Before leaving these particulars, it will probably be of service to the designers of future stations if we tabulate the data collected.

*Table Showing Percentage of Maximum Lamp Supply at any Moment to Total Lamp Connection.*

| Station. | Percentage |
|---|---|
| House-to-House ................................................ | 42 |
| Kensington and Knightsbridge ........................ | 30 to 40 |
| St. James' and Pall-mall ................................. | 57 |
| Sardinia-street.................................................. | 45 |
| Rathbone-place ................................................ | 64 |
| Manchester-square ........................................... | 45 |

It may perhaps be of interest if I draw your attention to the following Table, based upon data which has come under my observation, showing the candle-power of lamps mostly used :—

*Lamps (50 volts).*

| 8 c.p. | 16 c.p. | 32 c.p. | 50 c.p. | 100 c.p. | 200 c.p. | 500 c.p. |
|---|---|---|---|---|---|---|
| 597 | 1,666 | 62 | 13 | 8 | 8 | 3 |

*Lamps (100 volts).*

| 8 c.p. | 16 c.p. | 32 c.p. | 50 c.p. | 100 c.p. | 200 c.p. | 500 c.p. |
|---|---|---|---|---|---|---|
| 5,437 | 5,131 | 176 | 26 | 57 | 40 | 3 |

During 1886 and part of 1887 I was able to collect the following data of the behaviour of incandescent lamps, each of 25 candle-power, with an efficiency of 3½ watts per candle, and I trust that more information of this kind will be collected :—

*Incandescent Lamps.—Life, and Nature of Fracture.*

All Lamps 25 c.p. Brass Collar, Edison-Swan.

| Lamps. | | | Nature of Failure. | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Glass Globe. | | | | | | Filament Fractured. | | | | | |
| Volts. | No. of lamps renewed. | Average life hours. | Broken. | Per cent. | Blackened. | Per cent. | Plaster. | Per cent. | Loop. | Per cent. | Stem. | Per cent. | Joint. | Per cent. |
| 151 | 536 | 861 | 114 | 21·2 | 21 | 3·91 | 56 | 10·44 | 208 | 38·80 | 114 | 21·26 | 23 | 4·29 |
| 142 | 189 | 789 | 19 | 10·0 | 4 | 2·11 | 41 | 21·69 | 67 | 35·45 | 47 | 24·96 | 11 | 5·82 |
| 120 | 2,549 | 923 | 273 | 10·7 | 92 | 3·60 | 334 | 13·1 | 1,114 | 43·70 | 693 | 27·10 | 43 | 1·68 |
| 99 | 588 | 1,423 | 122 | 20·0 | 61 | 10·37 | 92 | 15·64 | 212 | 36·00 | 95 | 16·10 | 6 | 1·02 |
| | 3,862 | | 528 | | 178 | | 523 | | 1,601 | | 949 | | 83 | |
| | | | | 13·67 | | 4·61 | | 13·54 | | 41·46 | | 24·57 | | 2·15 |

Digitized by Google

With reference to arc lighting considerable progress is being made; and although the number now in use in London does not much exceed 1,000 lamps, there is no doubt that rapid progress will be made.

Prof. Silvanus Thompson, in March, 1889, showed you all the best known arc lamps; and for further information of their development, I must refer you to his most complete Paper on this subject, published in the Society's *Journal*, March 8, 1889. (*The Electrician*, Vol. XXII., p. 534).

It is a matter for regret that there is no progress to be noticed in connection with the efficiency of the incandescent lamp, which remains much the same as it was five years ago. It will be apparent from the table showing the candle-power of lamps mostly used that a really efficient 100 volt 8 candle-power lamp is much needed; the present lamps of this kind have such a short life that customers, contractors, and electric supply companies would all hail its advent as a boon.

We must also remember that the future progress of electric lighting depends in no small measure on the lampmakers, and as the manufacture of the incandescent lamp will soon be open to all (owing to the expiration of the present patents) the absolute necessity of a standardising laboratory must compel its adoption where not only instruments but lamps can be tested, so that people may know when they ask for an 8 candle-power 100 volt lamp, with or without a guaranteed life of, say, 1,000 hours at an efficiency of 3½ watts per candle, that they get what they have asked for.

That this question of lamp efficiency is of importance to customers and supply companies alike few will doubt, and the following table will probably explain itself:—

| Watts per candle. | Candles per 1,000 watts. | Lamps per 1,000 watts. | | | |
|---|---|---|---|---|---|
| | | 8 c.p. | 16 c.p. | 20 c.p. | 32 c.p. |
| 2·00 | 500·0 | 62·5 | 31·2 | 25·0 | 15·6 |
| 2·25 | 444·5 | 55·5 | 27·7 | 22·2 | 13·9 |
| 2·50 | 400·0 | 50·0 | 25·0 | 20·0 | 12·5 |
| 2·75 | 363·6 | 45·4 | 22·7 | 18·2 | 11·4 |
| 3·00 | 333·3 | 41·7 | 20·8 | 16·7 | 10·4 |
| 3·25 | 307·6 | 38·4 | 19·2 | 15·4 | 9·6 |
| 3·50 | 285·7 | 35·7 | 17·8 | 14·3 | 8·9 |
| 3·75 | 266·6 | 33·3 | 16·7 | 13·3 | 8·3 |
| 4·00 | 250·0 | 31·2 | 15·6 | 12·5 | 7·8 |

We see then how an improved lamp efficiency will benefit the supply companies, by enabling them to increase their lamp connection.

The following table will appeal most strongly to all users of the incandescent lamp; but it must be assumed that an increased efficiency is not obtained at the expense of a reduced life of the lamps.

The most satisfactory feature, however, of the present Edison-Swan lamps is the uniformity of their voltage; and the scientific department of the Edison and Swan Company's works is to be congratulated on the assistance they have given to the industry by practically enabling voltmeters to be set by photometrical tests of the lamps.

*Cost per annum per 8 candle-power lamp at 8d. per unit, lamps burning an average of:—*

| Per day. | ½ hour per day. | 1 hour per day. | 2 hours per day. | 3 hours per day. | 4 hours per day. |
|---|---|---|---|---|---|
| Hours per Annum. | 182·5 | 365 | 730 | 1,095 | 1,460 |
| Cost per annum with lamp efficiency of:— | | | | | |
| | £ s. d. | £ s. d. | £ s. d. | £ s. d. | £ s. d. |
| 2 watts per candle | 0 1 11 | 0 3 11 | 0 7 10 | 0 11 9 | 0 15 8 |
| 2·25 ,, | 0 2 2 | 0 4 5 | 0 8 9 | 0 13 2 | 0 17 6 |
| 2·50 ,, | 0 2 5 | 0 4 10 | 0 9 9 | 0 14 7 | 0 19 6 |
| 2·75 ,, | 0 2 8 | 0 5 4 | 0 10 9 | 0 16 1 | 1 1 5 |
| 3·00 ,, | 0 2 11 | 0 5 10 | 0 11 8 | 0 17 6 | 1 3 4 |
| 3·25 ,, | 0 3 2 | 0 6 4 | 0 12 8 | 0 19 0 | 1 5 4 |
| 3·50 ,, | 0 3 5 | 0 6 10 | 0 13 8 | 1 0 5 | 1 7 3 |
| 3·75 ,, | 0 3 8 | 0 7 4 | 0 14 7 | 1 1 11 | 1 9 2 |
| 4·00 ,, | 0 3 11 | 0 7 10 | 0 15 8 | 1 3 6 | 1 11 4 |

It may be thought that an estimated use of a lamp for only about 200 or 300 hours per annum is very low, but it should be remembered that the electric light need only be used when it is required, as the ease of switching it on and off makes us forget all our past troubles in hunting for gas taps, matches, and broken gas-globes. With ordinary care, the average cost of burning an 8 candle-power lamp for ordinary domestic use need not exceed ten shillings per annum.

Of course much depends on the wiring contractor, who not only has to be an accomplished art critic in designing or selecting the brackets, pendants, &c., but he also has to suggest the most advantageous positions for the lamps and switches. A switch placed near the door of every room, and not less than two lamps in any room will probably save annoyance.

The greatest progress has been made in the wiring of houses; not only is more work done, but it is better done and on more mechanical principles, for whereas some years ago a single main would have been run from top to bottom of a house with numerous T-joints, independent circuits will now be wired, and all brought to a neat form of distributing board.

The effect of the extra care which is now taken with this work is proved by the following table of insulation tests, taken with 100 volts at 200 houses:—

*Insulation tests of internal wiring (taken with 100 volts—Evershed Ohmmeter.)*

| Number of Points. | | Test Megohms. |
|---|---|---|
| 5 to 10 | Average of 15 houses | 4·0 |
| 10 „ 15 | „ 23 „ | 3·5 |
| 15 „ 20 | „ 18 „ | 2·8 |
| 20 „ 25 | „ 13 „ | 2·7 |
| 25 „ 35 | „ 33 „ | 1·8 |
| 35 „ 40 | „ 12 „ | 1·5 |
| 40 „ 50 | „ 16 „ | 1·2 |
| 50 „ 60 | „ 12 „ | 1·1 |
| 60 „ 70 | „ 9 „ | 1·0 |
| 70 „ 120 | „ 14 „ | ·4 |
| 120 „ 220 | „ 9 „ | ·25 |

I hoped to have been able to place before you some record of the improvement in the health of London owing to the progress of electric lighting, but so much has already been said and published about it that further facts appear needless. It is simply melancholy to see so many of our churches and halls not only burning their gas-jets for lighting, but also for "warming" the building. If culpable negligence amounts to manslaughter, the people responsible for this atrocity ought to receive their deserts.

Having now placed before you some account of the progress of electric lighting in London, I must ask you to compare our metropolis with other cities, and leave you to judge whether we are so far behind them as some would have us believe. Is it not more probable that other countries will be glad to avail themselves of the experience which London must gain in the working of so many distinct systems?

## DISCUSSION.

The CHAIRMAN said Mr. Bailey had been good enough to attribute to him a share in the Act of 1888, which he must disclaim. He took an active part in preparing a Bill which was not passed, and the one which did become law, for which they had mainly to thank Lord Thurlow and his colleagues, was one which he regretted was accepted, because it left in full force what he considered the vicious principle of Government trading, though it extended the previous impossible term of 21 years to 42, a term which he had hoped would also have been treated as impossible. Under the Act of 1882, public electric lighting in England was impossible, and progress was greatly retarded in consequence. Some astonishment had been expressed at the large number of private installations as compared with public one—practically half the number of lamps—but that was entirely due to that Act. People wanted the electric light, and as the Legislature prevented it from being supplied in the ordinary way in which such illuminants as gas was supplied, those who had the requisite means and space at command did it themselves.

Mr. R. E. CROMPTON said electric engineers might feel proud that, although they had been so heavily handicapped in the race, they had begun at last to bring London to the front, and it would not be long before they were as far ahead of any other town in the world in electric lighting as they were in most other respects. The Act of 1882 completely stopped electric lighting for several years, though, as engineer to the Edison and Swan Company, he then designed several central stations which, even in the light of present knowledge, he could say could have been carried out practically as well then as they could now. The one at Victoria Station, and another in the Strand district, were, in many respects, as well designed as those he had since been connected with. The chairman of the company at that time, however, thought—probably rightly—that it was not fair to put the shareholders' money at the mercy of the provisions of that Act, under which the undertaking could be purchased at breaking-up price at the end of such a short period, and the scheme was therefore never carried farther than the lighting of Victoria Station, though it could have been worked, within a small percentage, as economically and as well as many which had been started recently. In that station, the dynamos were on the upper floor

Digitized by Google

Five years ago, a gentleman called at his office and said he was connected with an estate company which had a subway, so that underground mains could be laid without coming under the Act, and the result was the formation of the Kensington-court Company, his informant being Mr. Granville Ryder, the present Chairman of the Company. At that time not a single underground main had been tried, and, but for this opportunity of testing the system, it was very improbable that either the Kensington-court, the Whitehall, or the Metropolitan Company would have occupied the positions they now did. The public should know that though they might have been inconvenienced by the breaking up of the streets, it was a very different thing from similar annoyances on the part of gas and water companies, because in most cases the work was done once for all. Conduits or pipes had been laid, into which the conductors could be drawn, and from which they could be withdrawn and repaired, so that connections could be made without further breaking up of the road. He did not know the exact mileage, but he should think nearly 150 miles had already been laid, which was no small feat to accomplish, since the provisional orders were obtained two years ago. In the system of underground conductors with which Mr. Bailey had connected his name —though he was by no means the sole inventor, many other engineers having contributed to its development—the idea was not only to give access to every house for the electric light, but to afford sufficient means of access for many other systems of conductors in future—telephone wires, fire alarms, and other means of communication, which would be greatly appreciated in future.

Professor KENNEDY, F.R.S., said this paper would be much quoted after a few years, for Mr. Bailey had given a most vivid picture of the state of electric lighting in London, just at the time when it was most interesting. As to the maximum number of lights at one time in use as compared to the total number on the station, he had been apparently very fortunate in one of his own districts. He had found in Westminster the usual average was about 40 to 42 per cent., but one foggy day in last week it went up to 60 or 61, judging from the amount of current going out. As to the state of electric lighting in London compared with other places, there was no other city in the world that had 250,000 lights, or anything like it. He believed it was about double the amount in use in New York, and before long people would be coming here for information, instead of scoffing at us for doing nothing. With regard to safety in working a station, he thought that there should always be power in reserve equal to one of the largest units; if 200 horse-power engines were the largest used, for instance, there should be 200 horse-power in reserve, but the use of one 500 horse-power engine necessitated at least 500 horse-power in reserve, and so on. He should be glad to think that putting a boiler on a lower level than the engine would ensure having dry steam, but rather doubted whether that was proved experimentally. If the particular boilers mentioned gave dry steam, he did not think it could be owing to their position in reference to the engine.

Professor FORBES, F.R.S., said that Mr. Bailey had collected an enormous number of the very facts engineers wanted to arrive at, and he hoped other gentlemen connected with central stations would follow his example and give the result of their experience. Mr. Bailey seemed rather hurt because various people had criticised the progress of electric lighting in this country, and contrasted it unfavourably with what was done elsewhere, and perhaps few had done more in that way than he (Mr. Forbes) had. He had taken the pains to learn what was being done in foreign countries by personal inspection, and had frequently, on his return from such inquiries, done his best to impress on those concerned at home the superiority of the work which was being done abroad. The last time he had occasion to do so was about three years ago, when hardly any of the work now described had been commenced; but he now thoroughly endorsed what had been said by Professor Kennedy, that there was not an example in the whole world of such enormous progress in so short a time. They were delayed for a long time by the former Act, but during all that time they were studying what was done elsewhere, so that when they began they were on sure ground, and went ahead with more confidence than people elsewhere had done. Not only was the scale of work greater in London than anywhere else, but the character of the work in the central stations would bear comparison with any. Anyone who had visited the Sardinia-street station would feel that it was as complete and satisfactory as it could possibly be.

Mr. W. M. MORDEY said that he believed this paper would be of the greatest value. He suggested that it should be followed, at fairly frequent intervals, with other accounts of the work that was actually being done. He remarked that Mr. Bailey's particular arrangement of primary mains, which was very simple and ingenious, had not been alluded to in the paper. It would be very useful if they could have not only the relative life of 50 and 100 volt lamps but their relative efficiency. It would be well to know how much the lowering of the candle-power of the former counter-balanced the advantage of the longer life, the blackening of the globe in a low voltage lamp being always more serious than in the case of a high one. A strong confirmation of what had fallen from the Chairman and Mr. Crompton as to the effect of the Act of 1882 was to be found in experience abroad. It was often stated that our knowledge of how to distribute electricity had greatly advanced since 1882. This was true, but it was also true that, so far as supplying lights in a densely inhabited district was concerned, no great advance had been made or was to be expected. As an illustration of this, he referred to Milan, where a large scheme had been carried out on the lines that were available in 1882. Just about 1883 a station was put down there which had never had the current off the mains for six years, and it was now supplying 25,000 16 candle-power lamps on the direct low-tension system. The history of that station showed that, in a dense area, the old-fashioned system was very good in its way, even without the advantage of the three-wire arrangement. Distant places—suburbs, and so on—could not be supplied, but they were now supplying the more distant parts on the high-tension system, somewhat similar to that mainly used by Mr. Bailey's company. The history of the Metropolitan Company illustrated the advance in knowledge of how to distribute light over a large area economically, especially in the early stages of the work. That company started with a low-tension system and with batteries; but all the stations added since were on the high-tension system, without batteries. They knew now how to supply both in dense areas and over long distances. Mr. Crompton had, in London, perhaps done more than any one in the former direction, and the Metropolitan Company more than any one—except, perhaps, Mr. Ferranti—in the latter. A great deal had been said by Mr. Preece and others in that room on the advantage of lighting streets by arc lamps. It appeared that there were only about 1,000 in use in London altogether. He thought the general public would never fully appreciate the advantages of electric lighting until the whole of the main streets were illuminated in that way. Nothing had been said about the electric lighting of the city, no doubt for the reason that there was at present no lighting in the city. This reproach would shortly be removed, his company and others having undertaken a general lighting scheme, which, he was glad to say, included street lighting by arc lamps.

Mr. R. W. WALLACE hoped that inventors would turn their attention in the direction of endeavouring to improve incandescent lamps.

Mr. BAILEY, in reply, said that so far as he could ascertain there were now 81½ miles of conduits of all kinds, in some cases pipes, in others concrete or brickwork; and into these conduits were led about 111¼ miles of cable, which were actually carrying current at the present moment; and that had practically been accomplished in eighteen months, in order to supply the public with electric lighting, but they had not yet got to street lighting. That brought him to the question of arc lamps. Everyone would like to see arc lighting, but they could never expect to see it in London in such perfection as in Milan and other places where the streets were practically built for it. One could not imagine the Strand looking particularly handsome, even with the aid of arc lamps; it was quite different in Berlin, where they could be placed in the centre of the roadway on very high masts; but such as the streets of London were, they would be immensely improved by arc lighting, and he believed this would come shortly; and in place of the very meagre account of this system which he had been able to give, he hoped before long to hear someone else give a much more ample description of what was being done in this way. Everything was now ready for it, and he could not quite understand what kept it back. Professor Kennedy had referred to the maximum percentage of supply to the total lamp connection, as to which you might take either the average or the heaviest day, the figures given in the paper being the heaviest lighting day in November; and he found that in all the districts from which he had collected information that the heaviest duty came on between four and five in the afternoon. (He exhibited a number of diagrams showing the varying amounts of current demanded during the day, plotted on a curve, taken at different stations and on different days, the highest point varying according as the district consisted mainly of offices, shops, or theatres and restaurants.) There were over 25 miles of these overhead lines, and he could not remember a single accident attributable to them. The prejudice which existed against them was due to the wretched work done in New York, where they neither suspended the wires nor properly insulated them, but left them to rot, and then people said how dangerous they were. Mr. Mordey had kindly alluded to the arrangement of mains which he was endeavouring to carry out, and which he (Mr. Bailey) did not allude to in the paper because he did not want to advertise himself. There was no particular novelty about it; they were merely acting on mechanical principles, and endeavouring to give people a double supply, one from each end of the cable, so that when a new customer wanted to come on, there was no need to go round to all the subscribers and tell them they must be shut off. With reference to the incandescent lamps, he hoped others would keep a record of the behaviour of all the lamps under their charge, which could easily be done. He had an india-rubber stamp, with a movable date, which was stamped on the cement when the lamp was sent out; when it failed, and was brought in to be replaced, the storekeeper could tabulate the date and the fracture in the filament, and these records would be very valuable. In a few years' time it would be open to anyone to make lamps; and people then would buy from those who produced the cheapest and most durable. Mr. Mordey had referred to the Whitehall Company and the alteration they had introduced in the other districts as the system developed. That was due to the size of the districts which that company had to light; it was not only a question of providing light, but of doing it quickly, for nowadays, as soon as anyone had his place wired, he wanted the current the next day; and if he did not get it, he worried the life out of the unfortunate engineer to the supply company. The other day a certain firm took proceedings against an electric light company for not continuing the supply, and stated on oath that whereas with the electric light they could go for six years without decorating their premises, when using gas they had to paint and whitewash every two years, and they claimed damages in consequence. He hoped the vestries would soon see the advisability of lighting the streets by arc lamps.

The CHAIRMAN, in proposing a vote of thanks to Mr. Bailey, said he prophesied two years ago that in ten years' time 90 per cent. of all the houses at the West-end of London, of £400 a year rental and upwards, would be lit by electricity. He now began to think that he had not been sufficiently sanguine, and that he might have mentioned a rental of £300 instead of £400. So long as gas was supplied at 2s. 9d. or 2s. 6d. per 1,000 feet, the electric light, until improved in some way—and the only improvement that seemed possible was economy in the lamp—must be a light of luxury; but persons who would pay £300 or £400 a year rent were willing to pay £20, £30, or even £40 more for electric lighting, as compared, not with gas, because many would not use it, but with the other illuminants they employed. After a year's experience of the use of a number of lamps equal to about 114 8-candle lamps, he found the extra cost was between

Digitized by Google

£20 and £25, as compared with the gas, candles, and lamps he used before, and in that he made no allowance for decreased expenditure in cleaning, painting, and matters of that kind, which was undoubtedly considerable. He had also a curious experience, during the summer quarter, of the truth of what Mr. Bailey said about the ease with which the electric light was extinguished and re-lighted. His summer quarter's bill for electric lighting was only a few shillings in excess of the gas bill for the previous year's summer quarter, and he bought no candles or lamp oil, having the electric light all over the house. The reason was simply this, that in a dark London basement, even in the summer time, the gas was kept constantly burning, but the electric light was turned out when not wanted, and though no doubt it was considerably dearer than gas, so much less of it was used, even by the servants, that it only cost a few shillings more.

## GAS AND ELECTRIC LIGHTING AND VENTILATION.*

Whatever may be the commercial prospects of central station electric lighting companies in this country, it is undeniable that this means of lighting for places of amusement and large public establishments is a present reality with which those who are interested in the gas industry must in future make their account. Such is the fashion of the time, that only impecuniosity prevents proprietors and lessees of theatres, assembly-rooms, &c., from taking to electric lighting, either as supplied from a central station or generated on the premises, keeping gas only as a reserve in case of accidents. Those proprietors of large establishments who can afford the outlay find it to their advantage to lay down electric lighting plant upon the premises—generating the power by means of gas-engines; because in this way they know what they have to depend upon, and the lighting comes cheaper in the long run. So much lighting is, as a rule, required for the offices, outbuildings, and corridors of places of amusement, that even when electric lighting is adopted for the auditorium and main approach, the gas bill still amounts to a respectable figure; and, of course, where gas-engines are used to generate the necessary power, the suppliers of the gas have no reason to begrudge the electric lamps their place in the best parts of the house. Moreover, it is hardly necessary to say that the better places of public resort are lighted, by whatever means, the better it is for the purveyors of all kinds of illuminating agents, since the heightening of the standard of artificial lighting in any way reacts upon the general estimation of what is desirable in this regard.

The particular object of this article, however, is not to minimise in the supposed interest of the gas industry the actual progress of electric lighting for public buildings—for this would be a vain endeavour, since nothing is ever gained by wilfully misreading the signs of the times—but to discuss the subject with reference to a point of definite public interest. It is scarcely necessary to remark, by way of preface, that the adoption of electric lighting for places of assemblies was originally advocated for two principal reasons—safety from fire and benefit to health. It was assumed that no electrically lighted theatre, for example, could ever burn down during a performance, through anything going wrong with the means of lighting; while it was also supposed, with equal confidence, that the substitution of incandescent electric lamps, radiating *in vacuo* without combustion, for the multitudinous flames of gas-burners, would be a vast improvement in the way of sanitation. Not a great lapse of time has been required, however, to demonstrate the truth that an electric current will set fire to a building, when improperly managed, as well as gas; and it is now universally agreed that the undiscriminating application of electric lighting to places of popular resort is to be deprecated out of consideration for the public safety. This means of lighting can be made practically safe, of course, and so can gas. But in both cases safety must be procured by precaution. Human error is capable of making mischief with either; and this reflection disposes of the claim for absolute and inherent safety once advanced on behalf of electric lighting. It has been seen that a careless workman can burn down an electric light station; and it remains to be proved that carelessness of the same order could not result in the destruction of a theatre.

With regard to the second consideration—that of public health—it may be observed that this is a matter upon which a verdict has been snapped by the electricians without sufficient evidence. They have asserted, and everybody has allowed the assumption, that the adoption of electric lighting in place of gas for theatres, music and lecture halls, &c., has invariably resulted in an improvement of the atmosphere and the prevention of overheating. Now, this is the point which we desire to see settled by reliable investigation. So far as we are aware, nothing of the kind has been attempted. It is true that the examination of the atmosphere of crowded places of assembly, with the express object of testing the efficacy of their ventilating arrangements, is generally neglected. We hear from time to time accounts, more or less after the nature of advertisements, of the methods adopted for the ventilation of public buildings; but it is very rarely indeed that anything is stated afterwards of the way in which these arrangements actually work. Which, for instance, is the best ventilated theatre in London? Can any hall in the Metropolitan area lay claim to a remarkably cool and wholesome atmosphere when packed to its utmost limits, without resort to the heroic procedure of sliding off the roof bodily? It is obvious that until it is exactly known how the ventilation of public rooms works with different means of lighting, it is vain to claim that one is preferable to the other. Incandescent electric lamps are presumed to be less destructive of the purity and coolness of the atmosphere of an enclosed place than gas-flames, because they do not require oxygen, and radiate less heat. Hence comes all the question-begging talk about the "barbarity" of depending upon combustion for light, which electricians use when they desire to emphasise the sanitary advantages of incandescent electric lamps. All this is very plausible, and many are carried away by it. Supposing that we have an enclosed place containing a quantity of oxygen in its atmosphere, a light that requires none will, of course, leave more for other uses than one which consumes this necessary supporter of fire and life. But in point of fact, the problem is by no means so simple as this. Instead of a closed room and a constant quantity of oxygen, any desired supply of the latter may be had from outside. Besides, it is not only a question of the inlet of a current of fresh air for the lights; but this must be done in any case for the human occupants of the room. So that it is only a matter of degree whether oxygen has to be supplied for both purposes or for only one. It is therefore possible to say that the method by which a public hall is lighted cannot make much difference to the fundamental obligation to ventilate it with due regard to the health and comfort of the people who use it. Now, a system has become general for combining the gas lighting and ventilation of public halls by the aid of sun-lights. Where this class of gas-burners is in use an enormous up-current of air is created in the chimney by the burning gas, which at the same time is so high overhead that its radiant heat is practically imperceptible; and this artificial draught sweeps out all the foul air of the upper part of the room, together with the products of combustion. The efficiency of this means of ventilation is only limited by the quantity of gas burnt, the dimensions of the chimney, and the completeness of the arrangements for the supply of fresh air to take the place of what is removed.

It is therefore a mistake to think that the ventilation of any hall lighted in the manner just described will be improved by substituting electric lamps for the gas-burners. Quite the contrary effect is, in reality, to be expected; and there are now facilities enough, through the introduction of electric lighting into places formerly lighted by sun-burners, for an experimental investigation into this important question. We have every reason to believe that the result of such an inquiry would be to show that in many cases the substitution of electric lighting for gas has absolutely upset the ventilation arrangements, without conferring any corresponding advantage of a sanitary order. Incandescent electric lamps do, as a matter of fact, radiate an appreciable amount of heat; but as they are usually distributed, none of this can be utilised for assisting in the work of ventilation. We should not like to say that the quantity of gas needed to create a sufficient chimney draught for changing the air of any hall would be enough to light it, because every separate case must be dealt with according to its special requirements. What we do contend for is that the responsible managers of places of public resort should have their eyes open to the consequences of changing their system of lighting without attending to the ventilation. When the hall is first occupied of any evening, it is possible that there may be a cooler atmosphere with electric lighting than with gas. This difference will soon vanish, however, as the evening wears on, and the ventilation that the gas would ensure is found to be absent. Moreover, in cold weather it is necessary to warm the hall by stove heat; and the want of ventilation then very speedily tells, notwithstanding the imaginary superiority of the electric light in consuming no oxygen. Given a frosty night, a warmed hall, a crowded meeting, and electric lighting, and the condition of the atmosphere of that place, after an hour's occupation, will not be any credit to the method of lighting. We do not speak, of course, of cases where mechanical ventilation is employed; but even then it would probably be found that different systems of lighting make little alteration in the work of changing the air.

There is no need for talking vaguely on this subject; and, in order to bring the question to an issue, we will take a familiar example—the hall of the Society of Arts. This hall is supposed to be ventilated in the so-called "natural," as distinguished from the "mechanical" method, by a sun-light exit shaft, and fresh air admission behind the dado. The sun-light is now replaced by

*From the *Journal of Gas Lighting*.

Digitized by Google

pendants of electric lamps. It would be impossible to exaggerate the stuffiness of this room after half-an-hour's use with closed doors if even only half filled. The question is whether it is better or worse with electric lighting than when gas was solely used. We believe it is much worse; but this is a point the Society ought, in justice to itself, to set right by competent inquiry. Until this is done, and the reputation of the electric lighting is cleared, we shall continue to hold, on *primâ facie* evidence, that the Society's hall is now one of the worst-ventilated public rooms in all London, thanks to its electric lamps. And what is true of this hall is probably true, in degree, of many others.

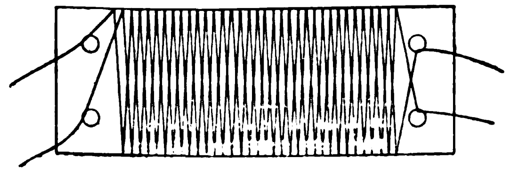
## THE PHYSICAL SOCIETY.

At the meeting of the Physical Society, held on the 12th inst., Mr. Shelford Bidwell, F.R.S., made a communication on

### Some Experiments with Selenium Cells.

Selenium exists in two allotropic forms, the one, vitreous, as structureless as glass, closely resembling black sealing wax, and when in thin films is capable of transmitting ruby coloured light; the other form is amorphous, and exists as a red powder. If left for half-an-hour at a temperature of 200deg. it becomes black. The amorphous variety is a non-conductor. The author observed that it was pretty generally stated in books that selenium in this condition was a good conductor, but this he had not found to be the case; for example, the specific resistance of one specimen, which had been carefully annealed, was as high as 2,500 megohms. When the annealing took place in contact with copper, the specific resistance fell to some 900,000 ohms, and he considered that the diminution of the resistance of selenium cells during the so-called annealing process was due, not to the effect of annealing, but to the formation of a conducting selenide of copper throughout the mass of selenium, beginning at the copper electrode.

The author observed that Willoughby Smith, in the year 1873, first discovered the variation in the resistance of crystalline selenium under the influence of light, and that the name selenium cell was due to Graham Bell. Graham Bell's photophone cells had a resistance of several megohms, and some ten years ago the author had suggested the following modification of Bell's cells in order to diminish this resistance. A strip of mica a few centimetres in length had copper wire wound over it from end to end, the distances between adjacent coils being about one-twentieth of an inch. The wire was wound in two parallel coils, the two coils being carefully prevented from touching each other at any point, and forming the positive and negative electrode respectively.



A Selenium Cell.

Melted selenium was poured on to the strip, and pressed in between the wires. The cell was then kept for some time at a temperature of about 217 degs., and the resistance was found to fall gradually to about 50,000 ohms. The author had made a number of these cells in the years 1880 and 1881, and had noticed that their sensitiveness to light gradually diminished, and in 1882 he laid aside a number of cells until 1885, when the greater number of them were found to be practically insensitive to light. He then (in 1885) laid aside 13 cells until the present year, and of these only one retained its sensitiveness. The resistance of this cell remained as high as 400,000 ohms, while the resistances of the others had all very greatly diminished. The resistance of another one was about 6,000 ohms. This cell was sensitive to light when employed in circuit with a single Leclanché cell; but with a number of cells the resistance broke down, falling to about 100 ohms, the cell at the same time becoming insensitive to light.

The resistances of the remaining 11 cells varied from 4 to 11 ohms, and they were all quite insensitive to the influence of light.

Professor W. G. Adams had found that the resistance of the selenium cells which he had constructed fell in the course of a year to about one-fortieth of their original value, this fall being in all probability due to the formation of selenide of copper.

The author mentioned that the resistance of one of his own cells had fallen in the course of ten years from 80,000 ohms to 10 ohms. In a paper previously read before the Society he had expressed the opinion that the presence of selenide of copper was necessary to the action of the cells, and that this was always formed during the so called annealing process which was found to be essential to make the cells sensitive to the action of light.

It had occurred to him that the effect of passing a strong current through one of his selenium cells might be to liberate selenium more rapidly than it could combine with the copper anode, and to test this he had connected one of the cells with a 26-volt battery. The result of this experiment was the formation of moist red tufts, consisting mainly of amorphous selenium all along the copper wire forming the anode. It was shown to consist of amorphous selenium, by turning black when warmed, and exhibiting the characteristic blue flame of selenium when burned.

The moistness of the tufts seemed greater than was to be expected, simply from the selenium being in the state of a fine powder. The red powder, when examined under the microscope, was found to be mixed with white lumps, which might consist of an oxide, or hydroxide of selenium, but he was not aware whether this was deliquescent.

In the discussion of the author's former paper the late Mr. J. W. Clark had objected to the hypothesis that the diminution of resistance was due to the electrolytic formation of selenide of copper, that in this case the selenide would only be found in the neighbourhood of the anode; but the author considered that it spread from the anode until it extended to the cathode wire. The selenium cells, he pointed out, showed polarisation effects, and developed an E.M.F. under the influence of light, forming photo-electric cells.

The author then exhibited some very striking experiments, to which he did not attach any serious importance, but which he thought were suitable for lecture demonstrations. The usual arrangement of indicating the presence of an electric current by means of a galvanometer and a spot of light is convincing, but not impressive, and might often be replaced by a selenium cell with advantage. A selenium cell was connected up with a delicate relay and electric bell in such a manner that the diminution in the resistance of the cell on exposure to light diminished the current through the relay, and caused the bell to stop ringing.

Different coloured plates of glass were then interposed between the cell and the source of light—a gas-burner—and red, orange, and yellow glasses were found to exert no screening effect, but when a green glass was employed, the light was screened off, and the bell began to ring.

Two blue glasses were then tried, and the light blue was found to exert a screening effect, while a much darker blue did not. The reason of this, as shown by spectroscopic examination of the glasses, was that the dark blue glass, being coloured with cobalt, allowed a good deal of red light to traverse it, but the red light was entirely cut off by the light blue glass. The author suggested that an arrangement of this kind might possibly be employed to ring a bell in case of the extinction of a ship's light or of a railway signal light, or to turn on electric light when daylight falls below a certain point, or apparatus arranged to ring a bell when the cell was exposed to light might be employed in a safe or strong room, and made sufficiently delicate to be thrown into action by the lighting of a burglar's lantern.

DISCUSSION.

Prof. G. M. MINCHIN stated that he had been engaged in the investigation of some of the properties of selenium cells, and a Paper on the subject would be laid before the Society at its next meeting. More attention had, he thought, been given to the influence of light on the resistance of these cells than to its power of developing an E.M.F. in them. The cells which he had constructed gave a considerable E.M.F. when exposed to light; and as an instance of their sensitiveness, he stated that some of his cells developed an E.M.F. of 0·25 volt under exposure to the very small amount of daylight which percolated through the dense fog which prevailed on that day. It had been stated that it was necessary to heat the selenium for a considerable time, and Sir William Siemens stated that the subsequent cooling must also be long continued. He did not find a long continuance either of the heating or cooling process to be necessary, but was able to complete the manufacture of a sensitive selenium cell within 10 minutes. He had not made any experiments on the effect of prolonged exposure to light on the resistance of a cell, but in his experiments on the E.M.F. developed by the cells, and measured by an electrometer, he had found no such deterioration when the cells were kept on open circuit, but there was a deterioration when the circuit was kept closed. He found the maximum E.M.F. to be caused by light from that portion of the spectrum between the yellow and the green, which was in agreement with Mr. Bidwell's results. He had also found that within 24 hours or so of the formation of the cell both the development and the disappearance of the E.M.F. were instantaneous; but after a day or two there was a lagging effect, although the same maximum E.M.F. was ultimately attained.

Mr. MORDEY called attention to the chemical similarity of sulphur and selenium, and pointed out that copper was specially liable to be acted on by sulphur. He asked if other metals had been tried that were not so readily attacked; and, if so, whether it had been found that the deterioration of the cells was lessened.

Mr. PICKERING stated that both the oxides of selenium were deliquescent, and that if the white lumps observed by the author consisted of one of these oxides, they would exhibit an acid reaction.

Digitized by Google

Mr. H. TOMLINSON (in the absence of Prof. W. G. Adams) said that Prof. Adams had employed platinum electrodes in some of his selenium cells, but he was not able to say with what result.

Prof. S. P. THOMPSON had tried using platinum electrodes in his photo-electric selenium cells, but gave it up on account of the high resistance of the cells, which he attributed to a better adhesion between the selenium and copper than between platinum and selenium. With regard to the length of time required for annealing, he stated that it was only necessary to continue the process until the colour of the selenium became slatey grey, and this did not necessarily require any long time. He suggested that the selenium cells might be applied to the regulation of a seconds pendulum with absolute freedom from contact of any kind.

Mr. TRIBE said that in some investigations which he had carried out in conjunction with Prof. Gladstone, and which were described in a Paper communicated to the British Association, they had found a very great difference electrolytically between the two sulphides of copper, and very probably it might be the same in the case of the selenides.

Prof. FORBES, referring to the red tufts which Mr. Bidwell had obtained on the anode, pointed out that Faraday had obtained black tufts of silver sulphide of a similar character on the anode by the long-continued action of a current.

Mr. BIDWELL, in replying, pointed out that there was no doubt that prolonged heating diminished the resistance, and the only question was whether it was due to annealing or to the formation of selenide of copper, as he believed. Prof. Graham Bell had found the resistance of his photophone cells too high when platinum electrodes were employed, and attributed this to imperfect adhesion between the platinum and selenium. It might, on the other hand, be due to the non-formation of a selenide with platinum electrodes and its formation with copper electrodes. He would feel greatly indebted to any chemist who would analyse the material of some of his cells to determine whether or no selenide of copper was present. In reply to a question by Mr. de Tunzelmann, the author stated that though he had made experiments with both copper and platinum electrodes, he had been unable to decide whether the higher resistance of those with platinum was due to imperfect adhesion or to non-formation of selenide, the form of cell employed by him not being suitable for the purpose of deciding the question. He, however, inclined to the opinion that Graham Bell was right in attributing the difference to imperfect adhesion in the case of platinum.

MR. JAMES SWINBURNE read a paper

## On "Alternate Current Condensers."

It is, he said, generally assumed that there is no difficulty in making commercial condensers for high pressure alternating currents. The first difficulty is insulation, for the dielectric must be very thin else the volume of the condenser is too great. Some dielectrics 0·2mm. thick can be made to stand up to 8,000 volts when in small pieces, but in complete condensers a much greater margin must be allowed. Another difficulty arises from absorption, and whenever this occurs the apparent capacity is greater than the calculated. Supposing the fibres of paper in a paper condenser to be conductors embedded in insulating hydro-carbon, then every time the condenser is charged the fibres have their ends at different potentials, and a current passes to equalise them, and energy is lost. This current increases the capacity. One condenser made of paper boiled in ozokerite took an abnormally large current, and heated rapidly. At a high temperature it gave off water, and the power so wasted and current taken gradually decreased.

When a thin plate of mica is put between tin foils, it heats excessively; and the fall of potential over the air films separating the mica and foil is great enough to cause disruptive discharge to the surface of the mica. There appears to be a luminous layer of minute sparks under the foils, and there is a strong smell of ozone.

In a dielectric which heats there may be three kinds of conduction, viz.: metallic, when an ordinary conductor is embedded in an insulator; disruptise, as probably occurs in the case or mica, and electrolytic, which might occur in glass. In a transparent di-electric the conduction must be either electrolytic or disruptive, otherwise light vibrations would be damped.

The dielectric loss in a cable may be serious. Calculating from the waste in a condenser made of paper soaked in hot ozokerite, the loss in one of the Deptford mains came out 7,000 watts. Another effect observed at Deptford is a rise of pressure in the mains.

There is, as yet, no authoritative statement as to exactly what happens, and it is generally assumed that the effect depends on the relation of capacity to self-induction, and is a sort of resonator action. This would need a large self-induction, and a small change of speed would stop the effect. The following explanation is suggested. When a condensor is put on a dynamo the condensor current leads relatively to the electromotive force, and therefore strengthens the field magnets and increases the pressure. In order to test this the following experiment was made for the author by Mr. W. F. Bourne. A gramme alternator was coupled to the low pressure coil of a transformer, and a hot-wire voltmeter put across the primary circuit. On putting a condenser on the high pressure circuit the voltmeter wire fused. The possibility of making an alternator excite itself like a series machine, by putting a condensor on it, is pointed out.

DISCUSSION.

Prof. PERRY said it would seem possible to obtain energy from an alternator without exciting the magnets independently, the field being altogether due to the armature currents.

Mr. SWINBURNE remarked that this could be done by making the rotating magnets a star-shaped mass of iron.

Sir W. THOMSON thought Mr. Swinburne's estimate of the loss in the Deptford mains was rather high. He himself had calculated the power spent in charging them and found it to be about 16 horse-power, and, although a considerable fraction might be lost, it would not amount to nine-sixteenths. He was surprised to hear that glass condensers heated, and inquired whether this heating was due to flashes passing between the foil and the glass.

Mr. A. P. TROTTER said Mr. Ferranti informed him that the capacity of his mains was about one-third microfarad per mile, thus making two-and a third microfarads for the seven miles. The heaping up of the potential only took place when transformers were used, and not when the dynamos were connected direct. In the former case the increase of volts was proportional to the length of mains used, and 8,500 at Deptford gave 10,000 at London.

Mr. BLAKESLEY described a simple method of determining the loss of power in a condenser by the use of three electro-dynamometers, one of which has its coils separate. Of these coils, one is put in the condenser circuit and the other in series with a non-inductive resistance, $r$, shunting the condenser. If $a_2$ be the reading of a dynamometer in the shunt circuit, and $a_3$ that of the divided dynamometer, the power lost is given by $r\,(C\,a_3 - B\,a_2)$, where B and C are the constants of the instruments on which $a_2$ and $a_3$ are the respective readings.

Prof. S. P. THOMPSON asked if Mr. Swinburne had found any dielectric which had no absorption. So far as he was aware, pure quartz crystal was the only substance.

Prof. FORBES said Dr. Hopkinson had found a glass which showed none.

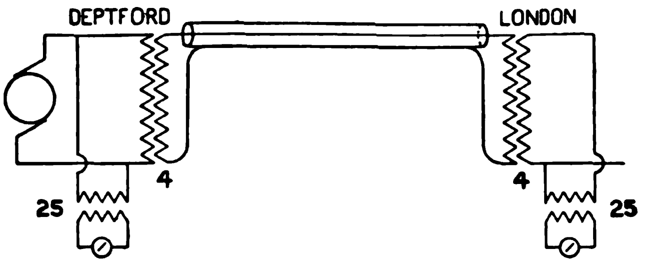
Sir W. THOMSON, referring to the same subject, said that many years ago he made some tests on glass bottles, which showed no appreciable absorption. Sulphuric acid was used for the coatings, and he found them to be completely discharged by an instantaneous contact of two balls; the duration of contact would, according to some remarkable mathematical work done by Hertz in 1882, be about 0·0004 second, and even this short time sufficed to discharge them completely. On the other hand, Leyden jars with tinfoil coatings showed considerable absorption, and this he thought due to want of close contact between the foil and the glass. To test this he suggested that mercury coatings be tried.

Mr. KAPP considered the loss of power in condensers due to two causes; first that due to the charge soaking in, and, second, to imperfect elasticity of the dielectric. Speaking of the extraordinary rise of pressure on the Deptford mains, he said he had observed similar effects with other cables. In his experiments the sparking distance of a 1,400 volt transformer was increased from fifteen-sixteenths of an inch to one inch by connecting the cables to its terminals. No difference was detected between the sparking distance at the two ends of the cable, nor was any rise of pressure observed when the cables were joined direct on the dynamo. In his opinion the rise was due to some kind of resonance, and would be a maximum for some particular frequency.

Mr. MORDEY mentioned a peculiar phenomenon observed in the manufacture of his alternators as bearing on the subject under discussion. Each separate armature coil was tested at a very high pressure, and then, when an armature was completed, it was subjected to double the pressure at which it would be required to work. It was found that the insulation of the armature as a whole could be broken through by a pressure less than that necessary to break through a single coil. This was, of course, easily overcome, but an explanation was not easy to find.

Prof. RÜCKER called attention to the fact that dielectrics alter in volume under electric stress, and said that if the material was imperfectly elastic some loss would result.

The PRESIDENT said that as some doubt existed as to what Mr. Ferranti had actually observed, he would illustrate the arrangements by a diagram.




Arrangement of Transformers between Deptford and London, and small Transformers on Voltmeters. The figures relate to the transforming ratio in each case.

Speaking of condensers, he said he had recently tried lead plates in water to get large capacities, but, so far, had not been successful.

Mr. SWINBURNE, in replying, said he had not made a perfect condenser yet, for although he had some which did not heat much, they made a great noise. He did not see how the rise of pressure observed by Mr. Ferranti and Mr. Kapp could be due to resonance. Mr. Kapp's experiment was not conclusive, for the length of spark is not an accurate measure of electromotive force. As regards Mr. Mordey's observation, he thought the action explicable on the theory of the leading condenser current acting on

Digitized by Google

the field magnets. The same explanation is also applicable to the Deptford case, for when the dynamo is direct on, the condenser current is about 10 amperes, and this exerts only a small influence on the strongly magnetised magnets. When transformers are used the field magnets are weak, whilst the condenser current rises 40 amperes. Mr. Blakesley's method of determining losses was, he said, inapplicable, except when the currents were sine functions of the time, and consequently could not be used to determine loss due to hysteresis in iron, or in a transparent dielectric.

Mr. Swinburne's "Note on Electrolysis" was postponed till next meeting.

## NOTES ON THE CHEMISTRY OF SECONDARY CELLS.*

By Professor W. E. AYRTON, Vice-President; C. G. LAMB, B.Sc., and E. W. SMITH, Associates.

*(Concluded from page 177.)*

DISCUSSION. (AUTHORISED ABSTRACT.)

THURSDAY, DECEMBER 11, 1890.

Mr. S. JOYCE, jun., said he gained some experience with pasted cells when discharged at high rates, and therefore requiring frequent repairs. After several repastings, he found it very difficult to make the red lead paste stick in the positive plates, and then tried litharge paste, similar to that used for negatives. Cells so made had proved very satisfactory.

Mr. D. G. FITZGERALD inquired by what authority and for what reasons the authors called the peroxidised plate the positive, and the spongy lead the negative. He himself had good reason for reversing the designations, and in this he was following the example of Volta and Berzelius. Speaking of the chemical constitution of the negative (peroxide) plate, he said it was generally believed that $PbO_2$ enters largely into its composition; there is, however, reason to doubt whether any of this compound is present, for the behaviour of the active substance on the plates is quite different from that of the pure peroxide of commerce. If a plate be made up of 80 per cent. of pure peroxide and 20 per cent. of the so-called peroxide produced by electrolysis, the E.M.F. falls when the electrolytic product is spent, and the subsequent action of the cell is unsatisfactory. In his analysis of the electrolytic peroxide he had always found some percentage of moisture present, even after it had been dried at a temparature above 212° Fah. He believes the chemical changes produced by electrolysis is represented by the equation $(PbO_2)_{10}, (H_2O)_5, PbSO_4 = (H_2Pb_2O_5)_5, PbSO_4$, and that electrolyic peroxide is $H_2Pb_2O_5$. As regards the best kind of support or grid for the spongy lead, he said it was a mistake to use lead, for copper is in many cases much better. If the copper be left exposed local action takes place, but this is retarded by the addition of any alkaline sulphate. The beneficial effect of soda in secondary cells he attributed to the formation of a double salt, which is easily reduced. Sulphate of magnesium has an extraordinary influence on lead plates, and by using a solution of it as electrolyte he had got discharges 30 or 40 times greater than those obtainable from sulphuric acid. The strength of acid required attention when dealing with heavy discharges. Recently he had used acid having a maximum density 1·252, so that its specific resistance diminished as the cell discharged. In this way, and by the aid of copper supports for the spongy lead, he obtained a comparatively steady discharge of two amperes per pound gross weight of cell for two hours. With ordinary lead grids this would have been impossible.

Prof. PERRY asked if the double sulphate really exists, and Prof. AYRTON inquired whether there were any simple tests by which such sulphates, if formed, could be detected.

Dr. GLADSTONE said Mr. Hibbert and himself had concluded that there was to evidence of double sulphate being formed in the action of secondary cells. He believed the general idea as to the influence of sodium sulphate was that lead sulphate was more soluble in the mixture than in simple acid; this, however, was not confirmed by experiments.

Mr. CROOKES, the new president, said sulphuric acid had a great tendency to form double salts, and thought it very probable that such salts would be formed in the case under discussion. Some results published by Dr. Gore in the *Phil. Magazine* also point to the same conclusion.

Prof. S. P. THOMPSON was interested to learn that, like any other battery, the greatest action occurs at the upper parts of the plates. This might perhaps have been expected, because of its being the path of least resistance; but as the variation of the resistance of sulphuric acid with density is peculiar, and as the denser acid falls to the bottom, the action might have been modified thereby. The details relating to the formation of plates, given in the second Paper, were, he thought, not new, and were practically what any one having a knowledge of the properties of the substances used, and of the reactions which it was desired to bring about, would have arrived at theoretically. For example, to oxidise the positives one would aim at producing the most powerful oxidiser in the shape of ozone, the formation of which is facilitated by strong acid, large current density, and low temperature; on the other hand to reduce the litharge on the negatives it was known that a large current density mainly produces gas, and that production is best effected by small current density at a fairly high temperature. Bearing in mind these opposite conditions, one readily realises that the plates should be formed separately, and that the negatives will require a much longer time. Several years ago he tried cells with electrolytes other than sulphuric acid, and found that phosphoric acid was the only one which gave fairly good results. Speaking of pasted cells Dr. Thompson inquired whether the authors had noticed that the oxidation of the positive paste begins over the grid, and gradually spreads through the mass of the plugs, and whether a useless nucleus remained unacted on in the centre of each.

Replying to Prof. Thompson, Mr. E. A. HALL said he had made experiments on the capacity of cells with plates of different thickness, and found it independent of the thickness. This, he thought, tended to confirm Prof. Thompson's view as regarded a useless nucleus. On the question of acid density he found that the capacity of a cell was increased 15 per cent. by using acid of specific gravity, 1·15 instead of 1·20.

Mr. PREECE rose to correct an error made by Mr. Drake at the last meeting, in stating that the density of acid in the P. and O. battery had been 1·40. Mr. Hall informed him (the speaker) that it had never exceeded 1·22.

Mr. T. FRAZER took exception to the remarks made by Mr. E. W. Smith, in his reply to the discussion at Edinburgh, with reference to the formulæ he (Mr. Frazer) had given for the resistance of cells for different currents, and for the fall of E.M.F. when the charging circuit is interrupted. In spite of what Mr. Smith said, he maintained that his own statements were correct.

Prof. AYRTON, in replying, said the authors greatly appreciated the cordial reception given to the Papers by practical engineers, for one of the aims of the Central Institution was to train students to do work and carry out investigations the results of which would be of commercial value. Referring to Dr. Gladstone's criticisms about the ammonium acetate method, he said that Mr. Robertson had used this method, but somehow or other the paragraph describing it had not been printed in the first proof. Speaking of measuring the resistances of cells, he pointed out that unless the curve

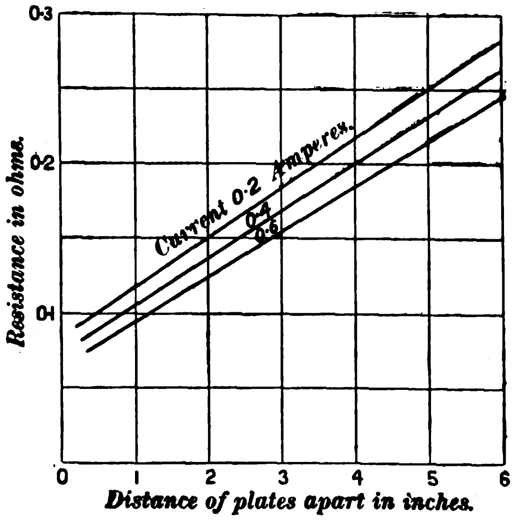



DIAGRAM A.—Resistances of Small Secondary Cell. Plates 4¼in. by 2¼in.

connecting time and E.M.F. was discontinuous at the instant of breaking circuit, the method used should give correct results. So far as he knew there was no evidence of any such discontinuity. Mr. Crompton had said the resistance was practically independent of the distance of the plates apart, and that the sulphating of the negatives during rest depended greatly on light. Taking the case of resistance first, they had made experiments on a small two-plate cell, and found that when the ordinary method of testing was employed, Mr. Crompton's statement seemed nearly correct, but on using the more sensitive method illustrated in Figs. 10 and 11 of the Edinburgh Paper, this was not the case. Diagram A represents the results of these experiments. To investigate the effects of light, darkness, and sulphate of soda on the liberation of gas from idle negatives, they had experimented on three similar E.P.S. cells. The fully charged negatives, designated by A, B and C respectively, were put in three different vessels of acid, one of which contained 0·8 per cent. of sodium sulphate and the gases collected. A powerful arc light illuminated one set of plates, whilst the others were kept dark. Plate A, when illuminated, gave off gas very rapidly, whilst B and C in the dark produced very small quantities which were about equal. On interchanging the plates, however, it was found that neither light or sodium sulphate had any marked effect on the rate at which gas was given off, for whether A was illuminated or kept dark, or put in ordinary acid or in the sodium sulphate solution, gas was liberated rapidly at about the same rate, whilst B and C were equally inactive under all the conditions. They therefore conclude that the rate at which gas is liberated depends on some peculiarity of the plates themselves. Some speakers, he said, had remarked that many of the facts brought forward in the papers were previously known. To this he replied that none of the facts given as new were known to the authors before they discovered them experimentally. Manufacturers might have been aware of them, but if so, they had kept them secret and never published them. For example, Dr. Gladstone, one of the highest authorities on secondary cells, was not aware of the differences in the hardness of the plugs at different parts of the plates until the appearance of their paper. Another case in point was the fact that Dr. Thompson said there was nothing new in the methods of forming the plates, whereas Mr. King apparently did not know of them. Mr. Swinburne had also called their attention to a prediction of the cooling of cells during discharge made in

* Paper read before the Institution of Electrical Engineers on Thursday, November 13, 1890.

Digitized by Google

1887, but at that time he admitted that he had not observed it. Speaking of the efficiency of cells, he said some people think the very perfect testing apparatus gave the cells their high efficiency; this of course was not true, for their figures merely express the results obtained when cells are used in a proper manner. Referring to a criticism on the Edinburgh paper which appeared in one of the leading technical papers of July 25th, he said the writer had only partly understood the early part of the paper, for they (the authors) had there explained that one of the objects of the investigation was to see what error could be made by neglecting the previous history, and the resuscitating power of cells. The same writer had also stated that the results of laboratory tests were not applicable to ordinary working conditions. Here, again, he had fallen into error, for a secondary cell is a thing complete in itself, and if two or three selected at random give good results under proper treatment, so any number, if similarly treated, will show equal efficiency.

## EXPERIMENTS ON THE MAGNETISATION OF THIN PLATES OF STEEL AT RIGHT ANGLES TO THEIR PLANE.*

BY W. DOULE.

The plates experimented on were squares (the side being from 10 to 20mm. in length), rectangles of various sizes and circles, cut from springs from 0·25 to 0·3mm. thick, or from sheets 0.35mm. thick. They were magnetised by means of two thick bobbins of 8,000 square centimetres surface, through which was passed the current from a dynamo. In order to produce an anomalous magnetisation, the current was gradually reduced by the insertion of resistance, as suggested by Von Waltenhofen.

The discs were first suspended by a silk fibre in order to determine the position they took up with regard to the magnetic meridian. Magnetic figures were then produced by sprinkling iron filings on a thin sheet of paper, and the spot indicated as poles by the arrangement of the filings were investigated with a small compass-needle 4mm. long.

For all the specimens tried, a magnetisation at right angles to their plane seemed to be impossible. Two poles always appeared, and they were so arranged as if, in the case of the squares, the magnetising force had acted along a diagonal, and in the case of the rectangles, parallel with the longer side.

When 80 square plates 0·25mm. thick and 10mm. length of side were placed together so as to form a square prism 20mm. long, and magnetised, the iron filings showed a perfectly regular distribution of magnetism, similar to what occurs in a solid magnet. As soon, however, as they were separated, the individual plates were found to be magnetised as above mentioned.

A series of steel cylinders, 22mm. in diameter, and of lengths varying from one to 20mm. were then experimented on. They were of Bessemer, tool, and manganese steel, and were supplied by Dr. M. T. Edelmann. Cylinders of a height of 10mm. and more showed a perfectly defined magnetisation in the direction of their axes. As the height was reduced the polar axis became more and more inclined to the geometrical one, until, at a thickness of 1mm., the same state of affairs as was observed with the thin square plates occurred.

It would therefore appear to be in the highest degree probable that a permanent magnetisation of thin steel plates at right angles to their planes is impossible when the ratio between their thickness and their other dimensions becomes reduced below a certain value.

## AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *December* 5, 1890.

**The Subway Question in New York.**—The subway situation is not in the way of immediate improvement. At a recent meeting of the Board of Electrical Control a specious proposition came in from the Company that has been put in charge of subway installation by the present City Authorities, announcing that a new subway company had been organised by persons interested in various telegraph and telephone companies, under the name of the Empire City Subway Company, and suggesting that the low-tension work be turned over to them. What the electrical companies are now interested in finding out is the scheme that in all probability lies under this plausible proposition. The relations between the new company and the present one remains to be determined, but it appears to be altogether too harmonious to augur much good to those who desire subway accommodation. Mayor Grant continues his old threat of lighting the streets by gas unless the electrical illuminating companies will furnish street-lighting at practically the old rates. In a word, the situation is this: the company that is permitted to put down subways is allowed to charge rentals that are nearly prohibitory. Owing to the extortionate prices demanded for subway accommodation, the electric light companies have raised their prices, and the Municipal Authorities are now trying to compel them to use the subways by threats of dispensing with electric light altogether.

**A Curious Lightning Accident.**—An interesting accident was recently reported on one of our electric street railways. It occurred during the past summer. The electric line in question has rather severe grades produced by series of ridges over which the road passes. During a severe thunderstorm lightning struck the trolley wire at a time when three of the cars were descending grades with the current cut off. The other cars were running on a level or up-grade. Each of the cars running down grade by gravity suffered the loss of a field coil. The others, although in quite as exposed a position, were uninjured. In every case the damage to the field was produced by the lightning piercing the insulation and jumping to the core of the magnet. The explanation seems comparatively simple, for the road in question was on the Sprague system, in which the field coils are wound in three sections, and even when the motor is not in use, one of them is energised. This energised coil was the one damaged in each case, the lightning passing into it and through into the core, while in the moving cars with the field magnets fully magnetised, the self-induction was sufficient to choke the lightning discharge, so that it did no damage. It was, it seems, a very pretty example of a coil of high impedance checking lightning discharge. The superintendent of the road averted the probability of a similar accident by changing the motor connections, so that the field coils would be cut off at the switch-box instead of one of them remaining connected.

**Electric Traction on the Chicago Elevated Railway.**—It is now reported that one of the elevated railroads that is to be built shortly in Chicago will adopt electricity for a motive power. The arrangements have not yet been made, but the company is in negotiation with several electrical companies concerning the equipment of the proposed road. There is every reason to believe that electric power will find its way into more than one of the new elevated systems of this country, for it is now evident that such an application will be a success.

**Storage Battery Traction.** — Storage battery traction is active just now, not less than half a dozen small companies having experimental cars in various stages of progress. It is to be noticed, however, that very few storage battery cars are operated by street railway companies quite independent of the company furnishing the battery, and the small number of cars that are independently operated have not, as a rule, given very great satisfaction. The feeling is strong among electricians that something radically new in the storage battery line must appear before electrical traction by this means can be made commercially advantageous.

## CORRESPONDENCE.

### EXPERIMENT WITH A CONDENSER AT DEPTFORD.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: On the day after our last meeting of the Physical Society I saw at Deptford, in a test by Mr. Ferranti of a vulcanite tray subjected to 20,000 volts (square root of mean square), a most interesting illustration of one of the subjects discussed in connection with Mr. Swinburne's Paper. The tray was rectangular, with rounded corners and edges, and may have been 8in. or 10in. long, by 5in. or 6in. broad, and 1½in. deep (I write from memory). The vertical sides ended in a flat lip, about 1in. broad, projecting horizontally on all sides. It was laid on the bottom of a large metal tray filled with

* *Wiedemann's Annalen*, Vol. XLI., Part 10.

Digitized by Google

water, and was filled up inside to a depth of about half an inch. During the test we observed a blue line of light all round the water-line, both inside and outside, which seemed to be everywhere about a quarter of an inch broad (we did not apply a ruler or compasses to measure it!). When the test was completed and the electrification stopped, we took the tray out and looked at it carefully all round. We found, as we expected, that there was no sign of perforation, but we saw a very remarkable appearance all along the lines, inside and outside, which had been the boundaries of the water. They showed, at regular intervals, little vertical marks; the explanation of which was, no doubt, capillary standing waves produced in the water by the electric force, and analogous in hydro-kinetic and capillary quality to the ripples seen inside a finger-glass caused to sound by a wetted finger drawn along its rim. The blue light which we saw was, of course, due to the same cause as the well-known sparkling at the edges of the coatings of a Leyden jar when suddenly charged or discharged. The sparkling described by Mr. Swinburne in his mica condenser was no doubt due to the same cause. When the breadth of a band of sparking round the edge of a metallic coating is considerable in comparison with the linear dimensions of the coating in any condenser subjected to rapidly alternating high potential, there must be considerable heating due to it; and the mere fact of heating would not prove that any sensible proportion of the heating is due to viscosity of electrostatic inductive capacity.

An internal sparkling or quasi-sparkling in some of the ingredients of heterogeneous insulators may be the cause of some of the heating of condensers which has been observed by Mr. Swinburne and others.

Recurring to the subject of duration of contact between two mutually impinging metal balls, we must not assume that this is the duration of electric conductance between them. On the contrary, when the potential of the charge is several thousand volts, there might be separation to the extent of a millimetre or two without cessation of very effective electric conductance. But it will be interesting to find whether, with charges of one or two volts, the exceeding shortness of the duration of metallic contact of mutually inpinging balls can suffice to let us sometimes find the electrification of a condenser reversed, after a discharge by impact, even in cases in which the period of the oscillatory discharge with constant resistance is only a few ten-thousandths of a second.—Yours, truly,

WILLIAM THOMSON.

The University, Glasgow, Dec. 15, 1890.

## FORCES BETWEEN CURRENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the note with which Dr. Lodge kindly prefaces my letter which you were good enough to insert in your issue of December 12th, he remarks that the stresses I notice have their analogies in electrostatic actions. This is undoubtedly the case with those depending on the pressure normal to the direction of the flow; but I think he will allow that the shearing stress due to tangential force on the sides of the tunnel seems more like an electro-magnetic effect.

The pressure normal to the tunnel, like the electrostatic action of a current, does not in all cases produce repulsion. In fact, in most cases the action is an attraction by which two cavities containing fluid at different pressures tend to move towards one another, if one of the pressures be less, and the other equal to or greater than that on the surface of the block.

The action of the shearing stress is quite different; it must always cause a push between contrary parallel currents, never a pull, and is thus, though in itself mechanical potential, more like electro-kinetic stress. Also, granting that Sir William Thomson's vortex ring theory of matter may be correct, must we not consider the molarly potential energy of mechanical stress to be molecularly kinetic?

Since my letter was written I have learned that Sir William Thomson has shown that the distribution of stress in the medium surrounding a magnet is the same as that in a jelly distorted by a torque applied to a rigid bar embedded in it. I think this justifies the idea that electro-kinetic actions may be likewise represented.—Yours truly,

JAMES ERSKINE MURRAY.

40, Montgomerie Drive, Glasgow, 14 December, 1890.

[Two or three years ago, while considering from a merely geometrical point of view some of the different displacements to which the ether might be subjected, we constructed diagrams

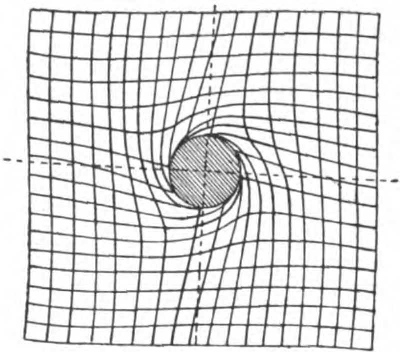


FIG. 1.—Strains set up in a Jelly by a Torque applied to a Cylinder. Twist through 45 deg.

showing the strains set up in a jelly by a torque as described by our correspondent. We herewith reproduce three of these, which present several points of interest, showing a tendency to

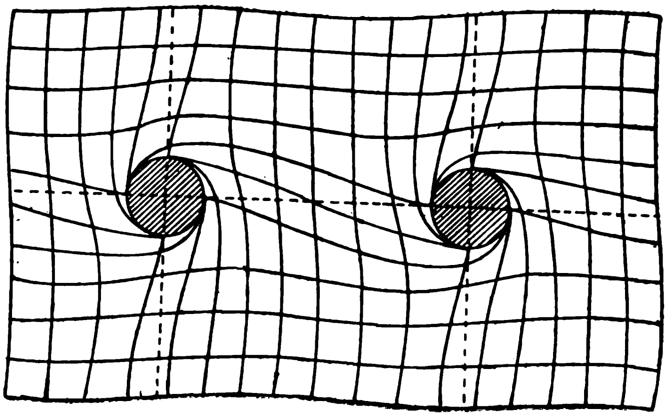


FIG. 2.—Cylinders twisted in same direction through 45 deg.

attraction and repulsion. The outline of Fig. 1 resembles that of a square bar subjected to a torque (*see* Perry's "Practical Mechanics," p. 98). The same outline is to be seen in Fig. 2,

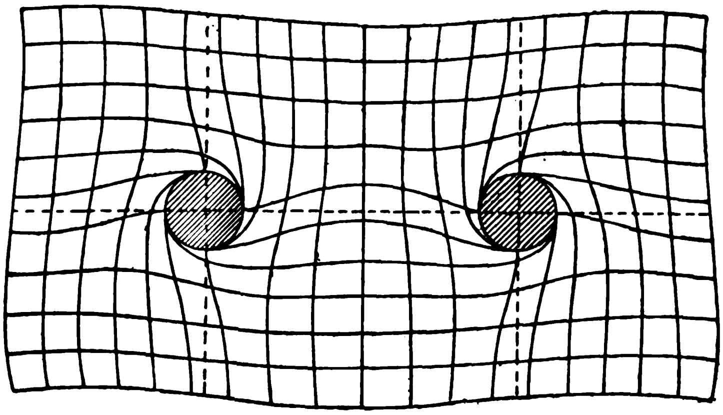


FIG. 3.—Cylinders twisted in opposite directions through 45 deg.

there being no tendency to alter it; but in Fig. 3, the two stresses being in opposite directions, the middle transverse line is straight, the upper part of it passing through a region of great compression, and the lower through a region of extension.—ED. *E.*]

Digitized by Google

## TENDERS FOR MULLINGAR ASYLUM.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Being greatly interested in the electrical engineering industry and its progress in Ireland, I naturally follow with keen interest any new development of the same over here. I was very much surprised and perplexed to notice in your this week's trade notes the material financial difference in the various tenders sent in for installing the electric light in Mullingar District Ayslum, and I absolutely fail to see how this can be satisfactorily accounted for. Taking the highest and lowest tender, there is the immense difference of £1,958, more than double the amount of the lowest tender (£1,755), both of them being London firms. Am I to understand that the Electric Engineering Corporation are prepared to carry out the same amount of work with the same class of goods and efficiency as Messrs. Siemens Brothers and Co. If this difference is the rule with all estimates these two firms are furnishing to intending clients, and presuming each have their share accepted, it will be very interesting to note and compare their individual profit and loss accounts when next audited. If one of these firms are manufacturers, and the others merely agents or warehousemen, some slight difference might be accounted for; but this, I believe, is not the case, both of them being manufacturers. There is little doubt that, were these the only two tenders sent in, the Commissioners would have little difficulty in deciding. Surely the business side of the electrical science has reached a higher stage of perfection in estimating than this unexplainable difference would indicate. Even the two Dublin firms who have furnished tenders show a difference of £715, which I should say would be a very handsome profit, presuming the higher tender be accepted.

Evidently the maxim, "small profits and quick returns," is not that closely followed by all electrical firms. Perhaps it is to the Commissioners' decision and the subsequent carrying out of the work that we must look for the solution of this problem.—Yours, &c., Arthur O'Brien.

Dublin, December 15, 1890.

[This is largely a question of specification. It would be much more interesting to compare two jobs when completed, according to the highest and by the lowest tenders, than to compare the profits. The specification was not short, but it did little but enumerate the items. Specifications for electrical work are as yet very much more vague than in other branches of engineering. A strictly-drawn specification, while it leaves but little room for divergence, will necessarily raise the average price by reducing the number of chances which a contractor has for introducing his own manufactures or specialities. After all, the best specification is but little protection to the purchaser without the additional services of a consulting engineer.—Ed. *E.*]

## ELECTRICAL TREATMENT OF SEWAGE.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I have been much interested in reading the abstract of Mr. Webster's Paper on "The Electrical Treatment of Sewage," published in your impression of last week, the more so because, when in Manchester last May, I took the opportunity of visiting the experimental plant erected by both the "Electric" and the "International" Companies; and by the courtesy of the gentleman who represented the Salford Corporation during the trials then just on the eve of commencement, I was enabled to see all but the work of purification in actual operation.

I was particularly struck by the extreme simplicity of the "International" plant as compared with that required by the Electric Company; on the one hand a sluice, into which "ferozone" is automatically fed and mixed with the flowing sewage, precipitating tanks, and polarite filters, on the other, an engine and boiler, dynamo and copper leads to the electrolytic conduit and sand filters.

It appeared to me, as an engineer, that provided equally good results were obtained in both cases, there could not be any hesitation in deciding which would give the least trouble in practice, more especially as the International process has been at work with success at Acton for the past three years.

What seemed to me strange was how the electrolytic conduit, consisting, as it does, of a large number of cast-iron plates, half an inch thick and ⅝ of an inch apart, could successfully treat the class of sewage often obtaining, namely, dead cats, rats, old boots, lumps of cotton waste, and kindred substances always met with in the sewage of a manufacturing district. Should it become necessary to strain all the sewage prior to allowing it to flow into the conduit, this would introduce a not inconsiderable item in the required plant, and in the cost of maintenance, which does not appear to be considered in the abstract you published.

You have rightly criticised the estimated cost of the requisite power set forth in the paper, and you have shown in your notes that on the evidence of the results, namely, 0·37 ampere-hour per gallon of sewage treated, the annual cost of producing the required electrical energy under the conditions stated in the paper would be something like £8,500 to £9,000 to treat ten million gallons of sewage per 24 hours.

You have further drawn attention to the fact that at the rate of consumption of iron claimed by the Company, namely, three grains per gallon, the cost of iron alone per year at £4 per ton would be about £2,500.

But what you have not pointed out, and what appears to me to be a most important point is this: that the plates cannot be used up to the last grain, for two reasons. As the plates get thinner the electrical resistance of the conduit would be much increased, and not only would more power be required to produce the necessary electrolytic effects under normal circumstances, but the state of things would be aggravated by some of the more liquid sewage flowing past, owing to the increased space between the plates, without being properly treated. It is therefore justifiable to anticipate that the consumption of iron, as well as the power required, would in practice work out to a higher figure than that mentioned in Mr. Webster's paper for the given degree of purification.

Since cast-iron at £4 per ton cannot be relied on as being very homogeneous in its texture, it is reasonable to suppose that the plates would not wear uniformly, but would tend to wear "in holes." It would, for this reason as well as for the above-mentioned, namely, the increased electrical resistance due to increase of space between the plates, not be wise, I take it, to allow the plates to wear to less than half their original thickness. Thus it would appear that another item, namely, frequency of renewals, have been overlooked.

There is just one more point which struck me as not being sufficiently detailed in the report of Mr. Webster's Paper, and that is the nature of the trials. Sewage, as is well-known, varies in quality sometimes very rapidly, generally according to the time of day or night. Now there is no evidence, as far as I can gather, that the power developed by the engine, or the electrical output, over any period was compared with the analysis of the sewage during that time and with the quality of the effluent of the sewage treated during that particular period. Nor is there any evidence that the degree of purification found by Sir H. Roscoe in previous experiments was realised in this case with the above-mentioned consumption of iron, namely, three grains per gallon. There is too much averaging, too much generalisation. The results may, of course, be perfectly accurate, but they may be quite misleading. The results of any tests or trials should always be given in such a manner that the method by which the average result is obtained is quite clear, so as to enable every one to form their own opinion as to the value of the average result for the purposes at issue.

Trusting the importance of this question may be some excuse for my having trespassed at such length on your valuable space, I remain, yours faithfully, Ed. C. de Segundo.

Whitehall Club, December 16, 1890.

## ELECTRICITY FOR HEATING PURPOSES.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: The subject of evaporating water and concentrating liquors by means of electricity is an interesting one to the manufacturing world, though I can find very little information on the matter in the most recent publications on electrica

Digitized by Google

science. In places where fuel is scarce and water-power is available, it is sometimes desirable to use heat for raising steam or evaporating, or even in localities where there is available fuel and a good water-power, it might be cheaper and preferable to use water-power. At any rate, the case I have in view is a borax marsh in California, near which place there is a waterfall of fully 500 feet. This fall can be utilised by the means of a Pelton water-wheel to drive a dynamo; and what I want to ask any of your readers through your medium, if I may venture to do so, is this:—

Has any method been devised of boiling water by electricity? If so, by whom? and where can I obtain particulars?

It has been suggested that a coil of wire circulating round an iron pipe will induce a certain amount of heat, and that the temperature of water passing through a pipe so arranged will be raised to the boiling point. If that be so, then the arrangement can be made applicable to manufacturing industries, and you can make a waterfall boil a pan of water, not to mention the great convenience it would be in domestic life where the current is laid on to a house for lighting, and power to have it available for hot water as well.—Yours, &c.,

E. L. Fleming.

19, Shaftesbury-road, Ravenscourt Park, W.

[Our correspondent further informs us that fuel is very scarce in the country referred to, and that he considers that 150 horse-power would practically cost him nothing. With this power he might, with perfect machinery, raise some 3,000 gallons 200deg. Fah., or might evaporate some 630 gallons in 24 hours; but in practice he could hardly expect to heat up and boil away as much as 400 gallons. As it would take nearly a ton of wood to do this, there may be something in the scheme which does not at first sight appear to be hopeful.—Ed. *E.*]

## TRADE NOTES AND NOTICES.

*[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.]*

Tender Wanted.—Tenders are invited up to December 23rd, at the Ministerium der Colonien, for the supply of iron telegraph posts (Henley system), iron insulator stems, and galvanised wire.

Electric Lighting Contracts.—We would remind our readers that the tenders for the electric lighting plant required by the Pretoria Lighting Company (Limited) must be sent in to Mr. A. Moir, the London Secretary of the Company, 29 and 30, Holborn-viaduct, E.C., by noon on December 20th. Mr. Moir will supply all particulars.

The Expiry of Telephone Patents.—Mr. G. A. Nussbaum, C.E., desires us to state that he has been appointed sole agent in this country for the Société Générale des Téléphones, who are the owners of Ader's patent telephone magneto transmitters and receivers with battery call.

The Electrical Supplies and Fittings Company (Limited.)—We are in receipt of an intimation from the Globe Electrical and Engineering Company that the business of that Company has been transferred to the Electrical Supplies and Fittings Company (Limited), by whom a complete catalogue of electrical supplies is in course of preparation.

Messrs. Mori and Moorhouse.—We have received from this firm a fully-illustrated catalogue and price list of their specialities, including electric bells, indicators, wood, china, and brass pushes, burglar and fire alarms, wires, &c. The catalogue is noticeable for its well-designed frontispiece.

Anglo-American Telegraph Company.—We have received from this Company a useful blotting pad and calendar for 1891-1892.

Mr. F. W. Ness.—Mr. Ness sends us from Montreal a well got-up catalogue of electrical apparatus. The catalogue contains, in addition to the apparatus and machines usually to be found in a trade catalogue, some humorous illustrations on the subject of overhead wires.

## BOOKS, &c., RECEIVED.

Handy Lists of Technical Literature: Part IIa.: Electricity and Magnetism. (Milwaukee, Wis. H. E. Hafferkom.)

## PATENT RECORD.

### APPLICATIONS FOR PATENTS.

December 2, 1890.

19,601. W. Griffiths. Cardiff. Connecting and regulating telegraph, telephone, or electric lighting wires.

19,650. Siemens, Bros., and Co., Limited. London. Improvements in the distribution of electricity through accumulator batteries. (Siemens and Halske, Germany.)

19,665. M. W. Dewey. London. Improvements in and relating to electro-magnetic traction increasing apparatus for railways.

December 3, 1890.

19,740. F. H. W. Higgins. London. Improvements in column printing telegraph receivers.

19,744. C. B. Harness. London. Improvements in and relating to electric belts and similar appliances.

December 4, 1890.

19,762. W. C. Morison. Great Yarmouth. Improvements in and connected with electrically indicating pressure gauges.

19,806. N. Marshall. London. Improvements in circuit controllers or switches for incandescent electric lamps.

19,811. F. Wynne. London. Improvements in apparatus for use in propelling vehicles by electricity.

19,813. A. Gay, W. F. Taylor, and R. Hammond. London. Improvements in the production and distribution of alternate electric currents.

December 5, 1890.

19,834. W. H. Burleigh. London. Improvements in controlling levers of railway signal interlocking apparatus for the application of electricity.

### SPECIFICATIONS PUBLISHED.

1889.

19,079. Bryan. Electrical cut-outs. (Price 6d.)

19,813. Werndley and Foster. Heating, &c., metals by the applications of electric currents. (Price 11d.)

20,082. Turnbull. Signalling numerals, &c., by electric light. (Price 4d.)

20,582. Einstein and Kornprobst. Electric meters, &c. (Price 8d.)

20,646. Cassagnes. Printing telegraphic apparatus. (Price 1s. 1d.)

20,918. Thompson (Stanley). Dynamo electric machines. (Price 8d.)

1890.

42. Smith. Electric cables. (Price 6d.)

615. Evered and Rudling. Electric switches, &c. (Price 8d.)

1,658. Elieson. Electricity meters. (Price 8d.)

3,335. Schirner. Incandescent electric lamps. (Price 6d.)

8,427. Apps. Electric arc lighting. (Price 6d.)

11,240. Johnson (Bardou). Electric arc lamps. (Price 8d.)

13,190. Kennedy. Electro-magnets, &c. (Price 8d.)

14,232. Kennedy. Dynamo-electric machines. (Price 6d.)

16,518. Gwynne. Arc electric lamps. (Price 8d.)

16,522. Burton. Working metals by electricity. (Price 11d.)

16,571. Kennedy and Groswith. Secondary batteries. (Price 8d.)

## COMPANIES' MEETINGS & REPORTS.

### The Gulcher (New) Electric Light and Power Company (Limited).

The third ordinary general meeting of the Gülcher (New) Electric Light and Power Company (Limited) was held at Winchester House, Old Broad-street, yesterday (Thursday), under the presidency of Mr. D. de Castro.

The SECRETARY (Mr. T. C. Morgan) read the notice convening the meeting, and the minutes of the previous meeting, which were confirmed.

The CHAIRMAN said that the past year had been a very important one for the Company. On June 30, 1889, they had a very small Preference capital, which consisted of 12,277 shares, and they had at that date £10,000 Second Mortgage Debentures, to which they had to add another £6,000, which they were obliged to raise in order to meet the extraordinary difficulties in which the Company was placed by the contract they had entered into in New Zealand. This year he was happy to say that things were in an entirely different condition. They found that however prosperous the Company might be, or whatever might be its prospects, it was hopeless to expect that, having so small a capital, and being burdened with such heavy mortgages—£16,000, bearing the large rate of interest which they were obliged to pay before they could raise the money at all—it would be impossible to declare a dividend. He represented the case to some of their friends and supporters and the Board, and they agreed that their only course was to propose an issue of the balance of their capital, and to pay off these Debentures, which were absorbing all their profits. Accordingly, in the beginning of last year they issued the balance of their Preference capital, and he was happy to say that the whole of the amount had

Digitized by Google

been subscribed very largely by those who held the Ten per Cent. Debentures. The capital, therefore, now stood at £50,000 Preference shares of which £30,797 was paid up on June 30th, and he might tell them that at the present moment they had not only redeemed all their Ten per Cent. Debentures, with the exception of £200 held by one gentleman who declined to be bought up, but they had the handsome capital of £50,000 subscribed, and an uncalled capital exceeding £13,000. He thought that they would all admit that this was a position which neither the old nor the new Company had ever attained before. The business which had plunged them into difficulties in the infancy of the Company was the undertaking by mistake on the part of their late Manager of a contract in New Zealand, which had cost at least six times what it was estimated it would do. The original estimate of their engineer was £2,500, whereas the contract referred to had cost the Company £13,500. This was, even under their altered circumstances, a very large share of their capital to have locked up in what was not properly the business of the Company. They were a manufacturing electrical engineering company, not a supply company, which required a very much larger capital than a Company like theirs. The capital of £13,500, left alone, would not pay. It would not produce an income proportionate to the outlay, even if they consented to have it locked up, and to make it pay it would be necessary to lay out at least another £9,000 or £10,000 in order to produce a substantial interest upon the £25,000 or £26,000 which would then be invested there. It became, under these circumstances, a matter for the consideration of the Board whether they should lock it up, or a substantial part of it, and again leave themselves with very little free money. They decided in the early part of the year that if they could possibly avoid doing so to any substantial extent they would, and at the suggestion of his colleagues he had been since quite January 1st engaged in forming a syndicate, who, as was stated in the report, would provide for the private supply of the town of Wellington, and not only that, but would ultimately take over the Company's business in New Zealand, together with the benefit of the contract for the public lighting, entered into between the Company and the Mayor and Corporation of Wellington. That syndicate had been at last formed, and £10,000 had been subscribed, of which this Company would, at the most, have to risk £2,500 of their spare capital. He hoped, therefore, that when he met them again next year they would be able to report not only the completion of their contracts, but of the work which would be done by the expenditure of this money, and the receipt of a revenue which would enable them to declare a substantial dividend upon the whole of the capital of this Company. Another advantage to be considered was this. They were, as he had said before, a manufacturing Company, and this syndicate, which would probably grow into a much larger concern, would be a supply Company, and, *cæteris paribus*, he thought there could be no doubt that if the articles the Company sold in New Zealand continued to hold the position they now did there, the syndicate would become a very valuable customer to the Company, so that both directly and indirectly they would be gaining by the transaction. They thought it would be well, having regard to the tendency of electric lighting to run into independent installations that they should have an interest in the lighting of some district. While London was being apportioned out among the great companies, they thought, if they could see their way without material expenditure, to get a company registered, which would secure, or tend to secure, the preference, if not the monopoly of a district, it would be wise in the interests of the Company to secure that at an outlay of about £100. Accordingly, they had got a share in "The South Western District and Thames Valley Electricity Supply Company (Limited)," which had been registered, and he had received promises of support from established customers in the immediate neighbourhood of that Company's district. He was grieved to say that there was no net profit to show. The gross manufacturing profits for the year ended June 30, 1890, amounted to £3,097, and never since the Company was formed had they reached a third of that figure. But owing to the difficulties he had mentioned, they had made a loss last year of £1,417. Therefore they had been trading at an advantage of £4,503 over the previous year. The heavy interest payable on the Second Mortgage Debentures had been the real reason why they were unable to declare a profit, a circumstance which would not occur again. But for that they might have been able to declare a dividend of fully 3 per cent. Next year he thought that they might fairly anticipate being able to divide that and possibly more. He might mention that he was about to proceed to New Zealand to see if he could obtain powers, not only for lighting Wellington, but other places in the Colony. Having referred in detail to the various items in the balance-sheet and profit and loss account, he said that the Company had made arrangements for charging steam launches from their works on the river. This was a growing business, from which they anticipated good results. Their Mr. Fricker had also designed two very excellent little dynamos for the purpose of supplying houses, requiring from 20 to 50 lights, not within the district of any supply company. The same gentleman had also constructed a motor which would work during the daytime from those dynamos, and would do the work of small gas engines, or drive any small machinery that might be required. The dynamos were called the "Hercules" and the motor the "Midget," for both of which there was evidently going to be a considerable demand. Next week the instruments might be seen at work in a show-room at 139, Queen Victoria-street. They anticipated great advantage from these two branches of business next year, and a branch that was far more important than either—and far more important in his opinion than even the electrical business of New Zealand—was this. They had made a contract with the only people that he knew of who had been able hitherto to weld steel and cast iron with success where large castings were concerned, by which contract the Company would have a monopoly of the supply of the machinery, from which they anticipated great benefits to the Company. They had been lighting for the past two years the Spanish and French Exhibitions, and on the previous day he had succeeded in securing the lighting contract for the German Exhibition next year. He concluded by moving the adoption of the report (which appeared in our last issue) and accounts.

Mr. H. GREWING seconded the motion, which, after a short discussion, was carried unanimously.

The retiring Directors, Mr. De Castro and Mr. Hilton were afterwards re-elected on the motion of Mr. HARTON, seconded by Major COTTON, as was also the auditor, Mr. Russell Day, on the motion of Mr. LAMONT, seconded by Mr. OHMAN.

A vote of thanks having been passed to the Chairman and Directors, on the motion of Major COTTON, seconded by Mr. HARTON,

The CHAIRMAN briefly returned thanks, and the proceedings terminated.

## Western Counties and South Wales Telephone Company (Limited).

An extraordinary general meeting of this Company was held on Friday, at the Grand Hotel, Broad-street, Bristol, Mr. Charles Nash presiding.

The following report is from the *Bristol Mercury* :—

The SECRETARY (Mr. Henry F. Lewis) having read the notice convening the meeting,

The CHAIRMAN moved the adoption of the following :—

"*That the Directors be, and they are hereby, authorised by this general meeting to borrow any further sum or sums of money, on such security (but not so as to prejudice existing Debentures) and terms as to interest or otherwise as they may deem fit, and to secure the same by debentures upon the whole or any part of the property, funds, assets, or effects of the Company, and so that any sum not exceeding* £80,000, *including the* £50,000 *previously*

PATENT

SILICIUM BRONZE AND SILICIUM COPPER WIRE.

The best for overhead Telephone and Telegraph Lines,

AND ALL ELECTRICAL PURPOSES.

Hard Drawn High Conductivity Copper Wire.

ROLLED AND DRAWN PHOSPHOR BRONZE.

PHOSPHOR BRONZE — VULCAN — PHOSPHOR — DURO METAL

PHOSPHOR BRONZE BEARINGS, BUSHES, AND OTHER PARTS OF ELECTRICAL MACHINERY.

*SOLE PROPRIETORS of the British, Indian and Colonial Patents,*

THE PHOSPHOR BRONZE COMPANY (Limited),

*87, Sumner Street, Southwark, London, S.E.*

WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

Digitized by Google

*authorised and issued, may be owing at one time, but so that the money to be borrowed under the authority of this resolution or consent shall not bear a higher rate than 6 per cent. per annum, nor, without the consent of the National Telephone Company (Limited), a higher rate than 5 per cent. per annum.*"

He would say a very few words upon the progress of the Company's business during the present year. The number of subscribers to the exchange and to the trunk lines in 1885 was 779 ; in 1887 it had increased to 2,034, and in November, 1890, it had increased to 3,540. As to receipts, after the payment of royalties, they had increased from £8,064 in 1886 to £21,286 in 1889, and, judging from the progress made during the present year, he had no doubt that the amount for 1890 would exceed £26,000. It was also satisfactory to find that the increase was going on at a more rapid ratio than it was last year. In 1889 the increase in the business was at the rate of £325 per month ; during the present year the increase had been at the rate of £411 per month, so that the increase on that of last year had been at the rate of about £1,000 per annum. All that had required capital to be expended, and that was the reason of the proposal now to issue £30,000 on Five per Cent. Debentures. He need not say much about that. They believed the security was an excellent one. The surplus remaining last year, after paying interest on existing debentures, was £6,848. The surplus this year would certainly be very much larger, and the interest upon the debentures now proposed to be issued would be only £1,500, so that it appeared to the Directors that the security offered was a very excellent one.

Mr. READ seconded the motion. He remarked that the progress of the Company's business was satisfactory to the shareholders in every sense.

In reply to a question as to the expiration of certain patent rights at a future period, it was stated that the Company were covering their district so well that there would be little or no room for any competing company.

The motion was unanimously adopted.

## NEW COMPANIES REGISTERED.

**FOREIGN ELECTRIC DATE AND TIME STAMP COMPANY (LIMITED).**—Registered by F. Fearon, 25, Parliament-street, S.W., with a capital of £100,000 in £1 shares. Object: To acquire an invention of an electro-mechanical date and time stamp, for which patents have been obtained under the patent laws of France and Italy, numbered respectively 188,735 and 26,337.

**GLASS AND METAL ENGINEERING COMPANY (LIMITED).**—This Company has been registered in Glasgow, with a capital of £5,000 in £1 shares. Amongst the objects are the use of all kinds of processes in the art and business of electroplaters.

**LONDON METALLURGICAL COMPANY (LIMITED).**—Registered by Payne and Lattey, 24, Cornhill, E.C., with a capital of £15,000, in £10 shares. Objects: To acquire any patents, brevets d'invention, licences, &c., which may seem capable of being profitably dealt with.

**NEW YORK BELTING AND PACKING COMPANY (LIMITED).**—Registered by Parker, Garrett, and Parker, St. Michael's Rectory, Cornhill, E.C., with a capital of £426,000, in 22,500 Preference and 20,000 ordinary shares of £10, and 1,000 Founders' shares of £1 each. Object: to carry into effect, with or without modification, an agreement which has already been prepared, and is expressed to be made between the New York Belting and Packing Company, a Company organised under the laws of the State of Connecticut, United States of America, and this Company, to carry on the business heretofore carried on by the said American Company, and to carry on, as principals or agents, the manufacture and sale of indiarubber and other goods of all descriptions, and such other businesses as may be necessary or expedient to be carried on for the purpose of developing the business to be taken over under the agreement referred to, or any branch thereof, and for such purposes to acquire lands, works, property, and premises wherever convenient, machinery, patent rights, &c. The first subscribers are: Messrs. A. Vaughan-Stevens, J. C. Wylde, P. J. Bordessa, W. Tunstall, E. H. Tuthill, H. B. Bourne, and F. Spooner.

**SHETTLESTON OIL AND CHEMICAL COMPANY (LIMITED).**—Registered in Scotland, this Company has a capital of £5,000, in £10 shares. Objects: to take over, carry on, and develop the coal tar or chemical works, or carbonising works, carried on at Mount Vernon, Lanarkshire, and to carry on the business of chemical manufacturers, miners, smelters, colliery proprietors, engineers, ironmasters, ironfounders, and manufacturers of products of every description from minerals, and dealers in such products and minerals.

**J. TYLOR & SONS (LIMITED).**—Registered by Sydney Morse, 4, Fenchurch-avenue, E.C., with a capital of £100,000 in £10 shares. Object: to carry on business as mechanical and consulting engineers, sanitary engineers and contractors, &c., manufacturers of electrical plant and apparatus.

## CITY NOTES, &c.

**BRAZILIAN SUBMARINE TELEGRAPH COMPANY.**—The receipts of this Company for the week ended December 12th amounted to £5,282.

**CROMPTON AND CO.**—The Directors of this Company have declared an interim dividend on the Preference shares for the half-year ended September 30th last at the rate of 7 per cent. per annum.

**EASTERN TELEGRAPH COMPANY.**—The Directors of this Company announce the payment on January 15th next of interest of 3s. per share, less income-tax, or at the rate of 6 per cent. per annum on the Preference shares of the Company for the quarter ending December 31st, and the usual interim dividend of 2s. 6d. per share on the ordinary shares, free of income-tax, in respect of profits, for the quarter ended September 30th last. The register of transfers will be closed from January 8th to 15th, both days inclusive.

**EASTERN AND SOUTH AFRICAN TELEGRAPH COMPANY.**—This Company notifies that the coupons due on January 1, 1891, on their Five per Cent. Mortgage Debentures will be paid on and after that date at the banking house of Messrs. Barclay, Bevan, and Co., 54, Lombard-street, E.C. Coupons should be left at the bank three clear days for examination.

**EASTERN EXTENSION TELEGRAPH COMPANY.**—The Directors of this Company have declared an interim dividend for the quarter ended September 30th of 2s. 6d. per share, payable on the 15th proximo.

**GREAT NORTHERN TELEGRAPH COMPANY.**—A half-yearly interim dividend at the rate of 5 per cent. per annum is announced by the Board of this Company, payable on the 1st prox.

**GREENWOOD & BATLEY.**—The Directors of Greenwood & Batley have declared an interim dividend at the rate of 7 per cent. per annum on the Preference shares; but have decided to postpone the consideration of a dividend on the ordinary shares until the end of the financial year.

**SIMONDS STEEL AND IRON FORGING COMPANY.**—On Tuesday this Company was, upon the petition of a shareholder, ordered by Mr. Justice Chitty to be wound up.

**UNITED RIVER PLATE TELEPHONE COMPANY.**—This Company notifies that the transfer books of the 5 per cent. debenture stock of the Company will be closed from the 17th to the 31st inst. (both days inclusive), for the purpose of preparing the half-yearly interest warrants.

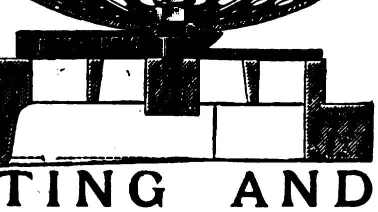
**WEST COAST OF AMERICA TELEGRAPH COMPANY.**—The coupons due December 31st on the Debentures of this Company will be paid by Messrs. Barclay and Co., Lombard-street. Coupons should be left three clear days for examination.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY.**—The traffic receipts of this Company for the week ending December 12, 1890, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £4,154.

**WHITE'S ASBESTOS (LIMITED) v. HOARE.**—This action came before Mr. Justice Day on Tuesday, and was adjourned until Friday. It is to recover £790, being the allotment money and first call of 5s. per share on 1,250 shares, and interest, the defendant bringing forward a counter-claim asking to have the contract to take shares rescinded on the ground that some of the statements in the prospectus were not true.


NEW VALVE

No Rubber, Percha, or Leather.



One-half the price of Rubber or Metal.

FOR CIRCULATING AND AIR PUMPS.

Unaffected by any Lubricating Oils. Does not Expand in diameter. Feed Water may be worked at any temperature Suitable for any shaped guards. Only one quality manufactured.

"12, John-street, Sunderland, 26th Sept. 1885.

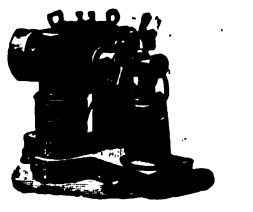
"DEAR SIRS,—In reply to your letter of the 25th inst., the Valves I got from you have done their work well, and ARE AN UNQUALIFIED SUCCESS. I will continue to get them from you as required.—Yours faithfully, JAMES WESTOLL."

For further Testimony and Prices, apply to MOSSES & MITCHELL, 68-71, Chiswell Street, London.


Digitized by Google

# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name. | Previous Week's Price, Dec. 10. | | Price Wednesday, Dec. 17. | | Rate per Cent. Yielded. £ s. d. | Dividend Due. | Business Done During Week Ending Dec. 17. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **TELEGRAPHS.** | | | | | | | | |
| £1,381,380 | Stock | 15/0 | Anglo-American | 48½ | 49½ | 48½ | 49½ | 5 16 2 | Jan., Apr., July, Oct | .. | .. |
| £2,809,310 | Stock | 30/0 | Do. Preferred | 85½ | 86½ | 84½ | 85½ | 6 14 6 | ,, ,, | 86½ | 85½ |
| £2,809,310 | Stock | .. | Do. Deferred | 13¼ | 13¾ | 13¼ | 13¾ | .. | ,, ,, | .. | .. |
| £250,000 | £100 | 4% | African Direct, 4 per Cent. Debentures | 98 | 101 | 98 | 101 | 3 19 3 | January and July .. | .. | .. |
| £130,000 | 10 | 6/0 | Brazilian Submarine | 11¼ | 11¾ | 11¼ | 11¾ | 6 7 8 | Mar., June, Oct., Dec. | 11½ | 11⅜ |
| £84,500 | 100 | 5% | Do. 5 per Cent. Bonds | 101 | 103 | 101 | 103 | 4 17 1 | January and July .. | .. | .. |
| £75,000 | 100 | 5% | Do. 5 per Cent. Bonds (2nd Series, 1906) | 104 | 108 | 104 | 108 | 4 12 7 | June and December | .. | .. |
| $7,216,000 | $100 | $1½ | Commercial Cables | 102 | 104 | 104 | 106 | 5 13 2 | April and October .. | 104¼ | 104¼ |
| £16,000 | £10 | 8/0 | Cuba Submarine | 11½ | 12 | 11½ | 12 | 7 1 8 | February and August | 11¾ | 11⅝ |
| £3,000 | 10 | 10% | Do. Preference 10% | 17 | 18 | 17 | 18 | 5 11 1 | ,, ,, | .. | .. |
| £12,931 | 5 | 2/4½ | Direct Spanish (£4 paid) | 3¾ | 4¼ | 3¾ | 4¼ | 5 12 11 | April and October.. | .. | .. |
| £6,000 | 5 | 10% | Do. Preference 10% | 9 | 10 | 9 | 10 | 5 0 0 | ,, ,, | .. | .. |
| £30,710 | 20 | 3/6 | Direct United States | 10⅛ | 10⅜ | 10⅛ | 10⅜ | 6 15 0 | Jan., Apr., July, Oct | 10⅜ | 10 5/16 |
| £100,000 | 10 | 2/6 | Eastern | 13⅞ | 14⅛ | 13⅞ | 14⅛ | 4 12 0 | ,, ,, | 14 3/16 | 13 15/16 |
| £70,000 | 10 | 6% | Do. 6 per Cent. Preference | 14¾ | 15¼ | 14¾ | 15¼ | 3 18 8 | ,, ,, | 15⅛ | 14¾ |
| £1,200,000 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock | 104 | 107 | 104 | 107 | 3 14 9 | May and November | 105¼ | .. |
| £200,000 | £100 | 5% | Do. 5 per Cent Debentures, 1899 | 106 | 109 | 106 | 109 | 4 11 9 | February & August | .. | .. |
| £250,000 | 10 | 2/6 | Eastern Extension | 13⅞ | 14⅛ | 14 | 14¼ | 4 18 3 | Jan., Apr., July, Oct. | 14 3/16 | 14 |
| £320,000 | 100 | 6% | Do. 6 per Cent. Debentures, 1891 | 101 | 103 | 101 | 103 | 5 16 6 | February & August | .. | .. |
| £91,800 | 100 | 5% | Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900 | 102 | 105 | 102 | 105 | 4 15 3 | January and July .. | .. | .. |
| £145,300 | 100 | 5% | Eastern & S. African 5 per Cent. Mor. Deb., 1900 | 101 | 104 | 102 | 105 | 4 15 3 | ,, ,, | 103¾ | 103½ |
| £180,227 | 10 | 1/9 | Globe Telegraph and Trust | 8¾ | 9 | 8¾ | 9 | 5 8 4 | Jan., Apr., July, Oct. | 9 | 8 13/16 |
| £180,042 | 10 | 6% | Do. 6 per Cent. Preference | 14½ | 14¾ | 14½ | 14¾ | 4 1 4 | ,, ,, | 14⅝ | 14⅝ |
| £150,000 | 10 | 5/0 | Great Northern | 15¾ | 16¼ | 16 | 16½ | 4 10 11 | Jan., April, and July | .. | .. |
| £15,000 | 100 | 5% | Do. 5 per Cent Debentures, 1881 | 101 | 104 | 101 | 104 | 4 16 2 | January and July .. | .. | .. |
| £230,000 | 100 | 5% | Do. 5 per Cent. Debentures, 1883 | 104 | 107 | 104 | 107 | 4 13 6 | March & September | .. | .. |
| £17,000 | 25 | 12/6 | Indo-European | 36 | 37 | 35 | 37 | 6 15 2 | May and November | 36½ | .. |
| £38,348 | 10 | 4/0 | London Platino-Brazilian | 6 | 7 | 6 | 7 | 5 14 4 | ,, ,, | .. | .. |
| £100,000 | 100 | 6% | Do. 6 per Cent. Debentures | 106 | 109 | 106 | 109 | 5 10 1 | March & September | .. | .. |
| £9,000 | 8 | 4/0 | Reuter's | 8½ | 9 | 8½ | 9 | 5 11 1 | April and October.. | .. | .. |
| £3,381 | £100 Cert. | 6% | Submarine Cables Trust | 108 | 112 | 108 | 112 | 5 7 2 | ,, ,, | 109½ | 109 |
| £15,609 | £10 | 6/6 | West African | 8½ | 9½ | 8½ | 9½ | 5 5 3 | January and July .. | .. | .. |
| £290,000 | 100 | 5% | Do. 5 per Cent. Debentures | 98 | 101 | 98 | 101 | 4 19 0 | March & September | 98⅛ | .. |
| £30,000 | 10 | 3/0 | West Coast of America | 2 | 4 | 2 | 4 | .. | January and July .. | 2⅞ | 2¾ |
| £150,000 | 100 | 8% | Do. Debentures 8% | 101 | 106 | 101 | 106 | 7 10 11 | June and December | .. | .. |
| £38,321 | 10 | Nil. | West India and Panama | 2⅞ | 3⅛ | 2⅞ | 3⅛ | .. | .. | 3 | .. |
| £34,563 | 10 | 6/0 | Do. 1st Preference 6% | 11¼ | 11¾ | 11¼ | 11¾ | 5 2 2 | May and November | 11⅝ | .. |
| £4,669 | 10 | £3 | Do. 6 p. c. 2nd Pref. | 11 | 12 | 11 | 12 | 5 0 0 | ,, ,, | .. | .. |
| £34,174 | 15 | 6/0 | Western and Brazilian | 10¾ | 11¼ | 10¾ | 11¼ | 5 6 8 | ,, ,, | 11⅛ | 11 |
| £27,873 | 7½ | 6/0 | Do. 5 per Cent. Cumulative Preferred | 6¼ | 6¾ | 6¼ | 6¾ | .. | — | 6 9/16 | 6½ |
| £27,873 | 7½ | 4/6 | Do. 5 per Cent. Deferred | 4½ | 5 | 4½ | 5 | .. | .. | .. | .. |
| £200,000 | 100 | 6% | Do. 6 per Cent. Debs., Series "A" | 103 | 106 | 103 | 106 | 5 13 2 | February & August | .. | .. |
| £250,000 | 100 | 6% | Do. 6 per Cent. Mort. Debs., Series "B" | 103 | 106 | 103 | 106 | 5 13 2 | ,, ,, | .. | .. |
| $1,336,000 | $1,000 | 7% | Western Union 7 per Cent. 1st Mortgage | 120 | 125 | 120 | 125 | 5 12 0 | May and November | .. | .. |
| £175,100 | £100 | 6% | Do. 6 per Cent. Sterling Bonds | 99 | 103 | 99 | 103 | 5 16 0 | March & September | .. | .. |
| | | | **TELEPHONES.** | | | | | | | | |
| £224,850 | 14/0 | 0/4½ | Consolidated Telephone Const. & Maintenance. | 7/16 | 9/16 | 7/16 | 9/16 | .. | May and November | .. | .. |
| £220,000 | £1 | 3% | Oriental (11s. paid) | ¼ | ⅜ | ¼ | ⅜ | 4 8 3 | Yearly | ¼ | .. |
| £138,984 | 5 | 3/0 | National ...xd | 4⅜ | 4⅝ | 4⅜ | 4⅝ | 5 18 11 | June and December | 4⅝ | 4⅜ |
| £15,000 | 10 | 6/0 | Do. 6 per Cent. Cumulative 1st Pref. ....xd | 12¼ | 12¾ | 12 | 12½ | .. | ,, ,, | 12 | .. |
| £15,000 | 10 | 4/9¾ | Do. 6 per Cent. Cumulative 2nd Pref. ....xd | 9¾ | 10¼ | 9¾ | 10¼ | 5 17 1 | ,, ,, | .. | .. |
| £209,750 | 1 | ½% | South of England, Ordinary | ⅛ | ⅜ | ⅛ | ⅜ | .. | .. | .. | .. |
| £20,000 | 5 | 2/1 | Do. 6 per Cent. Cumulative Pf. (£3 10s. pd) | 2½ | 3 | 2½ | 3 | .. | .. | .. | .. |
| £58,000 | 5 | 1/0 | United River Plate | 3 | 4 | 3 | 4 | .. | January and July .. | .. | .. |
| £146,128 | Stock | 5% | Do. 5 per Cent. Debenture Stock | 90 | 95 | 90 | 95 | 5 5 3 | .. | .. | .. |
| £3,200 | 100 | 7% | Do. 7 per Cent. Debentures | .. | | .. | | .. | .. | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | | | |
| £200,000 | £5 | .. | London Electric Supply | 2 | 2¼ | 1¾ | 2 | .. | .. | .. | .. |
| £13,900 | 10 | .. | Metropolitan Electric Supply (£8 paid) | 7 | 7½ | 7½ | 8 | .. | .. | 7¾ | 7¼ |
| £12,853 | 5 | .. | Westminster Electric Supply (£3 paid) | 2¼ | 2¾ | 2¼ | 2¾ | .. | .. | .. | .. |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | | | |
| £33,416 | 3 | .. | Brush Electrical Engineering | 1¼ | 1¾ | 1¼ | 1¾ | .. | .. | 1 11/16 | 1⅝ |
| £63,416 | 2 | 0/10 | Do. 6 per Cent. Preference | 1½ | 2 | 1½ | 2 | 6 0 0 | June and December | .. | .. |
| £20,000 | 5 | 7% | Crompton and Co., 7 per Cent. Pref. Shares | 5¼ | 5¾ | 5¼ | 5¾ | 6 1 9 | January and July .. | .. | .. |
| £17,130 | 5 | .. | Edison and Swan United | .. | | .. | | .. | .. | .. | .. |
| £45,000 | 10 | 6% | Electric Construction ...xd | 7¾ | 8¼ | 7 | 7½ | 8 0 0 | .. | 8¼ | 7½ |
| £70,000 | 2 | 10/0 | Elmore's Patent Copper Depositing | 3½ | 4 | 3½ | 3¾ | .. | .. | 3½ | 3⅜ |
| £20,000 | 5 | .. | Fowler-Waring Cables (£4 paid) | 2½ | 3½ | 2½ | 3½ | .. | .. | .. | .. |
| £41,600 | 10 | 10/0 | India Rubber, Gutta Percha & Telegraph Works | 18½ | 19½ | 18½ | 19½ | 5 2 7 | February & August | 19 | 18½ |
| £200,000 | 100 | 4½% | Do. 4½ per Cent. Debentures, 1896 | 100 | 102 | 100 | 102 | 4 8 3 | March & September | .. | .. |
| £78,949 | 5 | 10% | Swan United (£3. 10s. paid) ..10% for year | 4½ | 5 | 4½ | 5 | 6 19 10 | May and November | 4⅞ | 4¾ |
| £37,350 | 12 | 12/0 | Telegraph Construction and Maintenance | 43 | 45 | 43 | 45 | 5 6 8 | March and July..... | .. | .. |
| £150,000 | 100 | 5% | Do. 5 per Cent. Bonds, red. 1894 | 100 | 102 | 100 | 102 | 4 18 0 | January and July .. | .. | .. |



BEFORE ORDERING!

ELECTRICAL PLANT & ACCESSORIES

(Statter's) WRITE FOR THE FOLLOWING PAMPHLETS TO THE (United)

ELECTRICAL ENGINEERING CORPORATION, Ld.

PLANT WORKS: WEST DRAYTON, near LONDON.
FITTINGS WORKS: ALBERT WORKS, 36, ALBERT EMBANKMENT, S.E.
LONDON OFFICES: 3, PRINCES MANSIONS, VICTORIA STREET, WESTMINSTER.

"ELECTRICAL DISTRIBUTION."—Commercially considered, with Estimates.

"MACHINE DRIVING BY ELECTRICITY."—The Uses of Electro-Motors for Traction and Stationary Purposes.

"THE TELPHER SYSTEM OF CHEAP TRANSPORT," for Minerals, Goods and Passengers.

"ELECTRICAL SUPPLIES."—Prices and Particulars of the most approved Electrical Appliances.

ELECTRICAL PLANT ON VIEW.

Digitized by Google

# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 658.—Vol. XXVI. FRIDAY, DECEMBER 26, 1890. Price Fourpence.


## NOTES.

If the duties of the committee which has been appointed by the Board of Trade be strictly "to consider whether any, or if so what, steps should be taken for the provision of electrical standards," it may be presumed that the work is of a purely scientific character. If so, the selection is an admirable one, and there are excellent reasons for excluding the commercial element. The legalisation of the ohm is a matter which can well be left to the distinguished representatives of the learned societies. But when the time comes to appoint a committee of reference in connection with the practical work which will soon have to be done, we hope that the representative principle of our national constitution will be observed, and that those for whom legislation is made, should have a hand in the making. We should like to have seen on the list the name of the man who in 1885 was the first to draw attention to "The Necessity for a National Standardising Laboratory for Electrical Instruments," and without whose services the recent movement which was initiated by the Electrical Trades Section of the London Chamber of Commerce would not have been put in so practical a shape.

The dispute between Mr. Chamberlain and the Chelsea Electricity Supply Company, which commenced in the House of Commons, has been continued in the columns of the *Times*, and the recent fogs have introduced a fresh element into the question. On Monday evening we visited the Chelsea station, with a view of ascertaining a few facts which may be of interest to our readers. In the first place, we understand that Mr. Chamberlain's house is near the middle of a block which is fed at each end from the station. The pressure at his terminals may therefore be somewhat lower than at the end of the feeder, but this will not account for any really appreciable fall. We understand that his voltmeter, of which we have heard so much, is of the Davies make, of which we know but little, and therefore can say nothing. There has been no regular and continuous automatic record of the volts at Chelsea, but a recording voltmeter has been used there of late, and very shortly similar instruments will be placed in each sub-station, and if Mr. Chamberlain does not cease from troubling it is probable that one will be fixed as near as possible to his terminals. His statement that his voltmeter has been carefully checked and passed as accurate by the officers of the Supply Company is not altogether exact. In the absence of a legal standard, voltage may be still said to be a matter of opinion; and, in the opinion of some, Mr. Chamberlain's voltmeter reads too low.

Passing now to the defect, which has been exaggerated into a breakdown, comparable almost with that of the London Electric Supply Corporation, the engineer of the Chelsea station has a very good case to make out, and one the facts of which all electrical engineers will be interested to learn. The distribution at Chelsea is effected, as most of our traders are aware, by the charging and discharging of batteries both at Draycott-place and at three sub-stations. From midnight until 4 p.m., when the ordinary load is light, half a battery—that is to say, one-half of the batteries at each sub-station—is being charged, all the sets being in series. The lighting during this period is carried on by means of the several "half-batteries." At about four o'clock in the afternoon, or at any other time occasioned by the demand, both halves are placed in parallel on the distributing circuit. Ever since the station has started this system has worked very well, and continued to do so until the fogs of the past few weeks.

We were prepared to hear that the Chelsea Company had yielded to the demands of consumers to such an extent that its generating and distributing plant had been overloaded in a manner similar to that of the London Electric Supply Corporation, and that a breakdown had ensued. We learn, however, that the sub-stations are not nearly loaded to their full capacity under ordinary circumstances, and in the spring of this year two continuous-current transformers and one additional dynamo had been ordered in view of the approaching winter, and it was the intention of the Company to run these motor transformers during periods of heavy load for the purpose of supplying current to the distributing circuits, and thus to relieve the batteries. But only one of these transformers has been delivered, and is at present under test at Draycott-place.

We have seen the output curve of the station during one of the recent foggy days, and found that at 7 in the morning instead of a fall, after a short early morning load, the output of the station was rising and continued to rise until 8 o'clock, after which there was a flat top until 2, then a sharp peak and a slight fall, after which the ordinary afternoon and evening load rose from 4 with a maximum from about 6:30 to 8 and then dropped into the usual way. The area as judged by eye was distinctly greater than *twice* that of an ordinary load curve so well known to our readers. This excessive output, due entirely to the fog, and not relieved, as had been intended, by the transformers, fell upon the batteries. It is obvious that there was no time during which they could be charged,

Digitized by Google

and hence it has been necessary on several occasions to cut off the consumers' circuits from 3 a.m. until 4 p.m., during which time charging took place.

THE so-called complete breakdown of the Chelsea Company therefore, resolves itself on investigation into a partial failure of supply under circumstances which, as Mr. IRVING COURTNEY states in his letter to *The Times*, puts the resources of even the old-established gas companies to a severe test. The inability, however, of the Chelsea Company to meet the sustained demand for current which results from that by no means uncommon occurrence, a London fog, is a somewhat curious commentary upon the many bold statements as to the great superiority of the "storage" system which were put forth at he time of the company's inception. A system of storage is undoubtedly a great desideratum, but secondary batteries as employed by the Chelsea Company are in reality not used as *storage* batteries, but merely as transformers; and apparently when there is any sudden strain, moving machinery, continuous current transformers, to wit, must as in other systems be relied on.

THE cleverly-written article which we reproduce in another column on the proposed railway under South Kensington will be appreciated more fully now than if it had appeared ten or twelve years. South Kensington science was then under a cloud. There was as much talk about and as poor teaching in science as there is at present in art. But it has lived through its period of sinecures and jobs, and the reputation which it has earned is solely due to the individual merits of such men as RÜCKER, BOYS, UNWIN, and AYRTON. These have completely thrown into the shade the old stock whose names are still to be found in "Whitaker's Almanac." It is probable that the promoters of the South Kensington and Paddington Subway Company overlooked the disaster with which they threatened the laboratories, or it is possible that they fail to appreciate their value. If a subway is to be made from north to south, we could suggest a more easterly route which would place Westminster engineers within reach of the Hampstead district.

IN a note presented recently to the Comptes Rendus Mr. BOULOUCH enters elaborately into the theory of the BUNSEN photometer, and shows that its accuracy depends on the truth of the assumption that the screen diffuses light equally in all directions. This is no doubt the case, not only with this photometer, but with RUMFORD'S; yet any error which may arise in this way must be quite negligible compared with the other errors of observation. If such screens were not equi-diffusive, they would appear to vary in brightness, according to the angle at which they are viewed. No difference of this kind is perceptible to the eye, and it is a needless refinement to consider such matters in detail, when large divergences in measurement are possible among different observers, and when it is not even possible for the same experimenter to reproduce his measurements with precision. It would be far more profitable to experiment with different varieties of BUNSEN screen, with the object of finding the conditions of greatest sensitiveness. The experiments of Mr. BOULOUCH only confirm these remarks, for, after finding how to eliminate any error due to the defective diffusion of the screen, observations are taken at different angles of incidence, and presumably with great care; yet the average error of observation is more than two per cent., and since it is well known that this is the limit of accuracy of a highly experienced observer, the source of error in question might well have been left unnoticed.

IT is well known that a thermo-electric junction forms, in conjunction with a delicate low-resistance galvanometer, an excellent form of thermometer. Its capacity for heat is very small, and it occupies little space. For the measurement of high temperatures it is especially suited, and as a pyrometer it has been advantageously used in many researches. Those fortunate enough to have the *entrée* to the Royal Society *soirée* in May last will remember the beautiful experiment shown by Professor ROBERTS AUSTIN, in which a simple thermo-electric joint was used for exhibiting the recalescence phenomena occurring in cooling iron and steel. One valuable property of such a thermometer is, however, not sufficiently recognised, viz., the great range of sensibilities which may be obtained by altering the resistance of the circuit. It is characteristic of electrical quantities generally, that while their magnitudes may vary between very wide limits, their values can always be determined with great accuracy; thus, with Sir WILLIAM THOMSON'S series of instruments, it is possible to measure with the same degree of precision currents varying enormously in magnitude; and a low resistance strip shunted with a sensitive high resistance galvanometer forms an ammeter whose range can be varied between very wide limits by the insertion of resistance into the shunted circuit. Many of these advantages are possessed by the electric thermometer, and it is only necessary to determine with precision the thermo-electric constants of the metals employed to render the instrument accurate as well as adaptable.

THIS task appears to have been undertaken by Messrs. CHASSAGNY and H. ABRAHAM, who have described their researches in three Papers presented to recent numbers of the *Comptes Rendus*. They have shown that the thermo-electromotive forces generated at temperatures varying between 0 deg. C. and 100 deg. C. can be determined to one ten-thousandth part of their value; and also that a parabolic function of the temparature is not a sufficiently accurate representation of the volts generated by the thermal actions going on in the circuit, since an error exceeding 0·2 per cent. may arise from using such a formula. According to these investigators, the formula which gives, correct to $\frac{1}{50}$th of a degree, the thermo-electric volts generated in an iron copper circuit, when the junctions vary between the temperatures of 0 deg. C. and 100 deg. C., is $V(t + 273) = a\,t + b\,t^2 + c\,t^3$, where V is the number of volts generated, $t$ is the temperature difference of the junctions in degrees Centigrade, $a = 3{\cdot}566 \times 10^{-3}$, $b = 8{\cdot}383 \times 10^{-6}$, and $c = -3{\cdot}265 \times 10^{-8}$.

IT might be imagined that after delivering the course of Cantor Lectures on "Electro-magnets" Prof. S. P. THOMPSON

Digitized by Google

would have exhausted his subject, dealing, as he did, not only with the theory of the subject, and providing a number of very useful working formulæ, but also going most fully into the history of the matter. He has, however, recently delivered a presidential address to the Junior Engineers on "Electro-magnetic Mechanisms," which were briefly touched upon in the concluding Cantor Lecture. The subject is dealt with from an engineering point of view, and deals with the details and construction of a large number of mechanical devices for taking advantage of the pull of electro-magnets for a great variety of purposes. We commence the publication of this address in the present issue.

**Dover.**—In his report to the Town Council, Mr. J. A. Timmis recommends the adoption of the three-wire system and the erection of a 20,000-light plant.

**Scarborough.**—The Scarborough Local Authority have decided to make application for a provisional order and the repeal the Scarborough Electric Lighting Order, 1883.

**The Electrical Census Counter.**—The counting of the population at the taking of the next census in Austria will be effected by means of the electrical counter, as was done in the recent American census.

**Nimes.**—The Compagnie Nationale d'Electricité (Ferranti system) are pushing forward the electric light installation at Nimes, which will probably be ready in four or five months, for the supply of some 2,000 lamps. The capacity of the station will be 5,000 to 6,000 lamps.

**Reduction of Telephone Rentals.**—The South of England Telephone Company has issued notices in towns served by their lines to the effect that they have reduced their tariff to a uniform rate of £8. 8s. per annum, on a yearly agreement, for lines within one mile radius of their exchange.

**The Telephone in Japan.**—A telephone trunk line between Tokio and Yokohama will be opened in January. The line is 18 miles long, and the charge to subscribers will be $40 per annum at the capital, and $35 at Yokohama. Five minutes' conversation between two non-subscribers will cost about 7d.

**A Government Report on Rubber.**—The United States Government has forwarded instructions to its Consuls throughout the world to prepare special reports relative to the India-rubber interest, whether it relates to the commerce in crude rubber or to the manufacture and sale of the finished product.

**The Electrical Transmission of Power.**—We have it on the authority of *l'Eletricité* that a leading French Company proposes to effect the electrical transmission of 10,000 horse-power to a distance of 120 miles at a pressure of 12,500 volts. The sea is being used as a return. The site of this proposed installation is stated to be in Spain.

**Mutual Telephone Company.**—Mr. George J. Somerville, who has been manager of the Aberdeen district of the National Telephone Company during the past six years, has been appointed by the Mutual Telephone Company as their district manager for Lancashire. At Manchester the erection of wires and the fitting up of the Exchange of the Mutual Company will be at once proceeded with.

**National Telephone Company.** — At the ninth annual *conversazione* of the National Telephone Company's staff and *employés*, which was recently held in Glasgow, some interesting statistics were given. It was stated that the average number of conversations carried over the company's wires in what may be called the Glasgow district, had risen during the past year to about 251,000 per week, or 13,052,000 per annum.

**Electric Traction in the United States.**—The 12 leading cities of the United States, from the point of view of electric traction, are Boston, with its 312 electric motor cars; St. Louis, 207; Rochester, 200; Pittsburg, 170; Cleveland, 162; Minneapolis, 110; St. Paul, 88; Cincinnati, 77; Nashville, 61; Davenport, 60; Milwaukee, 55; Richmond, 45. The systems represented are Sprague, Thomson-Houston, Short and Westinghouse. The Thomson-Houston Company has 130 lines, Sprague 108 lines, and Short 10 lines.

**A Long-lived Lamp.**—Mr. J. Lavender, jun., writes us as follows:—"*Re* long-lived lamp mentioned in your correspondence column of August 29th last. This lamp was removed from its holder on Thursday last, having done duty for 11,561¾ hours. The filament is unbroken. As stated in previous letter, it is an Edison-Swan lamp, 100 volt, 16 candle-power type. Total power in watts consumed prior to removal was 16·6. No photometrical measurement was taken. We have another lamp of same type, with record of 11,361 hours to Thursday last."

**Magnet for Blast Furnace Use.**—Messrs. Hughes and Gawthrop, of Pittsburg, employ a large electro-magnet for lifting pig iron from the pig bed in the cast house. It was manufactured by the Thomson-Houston Motor Company, and is capable of lifting a load of 3½ tons. In shape it somewhat resembles a bell with nearly vertical sides, standing about 20in. in height, and measuring about 24in. across the bottom. The magnet, which is attached to a crane, can be raised and lowered, and the load is dropped by simply shutting off the current.

**Croydon.**—The County Council has received from Mr. Preece a detailed report as to the electric lighting requirements of the town, and the probable cost of laying down the necessary mains. He estimates that a total length of 100 miles of mains will be necessary, of which 60 miles can be underground, and 40 miles overhead, the latter being for public lighting only. The underground mains will cost about £700 per mile, the overhead about £230 per mile. Under these circumstances the Corporation have decided, in their application to the Board of Trade, to mention £150,000 as the amount of capital which may be employed.

**Electricity on the Farm.**—M. Comille Gonzy, the proprietor of numerous small farms in the commune of Millas (Western Pyrenees), having an area altogether of nearly 1,500 acres, has, for some time past, been utilising a neighbouring stream for electric lighting purposes. He has now applied electric power to the working of a wine-crushing plant. Besides providing the power for lifting and driving purposes, electricity is made to work the pumps for irrigating the vines. The 180 16 candle-power lamps employed are distributed over all the farms, and the area which they cover may be judged from the fact that the length of telephone wire connecting the buildings is 62 miles.

**Guttapercha.**—The supply of guttapercha shows ominous signs of diminution, and the price has risen considerably. We give below the quantity imported and its value during the last four years:—

| Year. | Cwt. | £ | Per cwt. |
|---|---|---|---|
| 1887 ................ | 24,145 | 156,563 | £6·5 |
| 1888 ................ | 22,483 | 181,660 | 8 |
| 1889 ................ | 48,042 | 576,896 | 12 |
| 1890 (10 months)... | 60,494 | 686,013 | 11·3 |

**The Electrical Treatment of Wine.**—For the past twelve months a small 8 horse-power experimental plant, due to M. de Meritens, has been in operation at the Bercy works of MM. Pollet, where M. de Meriten's method of treating wine by electricity has been exhaustively tested and pronounced satisfactory by competent authorities. The dynamo employed is a 25 volt alternator, having a frequency of 116. The wine to be treated by electricity with a view of increasing its "keeping" qualities is passed through a small tube containing a series of silver discs connected to the poles of the alternator. The wine as it flows through the tube is thus traversed by a rapidly alternating current, which it is supposed destroys the ferments. The experimental plant is capable of treating 22 gallons of wine per hour. The process has been tried on wines of all kinds, and the results have been most marked with the light Algerian wines, whose bad "keeping" qualities have hitherto prevented their exportation.

**Spliced Carbons.**—According to *Modern Light and Heat* the Concord (N.H.) Gas and Electric Light Company is making

Digitized by Google

use of an ingenious appliance by which they use up all the short pieces of arc lamp carbons. When the trimmers bring in the pieces of carbon from the lamps they are assorted and laid end to end, to make about 8in. in length. They are then placed in a machine which makes a dowel on one piece and a socket in the other, after which they are joined together with a conducting, heat-proof cement of low resistance. This company has been using these spliced carbons as negatives for a year and more, and have fully proved their success. The saving in carbons is said to exceed 30 per cent.

**Proposed Electric Railway between Vienna and Budapest.**—It is announced, says the Vienna correspondent of *The Times*, that a company is about to be started, with a capital of 38,000,000fl. (£3,800,000), for constructing an electrical railway between Vienna and Budapest. The distance of 250 kilometres (156 miles) is to be accomplished in two hours and a-half by trains comprising only first-class carriages. The price of the return ticket is to be 9fl. 80kr., about 18s. As it now takes four hours and a-half to travel between the Austrian and the Hungarian capitals in an express train, the saving of time promised by the new company is a boon that will seem to many more tantalising than attainable.

**The Metropolitan Electric Supply Company and the Fogs.**—On making inquiries from the Metropolitan Electric Supply Company, we learn that as the fogs have not come upon them suddenly, the demand has been fairly easy to meet, though, of course, it has entailed considerable extra care on the part of the staff. The load from all the stations has been remarkably uniform, from 9 a.m. to 4 p.m. the average increase being about 15 per cent. more than the normal load. Of course, after 4 p.m. the ratio between the lamp supply and lamp connection has remained the same, being much about the same figures as were given at the Society of Arts, with the exception of Rathbone-place station, which is now assisting the London Company by lighting the Lyric Club, Prince of Wales Theatre, &c.

**Meserole Dry Battery.**—The mixture for filling dry cells prepared by Mr. A. V. Meserole consists of the following solid ingredients in the form of powder: Charcoal, 3 parts; mineral carbon or graphite, 1 part; peroxide of manganese, 3 parts; lime hydrate, 1 part; white arsenic (oxide), 1 part; and a mixture of glucose and dextrine or starch, 1 part; all by weight. These are intimately mixed dry and then worked into a paste of proper consistency with a fluid solution composed of equal parts of a saturated solution of chloride of ammonium and chloride of sodium in water, to which is added one-tenth volume of a solution of bichloride mercury and an equal volume of hydrochloric acid. The fluid is added gradually and the mass well worked up.

**Telegraphic Statistics.**—The following comparative figures may be of interest:—

| Country. | Miles of Telegraph Wire. | Messages per Annum. | Messages per Annum per Mile of Wire erected. |
|---|---|---|---|
| United States | 776,500 | 56,000,000 | 72 |
| France | 220,890 | 30,050,000 | 136 |
| England | 180,000 | 50,000,000 | 277 |
| Russia | 170,500 | 10,280,780 | 60 |
| Australia | 105,300 | 12,000,000 | 114 |
| Canada | 58,500 | 4,027,581 | 69 |
| Italy | 19,500 | 7,000,000 | 360 |
| Japan | 16,500 | 5,000,000 | 303 |
| New Zealand | 11,375 | 1,835,394 | 161 |

**A Proposed Electric Tramcar Gearing.**—According to the *Electrical Engineer* of New York, Mr. E. S. Pillsbury proposes to overcome the difficulties connected with tramcar starting by using a turbine as an intermediate gearing, or rather a combination of pump and turbine, constituting a liquid gearing. In effect the armature is coupled to a rotary pump, and the car wheel axle to a turbine; these two are enclosed together in a small iron vessel with water. The armature starts at full speed driving the pump, and the turbine takes up the speed evenly and gradually, the two being locked when the speed becomes equal. As, for high-speed turbines, a 15in. wheel of modern build will give 350 horse-power at 600 revolutions, it is easy to see that the size of the arrangement need not be great. The idea is very similar to the one which we suggested in an editorial note on the first page of the present volume, and if it were further improved by making the delivery of the pump it variable, would be identical.

**Electric Installation at Partenkirchen and Garmisch.**—According to the *Loisach Messenger*, May 1, 1891, has been fixed as the date for starting this installation. The plant will be supplied by the Esslingen Maschinenfabrik. Power is to be derived from the Loisach Falls, where generally there are at least 10 cubic metres of water per second available. Steam engines will, however, be put down as a reserve. The electrical plant will consist of two 60 horse-power dynamos coupled in parallel, and separately excited by two small machines. The current will be supplied at 1,500 volts pressure, and will, at the distributing stations in the two towns, drive motors, which will in turn drive 120 volt dynamos. The latter will supply the lights through a network of mains on the 3-wire system.

**Royal Naval Exhibition.**—The Electric Lighting Committee, the members of which are Sir William Thomson, Captain Eardley Wilmot, R.N., Mr. E. H. Carbutt, Mr. W. H. Preece, and Mr. J. I. Thorneycroft, have decided to entrust the lighting of the entire Exhibition to Messrs. Siemens Bros. and Co. The engines will be supplied by Messrs. Willans and Robinson; and the boilers for the electric light, as well as for the machinery in motion, will be from the well-known works of Messrs. Davey, Paxman, and Co. Some 200 arc lamps and 2,000 glow lamps will probably be required to illuminate the buildings and grounds, and the dynamos will also have to supply current for several interesting applications of the transmission of power and for the lighthouse of Messrs. Chance Bros., which will form one of the features of the Exhibition.

**Electrical Standards and the Board of Trade.**—The President of the Board of Trade has appointed a committee, consisting of the following gentlemen, to consider whether any, and if so, what steps should be taken for the provision of electrical standards:—Lord Rayleigh, F.R.S., Sir William Thomson, F.R.S., representing the Royal Society; Prof. G. Carey-Foster, F.R.S., R. T. Glazebrook, Esq., F.R.S., representing the British Association for the advancement of science; Dr. John Hopkinson, F.R.S., Prof. W. E. Ayrton, F.R.S., representing the Institution of Electrical Engineers; E. Graves, Esq., W. H. Preece, Esq., F.R.S., representing the General Post-Office; Courtenay Boyle, Esq., C.B., Major P. Cardew, R.E., representing the Board of Trade. The first meeting of the committee will be held at the Board of Trade on Thursday, January 15th. Sir Thomas Blomefield, of the Board of Trade, will act as secretary to the committee.

**The Carpenter-Nevens Electric Car Heater.**—This form of electric heater, which is being introduced in the United States, consists of three crimped wires of high resistance attached to a backing of asbestos. The asbestos is enclosed in sheet-iron strips about 3 inches in width and about ¼ inch in thickness. The heating apparatus extends from one end of the car to the other under the seats. It is enclosed on all sides except the face in a copper reflector, in order that the heat may be radiated in the proper direction. The circuits are arranged so that one, two, or three of the wires can be switched on in accordance with the demand for heat. The switches are located on the platform, and are in charge of the motor man. When current is turned into the cold resistances they will take at first 8½ or 9 amperes at 500 volts pressure (6 H.P.), but for a few minutes only. As the wires begin to heat the current decreases until it reaches about 1½ amperes (I.H.P.) The consumption of current will then remain constant at this point.

**The Chelsea Electricity Supply Company.**—At the meeting of the Chelsea Vestry on Tuesday last week a letter was read from the Chelsea Electricity Supply Company giving notice of their intention to discontinue the supply of electricity between the hours of midnight and four o'clock in the afternoon, and stating that this was only a temporary measure made necessary by the continuance for several days of heavy fogs.

Digitized by Google

Mr. H. J. Wright complained, as a consumer, of this proposal. He stated that the Company had already cut off the supply, and on Saturday morning he was without any light at all. He moved, "That as the Company are applying for a further extension of their area of supply, the Board of Trade should be asked to refuse their consent to such application, unless they can compel the Company to give a continuous supply night and day even during the foggy weather." Mr. Wall, in supporting the motion, said the Vestry should have kept the electric lighting of the parish in its own hand, and never allowed it to be taken up by such small companies. The motion was carried.

**Electricity in the U.S. Navy.**—Commodore G. Dewey, Chief of the Bureau of Equipment, in his annual report to the Secretary of the U.S. Navy, says:—"The lighting of ships of war by electricity, which was inaugurated by this Government, has now become so essential that no war ship is considered complete which is not so lighted. During the year substantial progress has been made in the development and advancement of the system, which is being employed in the new ships, and progress abroad has been critically noted. Electric lighting plants have been installed on board seven vessels, and the work of installation is actively progressing upon four others. Special attention has been given during the year to the subject of means of interior communication on shipboard, and a telephone system is soon to be added experimentally to other devices in use on board one of the new cruisers. Night signalling by electricity has also been, and is still, actively under consideration, and it is believed that a system will have been devised in the near future which will meet the increasing necessity of the service in this respect. The great importance of an adequate method of communication at night between ships of a squadron or fleet makes necessary the utmost care in the consideration of the subject."

**Sir William Thomson.**—A private meeting, convened by the Lord Provost, Principal Caird, Sheriff Berry, Sir James King, Bart., Sir John Neilson Cuthbertson, the Lord Dean of Guild, and Mr. William M'Ewen, was held in the Glasgow Municipal Buildings last week. It was unanimously resolved that Sir William Thomson should be asked to sit to some eminent artist for a portrait, to be placed in the University.—At the ordinary meeting of the Philosophical Society of Glasgow last week the following resolution was put from the chair and unanimously agreed to:—"That the Philosophical Society of Glasgow desires to convey to Sir William Thomson its congratulations on his election to the presidentship of the Royal Society. The members of the Society cannot forget the warm interest that Sir William has always shown in the Philosophical Society, and they feel proud that one who has been a member since 1846, and who has been twice its president, has been called upon to occupy the chair of the leading scientific society in the world. They feel sure that the accession to this office by Sir William Thomson will be hailed with acclamation by all scientific men as a just tribute, not only to his eminence as a mathematician, physicist, and electrician, but also to his many estimable qualities as a man."

**Swansea.**—At a meeting of the Electric Lighting Committee of the Swansea Corporation, which consists of the whole of the corporation, held on Tuesday last week, it was decided to accept the tender of Messrs. Crompton to erect 23 arc lights of 2,000 candle-power at a cost of £25 each per annum. Several reports on the subject of electric lighting were read, and, amongst others, one from Mr. W. H. Preece, who stated that the amount of popular support which the corporation would secure for their action in introducing the electric light into the borough depended entirely upon the success with which the principal streets were illuminated. The public, he said, expected a blaze of light, and they were invariably disappointed when the street illumination was not materially improved. Arc lamps, when placed not too far apart, and when they burnt with steadiness, invariably secured approbation. Glow lamps, unless of considerable power, rarely did so. The mere substitution of an incandescent fibre for a gas flame of similar light-giving power was generally a great disappointment. The success of the light either by arc or by glow lamps depended essentially on the way in which the light was distributed. After very careful consideration 120 feet had been taken as the standard distance at which 500 watt arc lamps should be placed apart in the main thoroughfares of the City of London. In Swansea they should not be further apart than 200ft. in the principal streets. The corporation must expect to pay more for the electric light than they had hitherto paid for gas, but they also must expect a very much better light.

**Complimentary Dinner to Prof. Ewing.**—On Saturday evening last Prof. Ewing, who has filled the chair of Engineering and Drawing in University College since its opening seven years ago, was entertained to dinner in the Queen's Hotel previous to his departure to occupy the chair of Mechanism and Applied Mechanics in Cambridge University. Lord Provost Mathewson presided, and there was an attendance of between 60 and 70 gentlemen. Mr. G. W. Baxter proposed the toast of the evening, and in doing so gave a brief sketch of the life of Prof. Ewing, stating that he had a most distinguished career as a student at the University of Edinburgh, and that the Japanese Government unsolicited extended the term of his tenure of office of the chair of Mechanical Engineering in the University of Tokio from three to five years. During the seven years that Prof. Ewing had been in University College he had done much excellent work both in civil and mechanical engineering, and as an electrical engineer he had made himself a name which would not easily be forgotten. Prof. Ewing, in reply, said he ventured to claim on behalf of his colleagues as well as of himself that they had endeavoured to aim high in University College, and if they had not succeeded in getting crowded benches they had at least succeeded in this, that the work which had proceeded from many of the laboratories had received the warmest possible welcome in the highest places, and that their little College, after only six years of existence, had had the official stamp placed upon it, which admitted it to the membership of the family of the Uuniversities of the country.

**Tariff Changes Made by the McKinley Bill.**—The changes in the tariff made by the McKinley Bill will affect material used in electrical interests as follows, says the *Electrical Engineer* of New York:—Aluminium, formerly free, increased to 15 per cent. *ad valorem.* Copper ores, reduced from 2½ cents to 1½ cents. Old copper for re-manufacture, reduced from 3 cents to 1 cent. a pound. Copper in plates, bars, or ingots not manufactured, reduced from 4 cents to 1¼ cents. Copper in rolled plates, rods, pipes, sheathing, remains at 35 per cent. *ad valorem.* Tin remains at 4 cents a pound. Zinc in blocks or pigs is increased from 1½ cents to 1¾ cents a pound. Old zinc, for re-manufacture, increased from 1¼ to 1¾. Chromic acid, 6 cents per pound instead of 15 per cent. *ad valorem.* Bichromate of potash remains the same at 3 cents per pound. Nickel, &c., per pound, 10 cents, reduced from 15 cents. Electrotype plates remain at 25 per cent. *ad valorem.* Thin blown glass is increased to 60 per cent. *ad valorem* from 45 per cent. Mica is raised from the free list to 35 per cent. *ad valorem.* Blue vitriol, or sulphate of copper, reduced from 3 cents to 2 cents. Sal-ammoniac changed from 10 per cent. *ad valorem* to ¾ cents specific. Sal-soda and soda ash remain at ¼ cent. Caustic soda has been reduced from 1½ cents to 1 cent. Sulphuric acid is increased from free to ¼ cent a pound. Wire and wire rods are reduced ¼ cent a pound where they are not covered. Where they are covered with cotton, silk, or the like, they are increased 1 cent a pound. Flat steel wire is increased from 45 to 50 per cent. *ad valorem.* The schedule shows that of the articles mentioned the tariff on 44 per cent. has been reduced materially, while it has been increased on 28 per cent., and unchanged on 28 per cent. Parts made of porcelain, such as switch bases, socket details, &c., promise to be dearer, and the manufacturers in this country are likely to have a large amount of business thrown into their hands. It is claimed that the German article will practically be excluded from the market. It is also claimed that a stimulus will be given by the tariff to the manufacture of fine instruments. The general belief, even among the many opposed to a higher tariff, is that the springing up of many new factories and shops requiring electric light and power will have a good effect on electrical industries.

Digitized by Google

## MAGNETISM IN IRON AND OTHER METALS.*

### XXXVIII.

BY PROF. J. A. EWING, F.R.S.

(*Continued from page 165.*)

§ 136. **Effects of Torsion on Magnetic Quality.**—The influences of twisting strain on the magnetic quality of metals has engaged the attention of many experimentalists, beginning with Matteucci,† who, in 1847, examined ballistically the change of magnetism undergone by an iron rod when it was twisted back and forth, while a magnetising current was kept up in a surrounding solenoid. Wertheim, E. Becquerel, and Wiedemann followed on the same lines,‡ and the subject was taken up by Sir William Thomson in one of the sections of his investigations of the electro-dynamic qualities of metals‖. More recently a number of other workers have pursued the matter in great detail. The results of their investigations are much too complicated to admit of anything like full statement here; we must be content with an account of some of the more conspicuous facts.

The general result of early experiments was to show that when a rod of soft iron, exposed to longitudinal magnetising force, was twisted, its magnetism was reduced, by torsion, in either direction. In this effect, as in all effects of stress, we have to distinguish between the irreversible initial effect of the first application (due to molecular instability) and the effect which becomes manifest when a cycle of strain is repeated. The initial effect of torsion will depend on the past history of the piece, but the cyclic effect is, in soft iron, of this character, that twisting, to either side, reduces the induced magnetism, and untwisting increases it. But this effect is very small for small angles of twist. Moreover, as with other effects of stress, the changes of magnetism exhibit hysteresis. This was pointed out by Sir William Thomson, who has given curves showing the manner in which the magnetism induced in an iron wire by a constant magnetic field changes as one end of the iron wire is twisted to and fro while the other end is held fixed. The typical form into which the curves settle after repeated twistings is shown in Fig 114, which is copied from his Paper. From the form of these curves it is clear that if the effects of hysteresis were eliminated—as they no doubt might be, at least in part, by vibrating the wire—we should have a single curve resembling a parabola with its vertex at the top of the diagram. Thus in the absence of hysteresis we should find the influence of torsion in reducing the induced magnetism to be indefinitely small for small angles of twist, and to increase initially in proportion to the square of the twist.

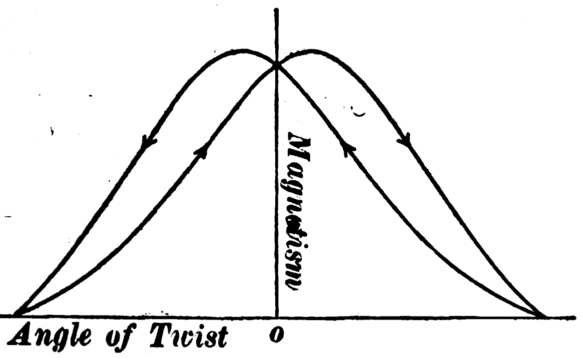



Fig. 114.—Effect of Twist on the Magnetism of Iron.

§ 137. **Effects of Torsion Due to Magnetic Aeolotropy.**—Sir William Thomson has, in fact, pointed out that these results are to be anticipated from what is known regarding the effects of simple torsion and simple compression on the magnetic susceptibility of iron.* Experiments in which the metal is subjected to longitudinal pull or push and to transverse pull, have shown that a simple pulling stress or a simple pushing stress develops an æolotropic quality in respect of magnetic susceptibility, producing (in iron) greater susceptibility along than across the lines of pull, or less susceptibility along than across the lines of push, provided the magnetisation is not so strong as to pass the Villari critical value. Now in torsional strain, each portion of the twisted rod experiences a simple shearing stress, which may be regarded as made up of a pulling stress in a direction inclined at 45deg. to the direction of the length, and an equal pushing stress also inclined at 45deg. and at right angles to the pulling stress. Thus, if *a b c d* (Fig. 115) is a particle anywhere in the front half of the rod, which is twisted in the manner shown by the arrows, the twisting produces a shearing stress in *a b c d* that is equivalent to a pull on the faces *a b* and *c d*, combined with an equal push on the faces *d a* and *b c*. The effect is to increase the magnetic susceptibility along the direction *p p* and to reduce it along *p′ p′*. For small stresses these effects are no doubt equal. Hence in the direction of the length of the rod, which is equally inclined to *p p* and *p p′*, there is, virtually, no change of susceptibility.

The effect of torsion is to give a helical quality to the magnetisation, producing a circular component which is superposed upon the original longitudinal magnetisation. The lines of magnetisation are no longer coincident in direction with the lines of magnetic force; they become in the case considered above right-handed screws. The effect of this on the magnitude of the longitudinal component is at first indefinitely small, but as the angle of torsion increases the growth of the circular component begins to detract from the longitudinal magnetism, for magnetisation in one direction is prejudicial to magnetisation in other directions, as the molecular theory and the phenomenon of saturation suggest.

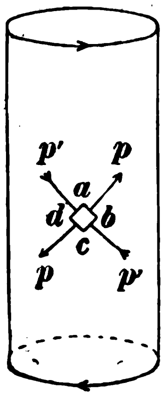



Fig. 115

This consideration of the magnetic æolotropy produced by the pull and push into which torsional stress may be resolved supplies a key to many of the observed facts about magnetism and torsion. At the same time it fails to explain many of the facts. The influence of æolotropy is, no doubt, always present in the phenomena of torsion, but other considerations of a less obvious kind also enter, and these become in some instances so influential that the effects of æolotropy are entirely masked. This is notably the case with nickel. With soft iron, on the other hand, most of the observed effects of torsion admit of fairly complete explanation in the lines suggested by Sir William Thomson, especially when allowance is made for the complications to be anticipated from hysteresis.

§ 138. **Production of Longitudinal Magnetism by Twisting a Circularly Magnetised Wire.**—From the foregoing account of how a circular component of magnetisation is developed by torsion in a longitudinally magnetised wire or rod, it will be evident that the converse action should occur, namely, that twisting a circularly magnetised rod should make it develop

* All rights are reserved.
† *Comptes Rendus*, Vol. XXIV., p. 301.
‡ For an abstract of these researches, *see* Wiedemann's *Elektricität*, Vol. III., p. 671, *et seq.*; *see* also Wiedemann, *Phil. Mag.*, 1886.
‖ *Phil. Trans.*, 1878, reprint of Papers, Vol. II., p. 374.

* Reprint of Paper, Vol. II., p. 374.

Digitized by Google

longitudinal magnetism. This fact was observed in 1858 by Wiedemann, who found that an iron wire conducting an electric current, and therefore circularly magnetised, becomes a magnet when twisted.* Following Thomson, we may explain this observation as a consequence of æolotropy by resolving the magnetising force, whose direction is O A (Fig. 116), into components along the lines of pull, O $p$, and push, O $p'$. Taking the case of iron, below the Villari critical point, and twisted in the manner shown in the diagram, the susceptibility is greater along the lines of pull, O $p$, than along the lines of push, O $p'$. Hence the resultant magnetisation will be less inclined to O $p$ than to O $p'$; in other words, it will take some direction, O R, which gives a longitudinal component of magnetisation directed towards the bottom of the rod. This is, in fact, the kind of longitudinal magnetism which is found.

It might, however, be supposed, in view of the Villari reversal, that under sufficiently strong circular magnetisation the longitudinal component developed by twisting would become reversed. Experiment shows that this does not happen even when a very strong current traverses the wire. The explanation appears to lie in the fact that the stresses of pull or push due to torsion act not on the whole intensity of circular magnetisation but on components inclined at 45deg. Hence, though the circular magnetising force be strong enough to bring about saturation, the components of magnetisation on which the pull and push act remain below the Villari critical value, so that the effect of pull is still to augment and of push to diminish the components on which the pull and push act.†

These effects of torsion are found in dealing with residual magnetism as well as with induced. In Wiedemann's experi-

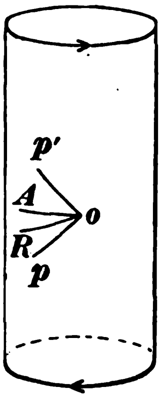



FIG. 116.

ment the same result (namely, the production of longitudinal magnetism by torsion) is noticed though the wire be not twisted until the current has ceased to pass. There is then a strong residual circular magnetism which is affected by torsion, just as might be anticipated from the fact that the residual magnetism of a bar magnetised in the usual way is affected like the induced magnetism by pull and push.

§ 139. **Torsional Strain Produced by Combining Circular with Longitudinal Magnetisation.**—A similar explanation applies to another discovery of Wiedemann's, namely, that if an iron wire or rod be both circularly and longitudinally magnetised, it becomes twisted, though no external mechanical force be used. The superposition of the two magnetisms turns the lines of magnetisation into screws, and the consequent expansion along the lines of the screws and contraction across these lines causes the rod to twist. In iron the effect of magnetising (unless the magnetising force be very strong) is to lengthen the metal in the direction of magnetisation. The direction which the twist is observed to take agrees with this.

In nickel, on the other hand, the effect of magnetising is to shorten the metal in the direction of the line of force. The twist taken by a nickel wire, subjected to superposed longitudinal and circular magnetising forces, is accordingly opposite to that of iron, as Prof. Knott has shown* by making a current traverse a nickel wire, which was at the same time exposed to the action of a magnetising solenoid.

(*To be continued.*)

* *Elektricität*, Vol. III., p. 680.

† This absence of reversal is referred to by Sir William Thomson as a difficulty; but the difficulty disappears when it is recognised that the Villari reversal depends rather on the value I in the direction of pull and push than on the value of H. Though the components of H along directions inclined at 45deg. to the axis may be indefinitely increased, the components of I along these lines remain too small to allow pull to produce reduction of magnetism.

## CAPACITY AND SELF-INDUCTION IN ALTERNATE CURRENT WORKING.—II.

BY GISBERT KAPP.

(*Concluded from page 199.*)

The analytical treatment of the various problems involved is rather complicated, and has the further disadvantage that the solution is generally obtained in the form of a more or less complex equation which does not directly appeal to our senses, but requires first some sort of translation from the mathematical into the common sense or practical form before we can make use of it. In this respect and also on account of its greater simplicity throughout, the graphic method of investigation is far preferable, and will in this article be exclusively employed. The general principle on which this method is based is so well known that only a few words of explanation are necessary. Imagine yourself looking at the crank of an engine, the line of vision being at right angles to the engine shaft. The crank pin will then appear to oscillate to both sides of the centre, and the distance at which you see the pin from the centre at any time will be a sine function of the time. Now substitute for the crank a line the length of which shall represent the maximum current, and let it revolve round one of its extremities with a speed corresponding to the frequency —for a frequency of 80 the line would have to make 80 revolutions per seconds—then the projection of this line on a vertical line would give the current flowing at any instant. Electromotive forces can also be represented in the same manner, but some care is required to plot the lines in the right direction so as to represent correctly not only the magnitude but also the sign of the quantities. We shall assume in all cases that the movement is clockwise. The top half of the diagram shall be positive and the bottom half negative. Now let us consider the current in a coil having self-induction at the moment when this current is a maximum—that is to say, when the line representing it is vertical. As soon as the current begins to diminish, that is as soon as the current line goes to the right of the vertical, the self-induction of the coil comes into play, tending to maintain the current at its maximum value. The E.M.F. of self-induction is, therefore, at this moment positive; that is to say, the projection of the line representing the maximum E.M.F. of self-induction in the coil must be in the upper or positive half of the diagram. This means that the E.M.F. of self-induction must be represented by a line at right angles to the current and to the left of it. Since this E.M.F. must be overcome by the E.M.F. of the machine, it follows that the latter (or at least that component of it which is necessary to counteract self-induction) must be at right angles to the current and to the right of it; or, as we may also express it, the E.M.F. must be in advance over the current by 90deg. That component of the E.M.F. of the machine necessary to overcome resistance must, of course, coincide with the current.

Now take the case of a condenser. When the E.M.F. between its plates has reached its maximum positive value the current is zero, and a moment after the condenser begins to discharge producing a positive current. If we represent the E.M.F. of the condenser by a vertical line in the top half of the diagram, we must therefore represent the current by a horizontal line to the left of the centre. The E.M.F. of the machine (or at least that component of it corresponding to the condenser) must of course be equal and opposite to the condenser E.M.F., and thus

* *Trans.* Roy. Soc. Edin., Vol. XXXII. (1883), p. 193.

Digitized by Google

we find that when a condenser is in circuit the machine E.M.F. lags a quarter period behind the current. We have, therefore, the following simple rules for determining the direction in which we must plot current and machine E.M.F.

I.—*Starting from the Current.*

(*a*). The E.M.F. required to overcome resistance coincides with the current.

(*b*). The E.M.F. necessary to overcome self-induction is a quarter period in advance of the current.

(*c*). The E.M.F. necessary to oppose the condenser E.M.F. lags by a quarter period behind the current.

II.—*Starting from the E.M.F.*

(*a*). Resistance-current coincides with E.M.F.

(*b*). Self-induction current lags by a quarter period behind E.M.F.

(*c*). Condenser-current is a quarter period in advance of E.M.F.

Bearing in mind these rules, it is always easy to build up the diagrams representing E.M.F. and current for any combination of resistance, self-induction, and capacity. Figs. 1 to 12 show how this is done for a few simple combinations. All the diagrams are drawn to scale, and the corresponding quantities are given in each case. In selecting these quantities the object was not so much to represent cases actually occurring in practice, but rather to make that selection which will render the diagram most instructive. In all cases the frequency has been assumed at 80 cycles per second, or $\omega = 500$.

I.—*Resistance and Self-Induction.*

Two cases are represented—the one with the self-induction coil L, in series with the resistance R (Fig. 1), and the other where the coil L forms a shunt to the mains leading from the alternator A to the resistance R (Fig. 3). In the latter case a resistance is assumed to be in series with the coil or forming part of it. The resistance R may be a useful resistance, such as a bank of glow lamps, but in it must, of course, be included the resistance of the mains. Fig. 2 is the diagram belonging to the series, and Fig. 4 that belonging to the parallel arrangement. In Fig. 4 $r$ is assumed to be zero, whilst in Fig. 4A it is assumed to represent a resistance of 33·4 ohms. In all diagrams the currents and electromotive forces are distinguished by indices referring to the corresponding part of the circuit. Thus, $I_R$ and $E_R$ denote current and E.M.F. in the resistance R, so that $I_R \times E_R$ represents the work done in the resistance. $I_A$, $I_C$, and $I_s$ denote respectively current through machine (alternator) into and out of a condenser and through the coil having self-induction. In the same way $E_A$, $E_C$, and $E_s$ represent respectively the E.M.F. generated in the armature of the alternator, the E.M.F. between the plates of a condenser, and the E.M.F. of self-induction. The indices are omitted where quantities coincide. For instance in Fig. 1, the current can only have one value, $I = I_A = I_s = I_R$, and hence the index is omitted in Fig. 2. Similarly the E.M.F. in the arrangement Fig. 3 can have only one value and the index of E is omitted in Fig. 4. The case represented in Fig. 1 is so simple as to require hardly any explanation. The E.M.F. of self-induction is $E_s = 5{,}000$ volts and necessitates the raising of the E.M.F. induced in the machine from 10,000 to 11,200 volts. In the case represented in Fig. 3 the machine E.M.F. need, of course, not be raised, but more current will flow through the armature. A self-induction coil of ·166 quadrants and no resistance will, under an E.M.F. of 10,000 volts allow 120 amperes to pass. This, combined with the 100 amperes flowing through R gives an armature current of 156 amperes. It is interesting to note how this result is affected by putting a resistance $r$ in series with the coil L. At first sight it might appear that now there should be less current passing through the machine. This is, however, not the case, as may be seen on inspection of Fig. $4_A$. Let $r = 33·4$, and assume for the moment that the current passing through the induction coil has remained unaltered. This gives us the point $I_s^1 = 120$ and $E_r^1 = 4{,}000$, being the product of $120 \times 33·4$, or the E.M.F. lost in the resistance $r$. To maintain this condition of things, the machine E.M.F. would have to be $E_A^1$, that is greater than 10,000 volts. The lamp current would be $I_R^1 > 100$, and the armature current would be $I_A^1$. Since, however, the machine E.M.F. is to be 10,000 volts, and not more, we must reduce the size of the whole diagram in the ratio of the lengths $0E_A^1 : 0E$. At the same time it will be convenient to rotate all the lines through an angle equal to that enclosed between these two lines in order to bring the lamp current back into the vertical position. This is a very simple geometrical operation, which need not be described at length, though it is shown in the diagram. The result is $I_r = 174$ amperes, $I_s = 110$ amperes, and $E_r = 3{,}700$ volts. Comparing these figures with those obtained from diagram Fig. 4, where $r = 0$, we find that although the addition of a resistance to the coil L (briefly called a choking coil) diminishes the current flowing through this coil, it has the opposite effect upon the total armature current. At the same time the lag is diminished, and consequently the load on the machine is increased. This is but natural, since the energy wasted in the resistance $r$ must be supplied by the machine.

II.—*Resistance and Capacity.*

Figs. 5 and 6 refer to the series, and Figs. 7, 8, and 8A to the parallel arrangement. In Fig. 6 we start with the assumption that the condenser E.M.F. shall be 10,000 volts. This gives the current $I = \frac{500 \cdot 5 \cdot 10{,}000}{10^6} = 25$ amperes, and $E_R = 25 \times 100 = 2{,}500$ volts. Combining the two voltages, we obtain the E.M.F. of the machine, $E_A = 10{,}300$ volts. If the lamp-voltage were prescribed instead of the condenser voltage, we would proceed as here shown, and then expand or contract the diagram to bring the lamp-voltage to the required figure. It is interesting to note what influence a change in capacity has. The smaller the capacity the greater does the discrepancy become between machine E.M.F. and lamp E.M.F. The larger the capacity the smaller is this discrepancy, until with a condenser of infinite capacity (that is, the condenser replaced by a short, stout conductor), the machine E.M.F. and the lamp E.M.F. become equal.

Fig. 7 shows a condenser placed as a shunt across the mains. Assuming $E = 10{,}000$ volts, and $R = 100$ ohms, we have a lamp current of 100 amperes, and a condenser current of 25 amperes, provided $r = 0$. This is shown in Fig. 8, from which we find that the machine current is 103 amperes. Suppose now that $r = 200$ ohms, then we must modify the diagram as shown in Fig. 8A.

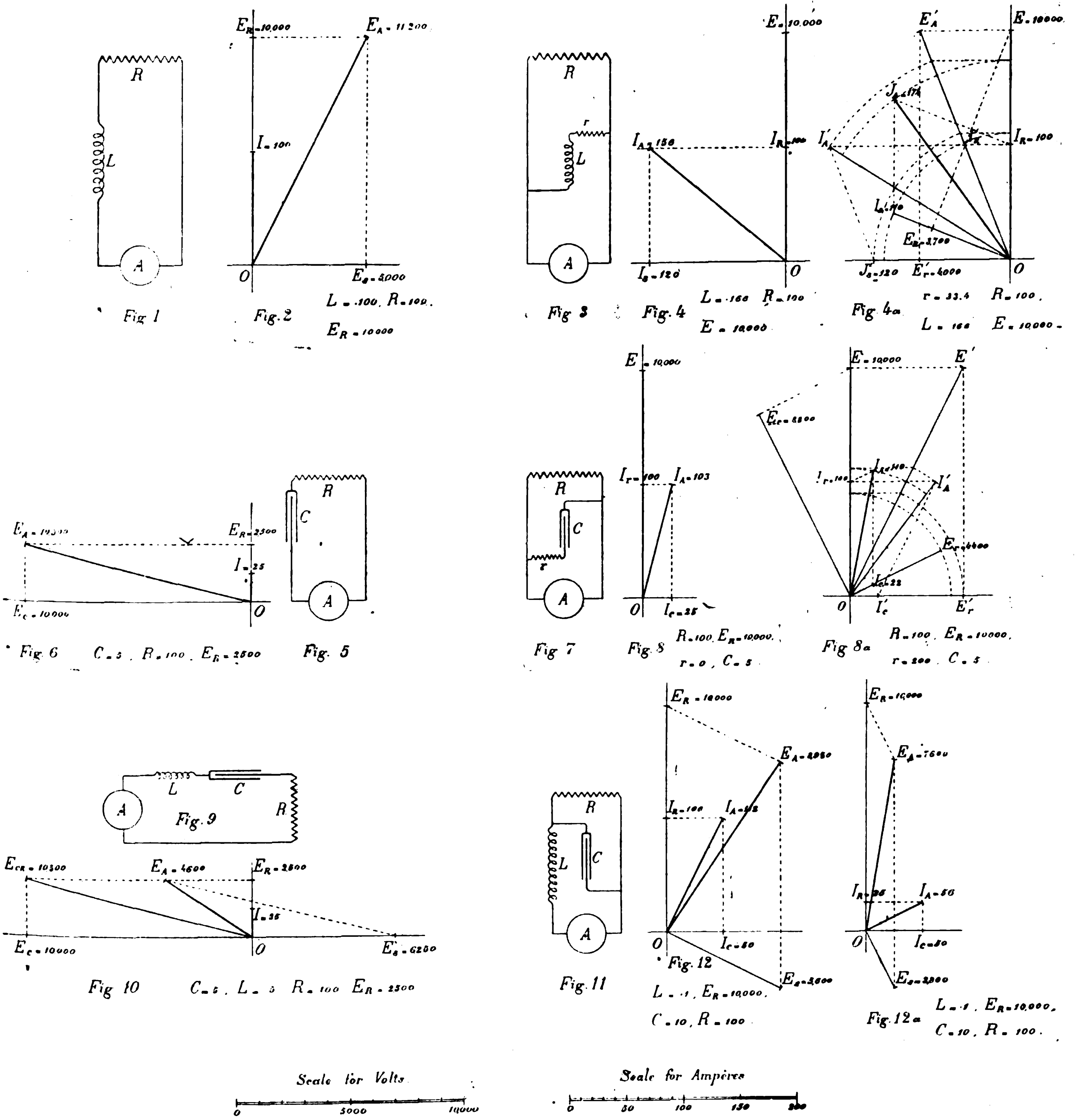
If the condenser current were the same as before it would be indicated by the length, O $I_c'$. At the same time an E.M.F. of 5,000 volts (O $E_r'$) would be required to overcome the resistance $r$. This, combined with $E = 10{,}000$, gives O $E^1$ as the machine E.M.F., which would be required under these conditions. The machine current would be O $I_A'$. But as by the terms of the problem the machine E.M.F., which is equal to the lamp E.M.F., is limited to 10,000 volts, we must contract the whole diagram in the ratio of O E to O E'. At the same time, and as a matter of convenience, we rotate the diagram through an angle equal to that between these two lines, and obtain by a simple geometrical process the true condenser current, as $I_c = 22$, and the true machine current, as $I_a = 110$ amperes. The condenser E.M.F. must stand at right angles, and to the left of the condenser current, and is 8,800 volts, as shown at $E_c$. By the introduction of the resistance $r$, we have, therefore, decreased the condenser current, but increased the machine current. We have also decreased the lag and increased the output of the machine, the additional power going to heat the resistance. It is important to note that in the cases considered up to the present the machine voltage is either equal to or higher than any other voltage in the circuit, so that we see that neither self-induction alone, or capacity alone, can in any way produce an increase of pressure, but such an increase may be produced if both are present in the same circuit, a case we now proceed to investigate.

III.—*Resistance, Self-Induction, and Capacity.*

In the arrangement represented by Fig. 9, a self-induction, a condenser, and a resistance are in series. Starting with the

Digitized by Google

assumption that the condenser E.M.F. shall be 10,000 volts, we get for $C = 5$ microfarads a current of 25 amperes. With a resistance of 100 ohms, this gives us a lamp E.M.F. of 2,500 volts. The machine E.M.F. required, if there were no self-induction, is as in Fig. 6 $E_{CR} = 10{,}300$ volts. But now we have a self-induction of ·5 quadrants. To force a current of 25 amperes through such a self-induction requires 6,250 volts, and this E.M.F. must be in advance over the current by 90deg. Thus we mark off to the right of the centre line the point $E_s = 6{,}250$ volts, and combinin this with $E_{CR} = 10{,}300$, we get the true machine voltage result will be that the current will increase to such a value as to absorb 2,500 volts in the smaller lamp resistance. An increase of current means, of course, a proportional increase in the condenser voltage beyond the 10,000 volts with which we started. Now suppose we reduce the lamp resistance to zero, then R will be simply the resistance of the mains; that is a very small amount, and consequently a very low machine E.M.F. will suffice for setting up an enormously high pressure in the circuit (always supposing $E_c = E_s$). Let us assume, by way of example, that R has been reduced to 10 ohms. Then




$E_A = 4{,}600$ volts. Here we have a case where the machine voltage is lower than some other voltage in the circuit, and it will be instructive to analyse it. In the first place, it will be clear that the lowest value which the machine voltage can assume equals that at the lamps. This represents the most dangerous condition of working, and it will be reached if $E_s = E_c$. If at the same time we lower the lamp voltage by reducing R, we must lower the machine voltage proportionately in order to keep $E_c$ at 10,000 volts. If we leave the machine voltage at 2,500, as in the diagram, the $E_R$ would be 250 volts if the current is to remain at 25 amperes. The E.M.F. induced in the armature of the machine would also be only 250 volts, and yet the pressure between the plates of the condenser would be 10,000 volts. If we increase the induced E.M.F. to 1,000 volts, the condenser E.M.F. would be 40,000 volts and so on. This particular condition of working, which is obviously the most dangerous possible, presupposes, however, that the E.M.F. of self-induction equals that existing between the plates of the condenser, or in symbols

$$L \omega I = E_c$$

Digitized by Google

Since $I = C E_c \omega 10^{-6}$ we have $E_c = \frac{I\,10^6}{C\omega}$ and $L\omega = \frac{10^6}{C\omega}$ from which we find the frequency for the most dangerous condition of working

$$\omega = 2\pi n = \frac{10^3}{\sqrt{CL}}$$

$$n = \frac{10^3}{2\pi\sqrt{CL}}$$

In the present case $C = 5$ and $L = \cdot 5$; inserting these values we find $n = 101$. If, therefore, we speed up the alternator so as to increase the frequency from 80 (which is the value assumed in all the diagrams) to 101, we shall work under the most dangerous conditions, and this is the case to which Mr. Swinburne referred in his remarks before the Physical Society, to which allusion has already been made in the first article. Although the condition of working here explained is the most dangerous, it is not the only dangerous condition, as can easily he seen by going back to Fig. 10. If we may neglect the resistance R (which is quite permissible, since it is merely the resistance of a heavy main), the point $E_R$ goes down very nearly to O, and the length $OE_a$ representing the E.M.F. induced in the armature of the machine, is very nearly equal to the difference between $E_c$ and $E_s$; in the case of the diagram 3,750 volts. This means that if we excite the alternator so that at the frequency of $n = 80$ it gives 3,750 volts on open circuit, and then join it with the main, the pressure on the main will be 10,000 volts. Whether the pressure on the terminals of the alternator will be 10,000 volts depends, of course, on the position of that part of the circuit which has the self-induction of ·5 quadrants. If this large amount of self-induction were all in the armature, then the terminal pressure would be 10,000 volts, but this is practically impossible. The self-induction of an armature is measured by hundreds not tenths of quadrants, and, therefore, to produce the case represented by Fig. 10 it would be necessary to put a special self-induction coil in circuit, or if not a simple coil, some device which adds to the self-induction of the armature, for instance, a step-up transformer. Even then the self-induction will be less than that which has been assumed in plotting the diagram, my object being, as already explained, not to represent any particular practical case, but such a case which will render it most easy to explain and analyse the various phenomena. The diagram has, therefore, qualitative but not quantitative importance. Bearing this in mind, let us now investigate what phenomena we have to expect in laying and testing a concentric main. The main itself is the condenser, and its resistance, taking the place of R, is very small; in fact, negligible with the small currents flowing when the far end is open. At the central station we have an alternator, and possibly a step-up transformer. If the latter be omitted L will be very small, and the effects represented by Fig. 10 will scarcely be noticeable, but with a step-up transformer in circuit L is somewhat larger, and the effects may become sensible. Even then, whilst the main is short, they will scarcely be noticed, for the capacity is then small, and consequently the condenser current is small. Now a small current flowing through even a sensible self-induction does not evoke any great back E.M.F of self-induction, and, consequently, the E.M.F. measured at the end of the main will be only insensibly greater than that corresponding to the excitation of the alternator. But as the operation of laying the main proceeds, the capacity of our condenser, and with it the condenser current, grows. In a like manner must the E.M.F. of self-induction grow, and, consequently, we find that the farther we proceed with the mains from the central station the higher becomes the condenser E.M.F., which we measure at the open end of the mains, or if we wish to keep this E.M.F. at its former value, we must reduce the excitation of the alternator.

The case represented by Fig. 10 is, however, not of any practical importance except in the laying and testing of mains. In actual work we have in addition to the condenser current also the current for working the lamps at the distant end, as represented by Fig. 11. This problem can also be easily solved by a diagram. Let in Fig. 12 $0E_R = 10{,}000$ represent the voltage at the far end of the main, and $I_R = 100$ the lamp current delivered under this pressure. If the capacity of the main is 10 microfarads, the condenser current will be $I_c = 50$ amperes. The armature current is therefore $I_a = 112$ amperes. Let $L = \cdot 1$, the E.M.F. of self-induction is $E_s = 5{,}600$ volts, and by combining this with $E_R$ we find the induced or machine E.M.F. $E_A = 8{,}950$ volts Thus we obtain 10,000 volts at the end of our main by exciting the alternator only to that extent which would give on open circuit 8,950 volts. The discrepancy becomes still greater if we reduce the lamp current to 25 amperes, as shown in Fig. 12A. There we have $E_s = 2{,}800$ volts, and $E_A = 7{,}600$ volts or 2,400 volts less than at the end of the main. It is necessary to remark that in reality the case is not quite so simple as represented by the diagram. We have at the far end of the line one or more step-down transformers which have self-induction. The result is that $I_R$ will be shifted to the left of the vertical. We have further some, though only a small amount of resistance in the main, and the condenser action, or, rather, the capacity, is spread all along the main instead of being concentrated at one point. We have also some resistance in those parts of the circuit having self-induction, and where more than one main is worked from one machine a certain correction is required to apportion the effect of the self-induction of the machine between the various mains. All these points can be treated graphically by an extension of the theory here developed. It should be noted that the figures given in the diagrams are convenient approximations.

---

[ERRATUM. ARTICLE I.—P. 198, col. 2, l. 31 from top, for T read I.]

---

## ON THE RISE OF ELECTROMOTIVE FORCE OBSERVED IN THE DEPTFORD MAINS.

BY R. T. GLAZEBROOK.

The following investigation will, I think, be found to contain the explanation of the curious effect discovered by Mr. Ferranti and described by Mr. Swinburne in his Paper before the Physical Society on December 12th. In it I consider the cable merely as a condenser. Since the wave length of the Deptford current is about 2,000 miles (*Electrician*, p. 205), it is clear variations in the potential at one end are propagated practically instantaneously to the other. The fall of potential along the cable which must exist when the current is flowing will not, I believe, seriously affect the result. I have not at present got the data for determining how far the self-induction of the cable comes in as an important factor; it is clear that this alone will not produce the effect, for it disappeared when a dynamo was substituted for the transformer.

Consider then two circuits, each having self-induction connected up in parallel with a condenser.

Let $L_1$ $L_2$ be the coefficients of self-induction of the circuits $R_1$ $R_2$ their resistances. Let C be the capacity of the condenser, Q the quantity of electricity on one plate at any moment, $i_1$, $i_2$ the currents in the two circuits, and suppose that in the one circuit there is a periodic electromotive force following the sine or cosine law, which we may denote by $E\,e^{\iota nt}$, where $\iota = \sqrt{-1}$. The full expression is $E\,e^{\iota nt} + E'\,e^{-\iota nt}$, and for the present we can work with the first term as typical. Then we have from the two circuits the equations

$$\left.\begin{aligned} &\frac{Q}{C} + L_1\frac{di_1}{Dt} + R_1 i_1 = Ee^{\iota nt} \\ &\frac{Q}{C} - L_2\frac{di_2}{dt} - R_2 i_2 = 0 \\ &\frac{dQ}{dt} = i_1 - i_2 \end{aligned}\right\} \quad . \; . \; . \quad (1)$$

Hence differentiating and substituting

$$\left.\begin{aligned} i_1 - i_2 + C\,L_1\frac{d^2 i_1}{d t^2} + C\,R_1\frac{d i_1}{d t} &= i\,n\,C\,E\,e^{int} \\ i_1 - i_2 - C\,L_2\frac{d^2 i_2}{d t^2} - C\,R_2\frac{d i_2}{d t} &= 0 \end{aligned}\right\} \quad . \; . \; . \quad (2)$$

Now assume

$$\left.\begin{aligned} i_1 &= I_1 \cos(n\,t + \epsilon_1) \\ &= J_1\,e^{int} + J_1^1\,e^{-int} \\ i_2 &= I_2 \cos(n\,t + \epsilon_2) \\ &= J_2\,e^{int} + J_2^1\,e^{-int} \end{aligned}\right\} \quad . \; . \; . \quad (3)$$

We need only deal with the first term in each case, and we can get the second term by changing the sign of $i$. We have also

$$\left.\begin{aligned} I_1 &= \sqrt{(J_1\,J'_1)} \\ i \tan \epsilon_1 &= \frac{J_1 - J'_1}{J_1 + J'_1} \end{aligned}\right\} \quad . \; . \; . \; . \; . \; . \quad (4)$$

Of course $J_1$ and $J'_1$ are complex quantities of the form

$$a + \beta\sqrt{-1}, \quad a - \beta\sqrt{-1}.$$

On substituting and dividing by $e^{int}$ we find

$$\left.\begin{aligned} J_1 - J_2 - C\,L_1\,n^2\,J_1 + in\,C\,R_1\,J_1 &= in\,C\,E \\ J_1 - J_2 + C\,L_2\,n^2\,J_2 - in\,C\,R_2\,J_2 &= 0 \end{aligned}\right\} \quad . \; . \; . \quad (5)$$

Hence

$$\left.\begin{aligned} &J_2(1 - C\,L_2\,n^2 + in\,C\,R_2) = J_1 \\ &J_1\left[(1 - C\,L_1\,n^2)(1 - C\,L_2\,n^2) - n^2 C^2 R_1\,R_2 - 1 \right. \\ &\quad \left. + in\{C\,R_1(1 - C\,L_2\,n^2) + C\,R_2(1 - C\,L_1\,n^2)\}\right] \\ &\quad = in\,C\{1 - C\,L_2\,n^2 + in\,C\,R_2\}\,E \end{aligned}\right\} \quad . \quad (6)$$

Writing down the values for $J'_1$ $J'_2$ in the same way we get the following expressions for $I_2$ and $I_1$.

$$I_2\{(1 - C\,L_2\,n^2)^2 + n^2\,C^2\,R_2^2\}^{\frac{1}{2}} = I_1 \quad . \; . \; . \; . \; . \; . \; . \quad (7)$$

$$I_2[\{R_1(1 - C\,L_2\,n^2) + R_2(1 - C\,L_1\,n^2)\}^2 + n^2\{C(n^2\,L_1\,L_2 - R_1\,R_2) - (L_1 + L_2)\}^2]^{\frac{1}{2}} = E \quad . \; . \; . \; . \; . \; . \; . \; . \quad (8)$$

The coefficient of $I_2$ may be written thus :—

$$[(R_1 + R_2)^2 + n^2(L_1 + L_2)^2 - 2\,C\,n^2\{R_1^2\,L_2 + R_2^2\,L_1 + n^2(L_1 + L_2)L_1\,L_2\} + C^2 n^2(R_1^2 + n^2 L_1^2)(R_2^2 + n^2 L_2^2)]^{\frac{1}{2}} \quad . \; . \quad (9)$$

This expression becomes the denominator of E in the value of $I_2$. When C is zero it is limited to the first line.

Now, it is clear that for small values of C, the term in C with a negative coefficient is more important than that in $C^2$, that is, the introduction of the condenser at first reduces the value of the denominator, and so increases the value of $I_2$. As the capacity of the condenser is increased, the denominator continues to fall in value, reaching a minimum when

$$C = \frac{R_1^2\,L_2 + R_2^2\,L_1 + n^2(L_1 + L_2)\,L_1\,L_2}{(R_1^2 + n^2\,L_1^2)\,(R_2^2 + n^2\,L_2^2)} \quad . \; . \quad (10)$$

For this value of C and for certain values of $n$, $R_1$, $R_2$, $L_1$, $L_2$, this minimum value of the denominator may vanish, since in the first form the expression is the sum of two squares it can never be negative.

Thus, as C increases from zero to the value just given, the value of $I_2$ increases, and may even under certain circumstances become infinite.

This circumstance will perhaps explain the difficulty met with by Mr. Mordey (*Electrician*, p. 214), the various coils of the armature will have a condenser action of the kind attributed to the cable.

As the value of C is still further increased, the denominator increases from its minimum value until when C has just double the above value, and becomes equal to

$$\frac{2\{R_1^2\,L_2 + R_2^2\,L_1 + n^2(L_1 + L_2)\,L_1\,L_2\}}{(R_1^2 + n^2\,L_1^2)\,(R_2^2 + n^2\,L_2^2)} \quad . \; . \; . \quad (11)$$

the terms in C disappear, and the condenser is without affect.

Thus, so long as C lies between zero and value last given, the current in the second circuit is increased by the condenser. For values of C greater than the above, the denominator is increased, and the condenser tends to reduce the value of $I_2$.

This critical value (as it may be called) of the capacity depends on $n^2$, though unless the self-induction is so large that $n$ L is comparable with R, changes in the value of $n$ will not have very great effect.

The greatest change which can take place in the denominator is given by

$$\frac{n^2\{R_1^2\,L_2 + R_2^2\,L_1 + n^2(L_1 + L_2)\,L_1\,L_2\}^2}{(R_1^2 + n^2\,L_1^2)\,(R_2^2 + n^2\,L_2^2)} \quad . \quad (12)$$

and this, of course, depends directly upon $n$. Thus the effect of the condenser will be more marked with rapid alternations than with slow ones. It would be interesting to see how far the above theory agrees with the results obtained by Mr. Ferranti by substituting in the various expressions the values of the resistances, self-inductions, and capacity which he used, the length of cable for which the effect would vanish might then be found by calculation. The quantities, $\epsilon_1$, $\epsilon_2$, which give the lag behind the E.M.F. for the two currents respectively can be written down without much difficulty, but it is hardly necessary to do this. It will be noticed that all the above expressions are simplified if either of the two self-inductions vanish. Thus, to produce the effect, it is only necessary to have self-induction in one of the two circuits.

I hope shortly to arrange some laboratory experiments to test the above theory, which, I think, accounts in a general way for most of the observed facts, though I am fully sensible of its incomplete nature. There would be no very serious difficulty in treating the problem completely so far as the cable is concerned. Much of the work for this has been done already by Prof. J. J. Thomson, and I think also by Mr. Heaviside, but I doubt if the gain resulting from this alone would be very great. There remains, however, the question as to what effect the electrostatic capacity of the transformers produces. This problem is, I fear, at present beyond the range of analysis, though some indications of the effect might be developed. The introduction to Mr. Kapp's Paper (*Electrician*, p. 197) seems to indicate that his solution of the problem is the same as that just given. I worked out the above results for my own satisfaction on reading Mr. Swinburne's Paper, with the discussion on it, and it may be of interest to have the solution given in various forms.

---

**The Dissociation of Carbon Dioxide Gas by the Electric Spark.**—An interesting paper, says *Nature*, is communicated by Prof. von Hofmann to the current number of the *Berichte* upon the dissociation of carbon dioxide gas into carbon monoxide and oxygen by means of the electric spark. Dalton and Henry long ago showed that carbon dioxide, although formed by exploding a mixture of two volumes of carbon monoxide with one volume of oxygen by the passage of an electric spark, is again partially decomposed into carbon monoxide and oxygen by the continued passage of the spark. Prof. Hofmann has now determined the exact conditions under which the explosive recombination occurs. The most suitable distance apart of the platinum terminals appears to be between two and a-half and three millimetres, and Prof. Hofmann advises the use of adjustable terminals rather than the ordinary platinum wires fused into the side of the eudiometer. A Leyden jar in the circuit renders the occurrence of periodical explosions more certain. The spark should also pass at about a quarter the height of the gas column instead of, as usual, near the top. The current itself, moreover, should not be too strong; that from two Bunsen cells and only a moderate sized Ruhmkorff coil yields the best results. It is also preferable to use a volume of carbon dioxide, previously dried over sulphuric acid, not exceeding ten cubic centimetres at a pressure of 650-700 mm. Under these conditions the first explosion usually occurs in about 15-20 minutes. The second and succeeding explosions occur after shorter intervals than the first. This experiment is certainly one of the most interesting in all the range of dissociation phenomena.

Digitized by Google

# The Electrician.

ublished every Friday, Price Fourpence; Post Free, Fourpence Halfpenny.
Editorial, Publishing, and Printing Offices:
SALISBURY COURT, FLEET ST., LONDON, E.C.
*Telephone No.* 2714. *Telegrams:* "ELECTRICIAN NEWSPAPER, LONDON."

*All Letters relating to Subscriptions, Advertisements and other business matters should be addressed to the Publisher, "*THE ELECTRICIAN,*" Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to "*THE ELECTRICIAN*" Printing and Publishing Company, Limited, and be crossed "Coutts and Co." All other letters to be addressed to the Editor.*

*All letters intended for insertion in "*THE ELECTRICIAN,*" or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith.*

*No notice whatever will be taken of anonymous communications.*

"THE ELECTRICIAN" *is published every Friday morning, in time for the morning mails. Subscribers should receive their copies by the first post on Friday morning.*

"THE ELECTRICIAN" *is on sale at the railway bookstalls throughout the Kingdom on Friday morning, and can be obtained of all Booksellers and Newsvendors; or direct from the Publishing Offices as above.*

*New Volumes of "*THE ELECTRICIAN*" commence in May and November.*

## SUBSCRIPTION RATES.

The rates for Subscriptions to "THE ELECTRICIAN" are as follows:—

| | 3 months. s. d. | 6 months. s. d. | 12 months. s. d. |
|---|---|---|---|
| For the United Kingdom | 5 0 | 10 0 | 19 6 |
| For Foreign Parts and Colonies:— | | | |
| Within Postal Union | 6 6 | 12 6 | 24 0 |
| Aden Borneo, Ceylon, China, India, Japan, Java, Labuan, Mozambique, New Caledonia, Persia, Philippine Islands, Siam, Transvaal, and Zanzibar | 7 6 | 14 6 | 28 0 |



## TO ADVERTISERS.

"THE ELECTRICIAN" *offers exceptional advantages to Advertisers.* **It has by far the largest circulation of any English Electrical paper, and circulates all over the World.**

*Particulars relating to Advertisements will be promptly forwarded on application to the Offices as above.*

TRADE ADVERTISEMENTS *intended for the current issue must reach the Offices not later than First Post on Thursday morning. Renewals of expiring advertisement orders and alterations to standing advertisements should be in the Publisher's hands by Wednesday at latest. No alteration can be made in Wrapper advertisements after Wednesday evening.*

SMALL PREPAID ADVERTISEMENTS *(for Rates see page xvii.) are accepted up to 4 p.m. on Thursday.*

## TECHNICAL PRINTING.

"THE ELECTRICIAN" PRINTING AND PUBLISHING COMPANY (LIMITED) *inform Electricians, Electric Light Engineers, &c., that they make a specialty of Technical Printing, and have a large Staff thoroughly acquainted with Electro-Technology. They can, therefore, promise Accuracy and Despatch in the Printing of Electro-Technical Literature, &c.*

## "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. (Royal 8vo.)

*Early in each year is issued* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. *The* DIRECTORY *was established in 1883, and the 1890 Edition consisted of about 850 pages of printed matter. The names and addresses of all persons engaged in the Electrical Industries at home and abroad may be relied upon as accurate. Useful Tables and Electrical Formulæ, and information specially compiled for this work are given, together with popularly-written Biographical Notices of the leading Electricians, Electrical Engineers, &c., accompanied in many cases by Portraits.*

*Orders for the 1890 issue should be forwarded* AT ONCE *to the Publishing Offices, Salisbury-court, Fleet-street, London, E.C.*

*The 1891 Edition is now preparing, and New Names, &c., can now be received.*

## ELECTRICAL BOOKS AND PUBLICATIONS.

*All Books, Newspapers, and other publications, dealing with Electrical and kindred subjects, can be ordered direct of "*THE ELECTRICIAN*" Printing and Publishing Company, who are proprietors of the well-known "*ELECTRICIAN*" Series of Standard Electrical Works, and re agents for all the leading publishing houses at home and abroad.*


## CONTENTS OF THE CURRENT NUMBER.


NOTES ... 223
Magnetism in Iron and other Metals.—XXXVIII. By Prof. J. A. Ewing, F.R.S. Illustrated. Continued ... 228
Capacity and Self-Induction in Alternate Current Working.—II. By Gisbert Kapp. Illustrated. Concluded ... 229
On the Rise of Electromotive Force observed in the Deptford Mains. By R. T. Glazebrook ... 232
LAPSE OF THE TELEPHONE PATENT ... 234
Reviews ... 236
Notes on Dynamos ... 236
Shaking the Foundations of Science ... 237
Electro-Magnetic Mechanisms. By Prof. S. P. Thompson, D.Sc., B.A. Illustrated ... 238
Telegraphic Transmission on Long Subterranean Lines without the Use of Relays. Illustrated ... 241
The Operation of Electric Railways ... 242
Automatic Filament Flashing Apparatus. Illustrated ... 243
Sable Island. Illustrated ... 244
The Ronald's Library. Illustrated ... 245
Books Received ... 245
American Notes ... 245
Vienna Notes ... 246
CORRESPONDENCE—
Secondary Batteries, Positive and Negative Plates—Gerald Molloy ... 246
Gas and Electric Lighting and Ventilation — Geo. Fletcher ... 246
The Chemistry of the Secondary Cell — Desmond G. FitzGerald ... 246
Selenium—Shelford Bidwell. 246
Trade Notes and Notices ... 247
PATENT RECORD ... 247
COMPANIES' MEETINGS, &c.—
Reuter's Telegram Company (Limited) ... 248
The Phonopore Syndicate (Limited) ... 248
New Companies Registered ... 249
City Notes, &c. ... 249


## LAPSE OF THE TELEPHONE PATENT.

Time brings round its revenges, even to the point of throwing open to public use the most jealously guarded of monopolies. Rarely in the history of patent law has any monopoly been upheld in a more merciless manner than that of the electric telephone. All the arts of legal intimidation, of buying up powerful rivals and bullying weaker ones, terrorising them with legal injunctions and persecuting them with legal costs, mercilessly exacted to the last legal farthing, have been resorted to in order to keep the great monopoly upon its throne. Company has succeeded company: lawsuit has followed lawsuit: one network after another has spread its ramifications over the great commercial centres, until the capital invested has grown into millions.

Now that the great telephone monopoly has come to its legal end, it is possible to review the chequered career of the invention. Without going back into the ancient history of the crude attempts made with more or less success before the year 1875 to bring out an electric telephone, we need only refer to the scientific journals of that time to discover that, as is the case with almost all great inventions, the subject was "in the air," waiting only to receive definite shape and name. In that year three or four electricians were at work on this very problem. In England there was VARLEY, in the United States ELISHA GRAY and ALEXANDER GRAHAM BELL, and, if all the affidavits in American patent cases are to be credited, at least three or four other inventors, including the notorious DANIEL DRAWBAUGH. At the end of that year GRAHAM BELL had worked out a system of harmonic telegraphy of a novel kind, dependent on the use of alternating or undulatory currents, and was preparing to put it into shape for patenting. It does not appear that undulatory currents were essential for the purpose in view, but that they *were* undulatory determined the ultimate success of the telephone. However, BELL's reasons for preferring them to an intermittent current were; that a larger number of telegraphic signals could be transmitted simulta-

Digitized by Google

neously, that for cable work dispatches might be transmitted more rapidly than by intermittent currents, as it was unnecessary to discharge a cable before a new signal was made; and lastly, that as the current was never broken, a spark arrester became unnecessary. VARLEY, on this side of the water, was also working at the transmission of harmonic signals. These harmonic telegraphs were called telephones, though the word telephone had previously been appropriated for an instrument that was not intended in the least as a harmonic telegraph.

ELISHA GRAY, on the other hand, was endeavouring to devise an articulating apparatus that should not be a telegraph at all, but a real speaking telephone. VARLEY'S telephone, after an ignominious failure at the now defunct Queen's Theatre, came to nought. And, as fate ordained, ELISHA GRAY'S speaking apparatus, and GRAHAM BELL'S harmonic telegraph working by alternating currents (induced by vibrating a tuned armature in front of an electro-magnet), were brought on the same day—February 14, 1876—to the United States Patent Office. Here begins a conflict of evidence as to what occurred: for the official of the Patent Office who received both communications has sworn that he revealed the invention of one party to the other; whilst in a subsequent affidavit he has sworn that his former declaration was made whilst under the influence of alcohol. Comparison of the original documents is interesting. It shows that ELISHA GRAY distinctly claimed, and illustrated by drawings, apparatus for transmitting articulate speech. "It is the object of my invention," he says, "to transmit the tones of the human voice through a telegraphic circuit, and reproduce them at the receiving end of the line, so that actual conversations can be carried on by persons at long distances apart." It shows also out of GRAHAM BELL'S own mouth what at that date he had, and what he had not invented. "Be it known," he begins, "that I, ALEXANDER GRAHAM BELL, of Salem, Massachusetts, have invented certain new and useful improvements in telegraphy." "My method of multiple telegraphy"; "The advantages that I claim are . . . that a very much larger number of signals can be transmitted"; "that cable despatches may be transmitted more rapidly than by means of an intermittent current"; "when a cylinder, upon which are arranged bar magnets, is made to rotate in front of the pole of an electro-magnet, an undulatory current of electricity is induced in the coils of the electro-magnet"; "a number of instruments may be placed on a telegraphic circuit . . . when the armature of any one of the instruments is set in vibration, all the other instruments upon the circuit which are in unison with it respond." The foregoing are samples from the body of the specification, and obviously have reference to telephones of the VARLEY order, not to articulating instruments. After a casual remark that there are other uses for these instruments, such as the telegraphic transmission of noises or sounds of any kind, the specification proceeds to the following, the only passage in it which can be construed into a reference to articulate speech:—"One of the ways in which the armature may be set in vibration has been stated before to be by wind. Another mode is shown in Fig. 7, whereby motion can be imparted to the armature [shown as a tuned vibrator or lever] by the human voice or by means of a musical instrument." This passage, coming in the middle of a specification on harmonic telegraphy, with no other explanation, can only mean that dot and dash might be transmitted to the vibrator by means of the voice or by a musical instrument. However it is not upon this passage but upon the instrument constructed by BELL that the monopoly of the American Bell Telephone Company has been practically built up, and hangs to-day. It appears, then, that ELISHA GRAY'S object was to transmit articulate speech, while it seems probable that GRAHAM BELL had no such aim, since he did not allude to it in his patent. But as the intentions of the inventors differed, so, too, did the capabilities of their inventions; but, strange to say, the difference was one which gave to him that asked not, and denied success to the man who conceived the idea. ELISHA GRAY expressed his *wish* to make his instrument talk; GRAHAM BELL at once grasped the idea that his *could* talk; and he made it talk.

ELISHA GRAY, beaten in the first round of the judicial fray, fell into the background. At the Centennial Exhibition both inventors showed instruments, and by this time BELL had dropped the tuned armatures and rotating bar magnets, and all the paraphernalia of multiple telegraphy, and his instrument had developed into an articulating telephone. The enthusiasm was immense, particularly about BELL'S instrument. Sir WILLIAM THOMSON, the leading juror of the electrical section, wrote an official report, narrating how in this instrument he heard the words:—"To be, or not to be; there's the rub" (a misquotation, it will be noted, of the well-known passage in Hamlet), uttered by a thin disc of iron which was held down all round by being magnetically attracted to an electro-magnet with an external iron tube; that being the form of instrument used as receiver. A pair of instruments he himself brought back and a showed publicly in Glasgow in September of that year, though he failed to make them work, apparently having neglected to apply a sufficiently powerful battery to cause the iron disc of the receiver to be held down by the electro-magnetic attraction.

Three months after this publication of the great invention, GRAHAM BELL filed the specification of his English patent, which has just expired. How any patent could be valid under such circumstances must ever remain a legal mystery. By this time the phrase "by the human voice," which was the solitary suggestion of the American specification capable of being construed as implying a speaking telephone, had been enlarged and expanded into a lengthy description of a speaking instrument. An elegant device for getting rid of a battery from the line circuit had also been imported as a novelty. When in 1882 this matter came into legal question it was held that the only two novelties of the December patent were holding down the iron disc (which it mis-describes as a steel plate) all round, instead of attaching it at one corner, and devising a new sort of electro-magnet, having permanent magnetism in the core—an invention for which, by the way, an eminent British electrician had been refused a patent in 1870 on the ground of want of novelty. Yet on these two pleas the BELL patent was upheld, first in an action tried in Edinburgh before Lord MACLAREN, then in London before Mr. (now Lord) JUSTICE FRY, and finally before the late Sir GEORGE JESSEL in the Court of Appeal. We do not intend to investigate the precise manner in which the credit for this invention should be given. Indeed, it is doubtful whether there was not, as far as GRAHAM BELL was concerned, a discovery rather than an invention. The discovery lay in the fact that the multiple telegraph instrument would talk.

Why then did ELISHA GRAY, who was an inventor and patentee, drop out of the running? This is the old question which is ever turning up in any industry where progress is being made. Shall credit be given to a man whose imagination and inventive faculties enable him to sketch and describe an instrument or device which shall achieve certain ends? No; we have too many such, they must do more than that. ELISHA GRAY did more. He made a talking telephone. But that is not all. Some would say let him patent it, and the credit shall be his. But even this he did. Why, then, is BELL'S name known in every civilized country while hundreds of thousands of the carefully-developed form of his telephones

Digitized by Google

are in daily use. Why is it that not nine out of ten of our readers could not describe ELISHA GRAY'S telephone? It is merely because GRAHAM BELL pushed, knew how to push, and succeeded in pushing, his telephone on to the market.

It is nevertheless sad to think how much activity has been crushed out of the electrical industry by this decision. One has only to look at the progress telephony has made in such countries as France, Sweden, and the South American Republics to see what might have happened here in England had the patent law not stepped in to arrest the hand of progress. Our patent laws were never framed to enable a patentee to build a huge monopoly upon an invention which, whether BELL really invented it or not, was in the possession of the public months before his patent was even applied for. That which happened in the case of the now expired BELL patent, though, unfortunately, not quite a unique experience, ought never again to be permitted to occur to the detriment of a whole industry.

## REVIEWS.

**The Art of Electrolytic Separation of Metals.** By G. GORE, LL.D., F.R.S. (*The Electrician* Printing and Publishing Company, London.)

Only those who have had to do with the industrial application of electrolysis to winning and refining metals can fully appreciate the need for a treatise dealing with the subject comprehensively. Information scattered through the pages of technical journals or existing as tantalising scraps in books on electro-deposition applied to the protection or reproduction of articles having a value apart from the material coating or forming them, has hitherto been all that was available—at least for the English reader. Any attempt, therefore, to fill the gap and provide us with a reliable compilation of existing knowledge is thoroughly meritorious. But Dr. Gore has produced a book which has other claims to consideration than that of supplying a real want, and which may be praised for its intrinsic qualities. Starting with an "historical sketch," mercifully brief, the "theoretical division," devoted to the exposition of the data and phenomena that must be known and understood to gain a clear insight into the causes and conditions governing the electrolytic separation of ions, is soon reached, and some 140 pages allotted thereto.

Nothing is more necessary than a complete grasp of the principles that underlie what is by no means an easy art, but it is questionable if it is wise to occupy considerable space with such matters as explanations and definitions of current electromotive force and chemical affinity. They are of necessity dealt with briefly, so that one ignorant of the subject would find the mental food rather too concentrated for comfortable digestion, while they are not needed by the electrolytician (to coin a name for the electro-chemical expert), as they form the very basis of his knowledge. Such subjects are better learned from books dealing with them exclusively. The same remark applies to much of "Section F" (for which Mr. Guy C. Fricker is responsible), which appears to us somewhat superfluous. But where the "theoretical division" touches upon *electrolysis*, as distinct from both *electricity* and *chemistry*, it is perfectly in place, and the subject being handled deftly, and in a manner eminently sound, it is in every way welcome.

On turning to the "practical division," there is first an excellent summary of the *pros* and *cons* that have to be considered before embarking on the establishment of an electrolytic copper refinery, which may be commended to those about to start such an enterprise. Hitherto but few successful attempts to reduce or refine other metals than copper on a large scale and make the process pay have been made, and the greater part of the next hundred pages is concerned with this material. Wherever the author treats of the energy relatively to a given reaction, he is always particularly lucid and accurate, and it is quite in keeping with the rest of his work to find him draw a clear distinction between the consumption of energy needed to actually reduce a metal from one of its salts and that required merely to transfer it from anode to cathode, if the former consist of the metal to be refined in a free state. He never, however, falls into the opposite error, and underestimates the waste due to non-essential causes, such as resistance of the electrolyte or corrosion and re-solution of the deposited metal. Among other qualities which differentiate this book from many slipshod productions, is the hearty goodwill with which certain popular fallacies are exploded. The purity of electrodeposited copper has long been an article of faith with the semi-ignorant, but, as Dr. Gore rightly points out, its degree of purity depends on the conditions of deposition, and may leave much to be desired.

Many very useful statistics are given of installations actually at work, the statements received from those interested in them being wisely indicated by quotation marks.

Although copper naturally occupies the largest amount of space, other metals are not overlooked, the separation of silver, lead, antimony, aluminium, zinc, magnesium, and the alkali metals being treated of fairly adequately. With regard to aluminium the Cowles process is mentioned, and is stated to depend probably on electrolysis as well as the production of an extremely high temperature, a view thoroughly consistent with the teachings of thermo-chemistry. Electrolytic methods for the extraction of the precious metals from their ores are discussed briefly at the end of the book, but the author preserves a judicious silence as to their success.

Sundry small errors call for notice. "Cuprous" is persistently misspelt "cupreous"; the atomic weight of platinum is erroneously given as higher than that of gold; the misleading Gallic term "metalloids" for "non-metals" is employed; "etherial" stands for "ethereal" on p. 136; and on p. 266 the zinc process for desilverising lead is credited to Pattison instead of Parkes. But these are trivial matters, and may be readily corrected in the second edition of what is a useful and valuable book. B. B.

## NOTES ON DYNAMOS.

The designing of continuous-current dynamos is settling down into two or three definite lines, and we rarely hear of any great or novel improvement. It is manifest that no considerable gain in efficiency is possible at full load, though something remains yet to be done in reducing the internal losses when the output is reduced. There is an obvious tendency to attach less importance to the economy of large dynamos on light loads, since it is a very common practice in supply stations to put down or to make provision for about ten or twelve machines, the idea being that one at least will be always loaded, and that, as the demand rises and falls, the dynamos are switched in one by one, so that theoretically all shall be under full load, except perhaps the last. But does this take place in practice? We think not. There is a tendency rather to distribute the load evenly among machines that are running, and it is generally supposed that no loss of economy is likely to arise by doing so. With exact distribution, the degree to which the dynamos are loaded would depend merely on the number at work, and we are inclined to think from what we have seen in the stations of the London supply companies, that for a considerable portion of the lighting hours the dynamos are working considerably below their full load. If this is the case, it would be well to pay a little more attention to the efficiency at reduced outputs, and endeavour to reduce the internal losses.

But in doing this, it must be remembered that with the modern practice of associating each dynamo with its own engine, and dispensing with counter-shafting, the economy of the engine must be considered from the same point of view. And there is a very serious and rapid decrease of efficiency in some engines, a decrease, in fact, which under the circumstances makes that of the dynamo of very secondary importance. According to the theory of design of these stations with their rows of dynamos and engines, this question is ignored, for it is supposed that all are fully loaded except, per-

Digitized by Google

haps, one. But a large engine such as those at the Stockwell depôt of the City and South London Railway, where the load is ever varying, but with far too great rapidity and irregularity to allow any switching in of machines, appears to offer advantages which have been somewhat neglected. One of the prominent features of these engines are their large and elaborate, though not complicated, governors, and next to these, the link gear to which they are attached is very noteworthy. In such an engine there may be a constant loss of energy due to friction, and an additional loss probably much smaller, which is a function of the load. But the steam consumption itself is closely regulated, and the losses due to wire drawing and other evils which arise as it were within the cylinder and passages, may be controlled by a good valve gear, and may be very approximately proportional to the horse-power delivered.

The question, then, resolves itself into one of cost of running; the mechanical excellence of both systems leaves little to be desired. The great differences which are to be found in the nature of the output of stations in different parts of London, differences which affect the average hours of lighting, the period of the maximum and the duration of the high load, together with the day work, would make comparison very difficult. We hope that by the time the Chamber of Commerce scheme for interchange of information has got under way, sufficient knowledge will have been gained on this point to enable the matter to be carefully analysed.

Though the connection between engine and the dynamo is very intimate where we are considering efficiencies, there are several points which are peculiar to the latter, and have but little to do with the motive power. One of these is the manner in which the field magnets are excited.

In central station work with continuous currents the shunt coils are generally fed from the mains through resistances which can either be adjusted singly, or which may be altered as a whole to control the entire station or separate feeders. The use of feeders—especially if the demand is irregular, or if it occurs in such a manner that first one part of the district and then another draws upon the supply—has prevented the use of ordinary compound wound dynamos, and unless any station for the supply of continuous current is erected on the principle of the few large units used at Deptford, the compound dynamo is likely to be used only for isolated plants or for such purposes or transmission of power as at Stockwell. Compound dynamos are sluggish in their response to sudden variations, but these do not as a rule occur in station work unless in connection with the supply to theatres. We have an interesting communication from a correspondent on this subject which we hope to publish next week.

The mode of calculating compound-winding has arrived at a settled condition. The theoretical men did their best to advance what seemed to them to be a mere matter of a few formulæ, while the dynamo builders, finding those few formulæ to be rather more ornamental than intelligible, used to try their machines with temporary coils under separate excitation, which could be measured, and on which the simple calculation of the winding could be based. Those fortunate firms who found it practicable to confine themselves to a few standard sizes were soon able to rely on previous experience, and only when an odd size, or an exceptionally large machine had to be built, did they resort either to a guess, or to the old way of making a preliminary excitation test. Most builders who have any pretensions to scientific methods have now arrived at some working formulæ of their own, and, needless to say, these are largely based on the work of the brothers Hopkinson. Dr. Louis Bell, in a recent Paper read before the American Institute of Electrical Engineers, put forward a *résumé* of the different systems of calculation in use, and developed a modification of his own. He divides the calculation into three terms, two of which are obtained from a permeability curve of the magnet iron, assuming that the density in the iron is known from the calculation of the shunt-winding. Thus he finds the magnetising force required to compensate for the fall of volts over the armature and series coils. The third term gives the magnetising force required to counteract the demagnetising effect of the armature. This term includes the leakage of the stray field. It is a question whether it would not be more satisfactory to calculate the characteristic curve in the well-known way, and from this find the ampere-turns needed in the two windings. This can easily be done from the data required for Dr. Bell's method, namely, the leakage, the permeability curve of the iron, and the dimensions of the machine. From this the ampere-turns for full load and for open circuit can be obtained, the difference giving the series turns, to which must be added sufficient ampere-turns to compensate for the demagnetising effect of the armature. This latter term has an element of uncertainty, for a good deal depends on the setting of the brushes. It is, however, best to allow a margin, as a volt or two of over-compounding is always advisable, even with the most regular speed, while under-compounding is an evil that should always be avoided.

## SHAKING THE FOUNDATIONS OF SCIENCE.*

During the past twenty years there has been gathered together round the site of the 1862 International Exhibition a national collection of museums and schools for instructing the people in art, natural history, and in pure and applied science. For a time a senseless howl was raised that the whole thing was a mighty job to benefit a few, and the antagonism reached its climax when it was proposed to celebrate the year of the Queen's Jubilee by erecting the Imperial Institute on the "inaccessible" spot at which so many millions from all parts of London—nay, from all parts of Great Britain—had congregated to study fishes and food, microbes and music, inventions and instantaneous illuminations, the colonies and coloured fountains.

At length the more sensible of the critics began to realise that the supposed sinecurists at South Kensington were enthusiastic workers who, had they devoted their intellectual powers to the common occupation of enlarging their balance at the bankers instead of to the uncommon occupation of enlarging our knowledge of Nature, would have become capitalists whose vested interests would have been deemed more sacred than life or honour. As it is, the hosts of Mammon now threaten the domain of science in Exhibition-road, for it is actually proposed to make an underground railway, with trains running at frequent intervals, right under Prof. Rücker's laboratory, right under Prof. Norman Lockyer's observatory, and skirting the electrical research laboratories of the City and Guilds Technical College, called the Central Institution.

The English nation (for what concerns the development of our science concerns the nation at large) must abandon its oft-boasted claim of being a practical people. Germany will laugh us to scorn, France will hit us with an epigram, and Italy will view us with polite amazement. To the Royal College of Science come from all parts of our country science teachers to be taught; to the Central Institution come, in addition to English lads, graduates from colleges in Europe and America to learn how England teaches the application of science to industry. Shall they come to find a rumbling earthquake led from early morn to late at night close to the foundations of the very pillars that have been erected at considerable cost in order to secure for the instruments placed on them freedom from even the vibration caused by passing footsteps? On concrete foundations, some 13 feet below the level of the street, rest many pillars of 9 feet square, each quite separate from its neighbour and from the floor on which the students stand; and the upper portion of each pillar is stuffed with a thick cushion of wool, so that the instrument resting on it may give as unwavering a decision as does the Lord Chancellor on the woolsack.

And even this is not sufficient to secure all the quiet that Urania loves, for, just as earthquakes are foretold by the fluttering of the wings of birds, so the approach of a cart at the other end of Exhibition-road is foreshadowed, long before it can be heard, by the uneasy trembling of the very delicate galvanometer needles. Hence must Urania's attendants, the students engaged in research, worship at her shrine by night; and woe

* From *Nature*.

Digitized by Google

betide them if they happen to assemble when a "small and early" is held in Exhibition-road; for then must they cover their heads and mournfully depart, persecuted by the rolling brougham, heartbroken by the rumbling growler, and driven to despair by the rattling hansom. Even at the Cavendish Laboratory, in a quiet back street in the peaceful University town of Cambridge, Lord Rayleigh's most accurate work on the electric units had to be done at night; and Wheatstone's galvanometer magnetic needles at King's College followed the penny iron steamers during the day rather than the electric currents he was measuring.

Judge, then, what will be the effect of passing trains, even though they be drawn by no

"Kittle of steäm,
Huzzin' and maäzin' the blessed ground with the Divil's oän teäm,"

on the telescopes in Exhibition-road, which, besides other work, by long-exposure photographs have discovered for us new stars never yet seen in telescope by human eye; or on the galvanometers, whose ray of light aids all electrical industries by pointing out electric flaws in glass and porcelain which the microscope would mistakenly pronounce perfect.

England has just given the Rumford Medal to Prof. Hertz, of Bonn, for his splendid work on electro-magnetic radiation. Will England allow the short-sighted policy of Mammon—

"Mammon the least erected spirit that fell from heaven"—

to prevent Prof. Boys continuing his work on the same subject at South Kensington? We honour Cavendish for weighing the earth; and now, when Boys has discovered how to hang bodies (not human) by quartz fibres, and so to weigh the earth with far greater accuracy than Cavendish could have done had his attracting balls been the size of houses, shall Boys be prevented from using his own apparatus? Shall the analysis of alternate-current waves at the Central Institution be interfered with by other waves set up by the new burrowing earthworm? We can hardly think so, when we remember how even a dear old soul has just received the news that an underground railway is to run close against our national science schools and laboratories. She, like Huxley's chum Gallio, cares for none of these things, but she had the sense to observe promptly, "Why, it will make all the things wriggle inside."

To study one set of vibrations in the laboratories in Exhibition-road, when another disturbing set is super-imposed by the vibration of the building itself, will be like listening to a violin solo when a brass band is braying in the neighbourhood. A prince, the Duke of Edinburgh, renowned for his musical skill, and distinguished as a violin-player at the Albert Hall close by, might fitly take the lead in jealously preserving the possibility for scientific research, the importance of which his father would have been the first to recognise. Urania's voice is like Cordelia's, "ever soft, gentle, and low," and catch it the student never can if his beams of light when moving across his galvanometer and electrometer scales begin

"To trip it as they go
On the light fantastic toe."

Radio-micrometers, magnetometers, and every other meter the motion of whose index must be greatly magnified, will become simply museum specimens, illustrating the blindly commercial enterprise of Englishmen, who removed from Trafalgar-square the statue of Jenner, because he only showed us how to save countless lives in every country, and was not distinguished, like the people whose statues remain, by killing many to add to England's landed estate. The 3ft. telescope now being erected in Exhibition-road will, of course, become useless when the earth-shaking train goes whirling underneath it. Why not leave it at once, like a broken monumental column, to mark the spot where lies buried many a noble hope?

But those who know, from past experience, how "great effects from little causes spring," already ask whether the scientific education of many, and the carrying on of scientific researches, such as have already been conducted in the laboratories in Exhibition-road, may not be worth more to the nation than any number of twopenny-ha'penny railway fares.

And others, whose only claim to be heard is the possession of that rarest of all senses—common sense—ask, Can it be possible that the nation, after having spent such vast sums on the erection and equipment of these laboratories, will now permit them to be rendered well nigh useless?

To move the laboratories of applied science is as undesirable as it is now impossible. Lord Carlingford, at their opening, congratulated the nation that a site had been selected for them close to the Museums, and stated that the French had even just moved the École Centrale of Paris, so that it might be placed in close proximity to the Conservatoire des Arts et Métiers. It is not likely that we shall now reverse our policy, divorce our schools from our Museums, and in securing such a result, waste all that has already been spent. If a railway is needed between South Kensington and Tyburnia, let it go under Queen's Gate, and not "round by the Serpentine under the trees," as sung Lord Algernon. The muse utters a cry of distress, let us join with her in shouting—

"Procul, oh! procul, este profani."

## ELECTRO-MAGNETIC MECHANISMS.

### PRESIDENTIAL ADDRESS TO THE JUNIOR ENGINEERING SOCIETY.

BY PROF. SILVANUS P. THOMPSON, D.SC., B.A.

*Introductory.*

To the mechanical engineer the study of the electro-magnet presents many interesting problems. By its means power transmitted electrically along a conducting wire produces a mechanical motion. The conditions of that motion constitute in one sense a purely mechanical problem, though the electric and magnetic conditions under which the power is supplied, and upon which the motion depends, belong to electrical science.

Consider at the outset in what an electro-magnet consists. The magnetic portion of it usually comprises two parts, a fixed iron core, straight or bent, and a movable piece of iron called the armature, the two being themselves portions of a magnetic circuit. The electric portion of it is a coil of insulated copper wire, usually encircling the iron core with numerous convolutions. When an electric current is switched on in the copper wire it produces upon the iron core a magnetic action. The magnetising force of the coil is strictly proportional to the electric current that is flowing in the wire and to the number of convolutions which that wire makes around the magnetic circuit. But the amount of magnetism induced in the core is not simply proportional to the magnetising force alone: it depends also upon the perfection or otherwise of the magnetic circuit. If the magnetic circuit constituted by the iron core and its armature and the intervening air-gaps is of insufficient cross-section, or of poor quality of material, or of inordinate length, or if the gaps in it are considerable, then its reluctance to magnetisation may be so great that very little magnetism will be induced in it, even by the application of considerable magnetising power. The principle of the magnetic circuit, about which much must presently be said, is of the first importance as a key to the behaviour of electro-magnets. A second guiding principle is to be found in the tendency which a magnetic circuit exhibits to perfect itself. That is to say, a magnetic circuit when subjected to a magnetic force tends, if so arranged that any part of it can move, to so alter its configuration as to become as compact as possible. If the armature, for example, is movable, and placed at some little distance away from the ends of the core or cores, it will be mechanically urged into greater proximity, so that core and armature may together constitute, as nearly as possible, a closed circuit of iron. In doing so the armature performs mechanical work. The action of the common horse-shoe form of electro-magnet in drawing up its armature, as in the ordinary sort of electric bell, is an elementary illustration of this principle.

A second form of electro-magnet consists of a tubular coil of copper wire into the hollow of which a long iron plunger is drawn when the electric current flows around the coil. This coil-and-plunger species of electro-magnet possesses several mechanical characteristics which distinguish it from the horse-shoe form; but the principle of the magnetic circuit applies equally to both.

*Modern Views of Magnetism.*

Now, in dealing with magnetic circuits we must carefully cut ourselves off from those medieval notions about magnetism which still haunt the text-books of physics, according to which magnetism is regarded as a sort of fluid (or fluids) distributed over the end-

Digitized by Google

surfaces (or poles) of magnets. With the polar distribution of supposed magnetic fluids we have nothing to do. The alleged fluids are pure fictions; the existence of a polar surface is a pure accident. The most highly magnetised part of a magnet is usually that part which shows upon its surface not a trace of polar action. The particular form of iron core which can be more highly magnetised than any other, namely, an iron ring closed upon itself, has no magnetic poles. Magnetism is, in truth, an internal rather than an external phenomenon. It is possible to have a steel ring so magnetised that the magnetisation shall be entirely internal; the magnetic lines flowing around wholly within the metal, and never coming up to the surface. Of course such a ring magnet is incapable of attracting iron filings or of perturbing a compass needle. The evidence that such a ring is magnetised internally is very simple. If cut or broken across, such a ring forthwith exhibits polar properties at the cut surface. A pole or polar region of a magnet is simply that part of the surface where the internal magnetic lines emerge into the air. Only such parts—the surfaces of gaps in the magnetic circuit—exhibit any such properties as those to which formerly the virtues of magnetic fluid were attributed.

The appropriate modern mode of regarding magnetic phenomena is to consider the various materials—iron, steel, air, and the rest—as being in various degrees *conductors of magnetic lines*, magnetic lines being stream-lines in the medium, conventionally taken to represent by their number and direction the quantity and direction of the flux of internal magnetisation. Soft annealed wrought iron is, for example, an excellent conductor of magnetic lines, being more permeable magnetically than any other known material. Magnetic permeability is a term to which a precise numerical notion has been attached, being the ratio between the magnetising force and the resulting intensity of magnetic induction in the specimen. This mode of regarding the matter has resulted from the modern study of electro-magnetic apparatus. The necessity of such ideas did not occur to the earlier workers in magnetism who were dealing exclusively with magnets made of steel or of loadstone permanently magnetised. They thought of poles acting from a point, as it were, attracting a piece of iron at a distance from it. We, on the other hand, have rather to think of stresses in the path of the magnetic lines. Wherever there is a gap in the magnetic circuit between iron and iron there is a magnetic stress urging the configuration so to change as to close up the gap. This stress urges the armature of the electro-magnet toward the iron core. You may call this an attraction of the one by the other if you prefer that way of putting it. Only beware, for this attraction does not vary as the inverse square of the distance between iron and iron; it depends solely upon the intensity of the magnetic flux in the intervening medium being proportional to the square of that intensity. The space crossed by magnetic stream lines wherein such magnetic stresses are in action is known as a magnetic *field*.

### *Invention and Development of the Electro-magnet.*

Immediately following the discoveries in 1820 and 1821 by Oersted, Ampère, and Arago of the magnetic properties of electric currents came, in 1825, the invention of the electro-magnet by William Sturgeon, of Woolwich. The apparatus he first produced consisted of a bent iron rod, about 1ft. long and ½in. in diameter, varnished over and then coiled with a single spiral of stout uncovered copper wire of 18 convolutions. For the first time there was thus put into the hands of the electrician a magnet capable not only of being excited and discharged at will, but of being operated from a relatively great distance by means of the electric wire. Sturgeon constructed numerous electro-magnets, some of the bent or horse-shoe pattern, others with straight bars or rods of iron as cores. In those days, copper wire overspun with silk or cotton was unknown as an article of commerce, and gutta-percha coverings were as yet undiscovered. Sturgeon was content to use uncovered copper wire of considerable thickness, wound in one layer only. To excite the power of electro-magnets furnished with so few convolutions of wire, it was necessary to work with relatively large electric currents; and to this end Sturgeon devised special forms of voltaic cell. Such currents cannot be conveyed to great distances through thin wires; hence the distance from which such primitive instruments can be operated is very limited. This objection was removed in 1828 by Prof. Henry, who discovered the great advantage to be gained in distant working by increasing the number of convolutions of wire. He employed copper wire from 25 to 40 mils in diameter, covered with silk, and coiled on in many successive layers. Shortly after Henry's modification of the apparatus to the purpose of efficient working at a distance through long lines of wire, Joule made further modifications for the purpose of obtaining the greatest adhesive or tractive power: the special forms of electro-magnet which he devised being distinguished by the compactness of their magnetic circuit. Other workers, such as Roberts, Radford, and Romershausen, followed in the track. In the United States Page applied the coil-and-plunger form to the construction of electro-magnetic engines. Telegraphic needs led to the production of forms of electro-magnet adapted to rapid working. Other forms specially intended to secure a greater range of action or greater uniformity of pull within the range were developed under the necessities arising from the application of the electro-magnet in the mechanism of electric arc lamps. Of all these various matters I have lately treated at some length in my Cantor Lectures before the Society of Arts.

### *Analogies between the Electro-magnet and the Steam Cylinder.*

In moving, under the stress of the magnetic field, the armature of an electro-magnet may do mechanical work. The work done will, of course, be the product of the displacement into the average force. One is naturally led to institute a comparison between the work done in the stroke of an ordinary steam-engine piston and the work done in the stroke of the armature of an ordinary electro-magnet. In neither case is the force uniform from end to end of the stroke. In the case of the engine piston the pressure rises very suddenly at the beginning of the stroke, remains at its maximum for but a very short period, then falls continuously to the end of the stroke, the precise manner of diminution being dependent upon the mode in which the valve is constructed and adjusted, and upon the conditions of supply generally. In like manner the magnetic stress which urges the armature, varies from end to end of the stroke, but in a wholly different manner. At the beginning of the stroke, when the armature is at some distance away from the fixed core, the stress is small. As it approaches, the magnetic field between them becomes more intense, and the stress, which is proportional to the square of that intensity, grows greater, becoming a maximum at the point of nearest approach at the end of the stroke. The range of motion in the case of the ordinary electro-magnet is extremely limited, measurable in tenths, or more ordinarily in hundredths only, of an inch. This is due simply to the smallness of the stress when any considerable thickness of air is interposed. Herein arises so serious a disadvantage in the mechanical problem of utilising electro-magnets for motive power that the late Robert Stephenson once gave this as an emphatic reason why electricity could never compete with steam power. Many devices have been suggested for increasing the range of action of electro-magnets, of which more must be said presently. The coil-and-plunger form of electro-magnet, which has a much greater range of motion though with feebler average force, presents a still greater similarity to the cylinder-and-piston mechanism of the steam engine. In this case the length of stroke and the distribution of the force between the beginning and end of the stroke depend not only on the length of the tubular coil but on the length and shape of the plunger. With a cylindrical plunger of soft iron of a length greatly exceeding that of the tubular coil, the pull increases gradually as the end of the plunger enters the mouth of the coil, becoming a maximum just as it emerges at the further end, and thence falls off again rapidly. If plungers are used not greater than the length of the coil, they reach the position of maximum pull when they are immersed to about half their own length into the mouth of the coil. A simple way of testing the fact is afforded by hanging the plunger to an ordinary spring balance, and noting the pull exerted by the coil as the plunger is immersed to various depths, as in Fig. 1. A very short cylinder or a sphere of iron is only pulled just as it enters the mouth of the coil. With coned plungers the range is extended, long coned plungers being pulled with a force that increases even after their tip has begun to protrude through the end of the tubular coil.

It is extremely important to note that whereas the steam cylinder is, in almost all modern engines, the electro-magnet is, in all ordinary cases, a single-acting mechanism. The armature is drawn magnetically up, but not driven magnetically back. It is simply allowed to return, the electric current being cut off to enable it to move away. The only exceptions to this rule are to be found in the few cases where so-called *polarised* armatures are used; that is to say, armatures previously magnetised in a particular direction. These can be alternately attracted and repelled by reversing the direction in which the current circulates around the electro-magnet core.

This analogy between electro-magnet and steam cylinder is no unimportant one. To the electric engineer the electro-magnet with its armature constitute the central organ of all electric machinery. Just as the mechanical engineer must acquaint himself to the last detail with all that goes on in the cylinder, must experiment and study, by the aid of indicator diagrams, the expansion of the working agent, the effect of the lap and lead of the valves, of fluid friction in the port-holes, of rapid condensation of the exhaust steam, and the like, so the electrical engineer must resort to experimental study, and use diagrams to enable him to follow the operations of the electro-magnet, must watch the progress of magnetic saturation of the core, ascertain its retentiveness, observe the effect upon its performance of varying the configuration of the parts, of throttling the induction by insufficiency of section, and the like.

Digitized by Google

*The Principle of Reversibility.*

Far as these analogies have been traced, they may be carried one stage further. The principle of reversibility which holds good of the steam cylinder, holds good of the electro-magnet also. In its usual function the cylinder and piston mechanism of the steam-engine serves to convert the latent energy of the steam under pressure into mechanical work; but the very same mechanism is capable of serving the inverse function of employing mechanical power to compress steam, air, or any other gas. The pump is the inverse of the engine in its functions; its action is simply the action of the engine reversed. From the thermodynamic point of view the action is equally inverse. In the engine heat is converted into work, or in other words, entropy is let down from a high temperature to a low one, thereby furnishing energy to a mechanical system. Reversing the action, energy furnished by a mechanical system is employed to transfer entropy from a low temperature to a high one, and the apparatus becomes a machine for artificial refrigeration.

Turning to the electro-magnet, energy furnished by letting electricity pass from a high potential to a low one is employed, magnetically, to produce a mechanical motion, and so to perform work. Reversing the action, energy furnished by a mechanical system is applied to an apparatus consisting of magnetic circuits and copper wire coils, which thereby becomes a machine for pumping up electricity from

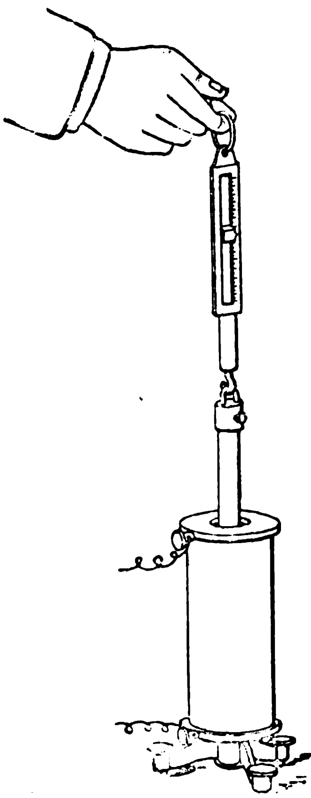


Fig. 1.

a low potential to a high one; in other words, it become a source of electric currents. The modern dynamo machine is simply an electric engine—a combination of iron cores and copper coils—capable of serving in either of two functions, as generator or as motor, each the inverse of the other.

*Relation between Magnetising Force and Magnetism.*

It is time to return to the principle of the magnetic circuit, briefly enunciated above, and to re-state it in more precise terms. The number of magnetic lines that will be evoked in any given magnetic circuit is directly proportional to the circulation of the surrounding electric current, and inversely proportional to the magnetic reluctance of the iron and air-gaps of the magnetic circuit. It is usual to specify the circulation of current in *ampere-turns*, meaning thereby the product of the amperes into the number of turns of wire in the coil. The reluctance of the magnetic circuit must usually be calculated in parts, to be added subsequently together, allowance being made for leakage of magnetic lines. The reluctance of each part is proportional directly to its length, inversely to its cross-section, and inversely also to its permeability.

All known substances possess permeability, none having yet been discovered that is impermeable to the flux of magnetic lines. The vast majority of media—including air, all gases, all liquids, all organic solids, all compound bodies save three, all metals save three—have a small and constant permeability, not differing sensibly from that of vacuum. The exceptions that have a relatively large and variable permeability are the three metals—iron (including steel), cobalt, and nickel (possibly also chromium and cerium), together with some of their alloys, and the compounds, loadstone (triferric tetroxide), pyrrhotine (magnetic pyrites), and ferroso-cobaltic oxide. Of these only iron need be here considered.

*Magnetic Qualities of Iron.*

Different specimens of iron differ widely in their permeability. Moreover, the permeability in any given specimen of iron varies with its degree of magnetic saturation; a sample that is already well magnetised being much less permeable than one that is less highly magnetised. Approximately the permeability of a specimen is proportional to the difference between the actual magnetic flux through it, and the maximum flux that can be forced through it. A certain specimen of annealed wrought-iron for example, which became saturated to a practical maximum when permeated with 18,000 lines per square centimetre, had at 17,000 lines per square centimetre a permeability of 161, and when only pushed to 16,000 lines per square centimetre, had a permeability of 320. The intensity of the magnetising force at any point, usually denoted by the letter H, is often expressed by saying that it would produce H magnetic lines per square centimetre if acting on an air core. Now, if the space were occupied by a core of iron instead of air, there would be produced by the same magnetic force a larger flux of magnetic lines per square centimetre. This larger number expresses the degree of magnetisation of the iron (also called the magnetic induction in the iron); it is denoted by the letter B. The

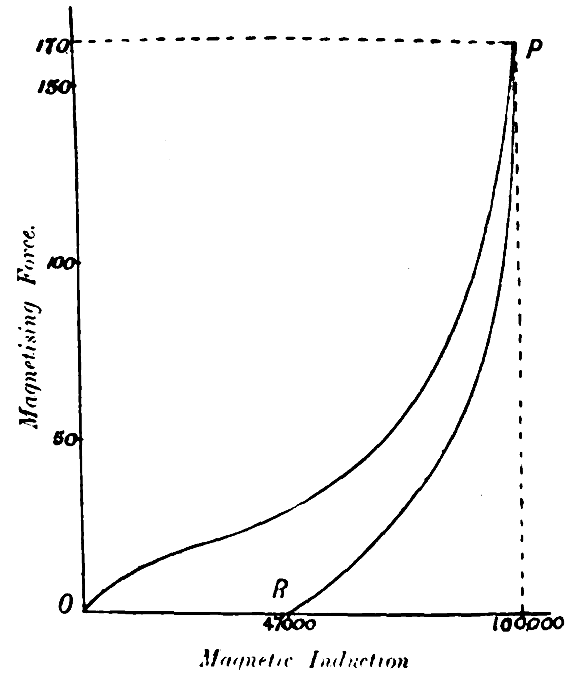



Fig 2.

ratio of B to H expresses the permeability of the material at that particular stage of magnetisation. To ascertain the magnetic properties of any specimen, a series of observations must be made with various intensities of magnetic force. In any complete research a number of such series have to be made at different temperatures; as certain materials, notably the alloys of iron and nickel lately investigated by Dr. J. Hopkinson, change their magnetic properties much when heated. A series of such observations made by Dr. Hopkinson on a specimen of wrought-iron are represented by the curves in Fig. 2. Two liberties have been taken with this figure. In the first place, the numbers plotted out are the numbers of magnetic lines per square inch, instead of the usual numbers per square centimetre. In the second place, the magnetic forces are plotted vertically, and the resulting induced magnetisation horizontally, the converse to the usual mode of plotting. The curve that starts from O represents the set of observations made with magnetic forces gradually increasing to about $H_{\prime\prime} = 170$, when the resulting number of magnetic lines per square inch in the iron is about 100,000. It will be noticed that when the magnetising force $H_{\prime\prime}$ approaches the value of 100, the curve becomes very steep, any further increase producing relatively little increase in the magnetisation. The second curve represents the result of then decreasing the magnetising forces back to zero, when there remain behind a

residual magnetisation of no fewer than 47,000 lines per square inch. To remove these would require the application of a reversed (or negative) magnetic force of about $H_H = -13$.

Applying the principle of the indicator diagram to these curves, it will be seen that the area below the first of these curves, down to the zero line, and bounded on the right by the ordinate of the point P, represents the integral product of magnetic force into magnetisation, and is consequently proportional to the work done (per cubic inch of the iron) in bringing about the magnetic state of things implied by the position on the diagram of point P. Similarly, the area under the descending curve represents the work restored in the demagnetising of the specimen down to the state of things represented by the point R, when the magnetising force has been removed. The narrow area enclosed between the curves represents the work not so restored, and for the expenditure of which the residual magnetism is all that there is to show. If the magnetising forces are carried through a complete cycle of alternations from $+H_H$ to $-H_H$ and back, the resulting magnetisation goes through a corresponding cycle, with the result that a definite closed area is completed between the curves in the diagram (Fig. 3). Were there no lagging in phase of the magnetisation behind that of the magnetising force, the ascending and descending curves would coincide instead of enclosing an area. Some specimens of magnetic material—particularly pure octahedral crystals of magnetic iron ore—show no such lag. They exhibit practically no residual magnetisation. The phenomena of lag have been studied particularly by Prof. Ewing and by Dr. John Hopkinson, to the former of whom we owe the term *hysteresis* to denote this lagging

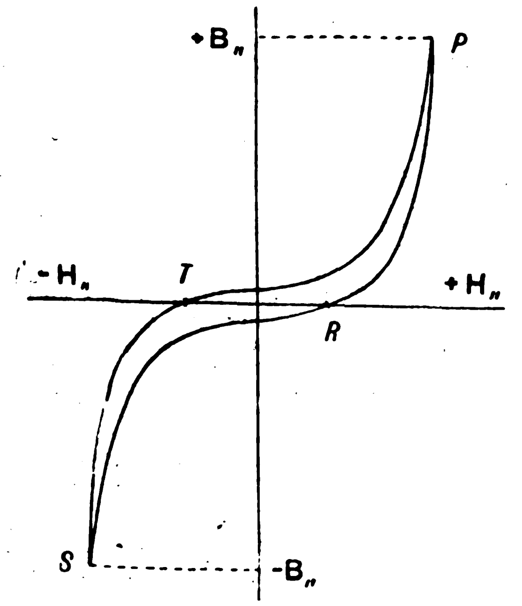



Fig. 3.

of effects behind the phase of their causes. When a specimen of iron is carried through such a complete cycle of magnetisation, and brought back to the same magnetic condition as that from which it started, there is nothing to show in the way of residual magnetisation; for in half the cycle work is spent in producing such a residuum, and in the other half work is spent also in destroying the residuum. In fact, the enclosed area represents the work lost by hysteresis. Its only effect is to heat the material; hysteresis being in magnetic problems as molecular friction in the problems of elasticity, always the cause of work being wasted.

*(To be continued.)*

**Royal Institution.**—The following are some of the Friday evening lectures which have been arranged for before Easter. On January 23rd Lord Rayleigh will lecture on "Some Applications of Photography;" Prof. J. W. Judd will, on February 6th, lecture on "The Rejuvenescence of Crystals;" while on Friday, March 6th, and on Friday, March 20th, respectively, Dr. Fleming will discourse on "Electro-magnetic Repulsion" and Prof. Ayrton will tell us all about "Electric Meters, Motors, and Money Matters." Commencing on Saturday, February 14th, Lord Rayleigh will deliver a course of six lectures on "The Forces of Cohesion."

## TELEGRAPHIC TRANSMISSION ON LONG SUBTERRANEAN LINES WITHOUT THE USE OF RELAYS.*

As is generally known, telegraphic transmission is not so easily carried out on long subterranean as on aerial circuits. On underground circuits of less than 190 miles retardation phenomena are scarcely noticeable, but for greater distances than this, electrostatic effects become increasingly troublesome, and since the underground telegraph system of Germany has assumed large proportions, the authorities have tried to annul these pernicious phenomena in a variety of ways. For instance, a short path to earth has been offered after each signal at either end of the line to the discharge current; alternate current working has been attempted, and condensers have been used to neutralise the charge of the cable by one of the opposite sign from the condensers. None of these methods, some of which involved the addition to the

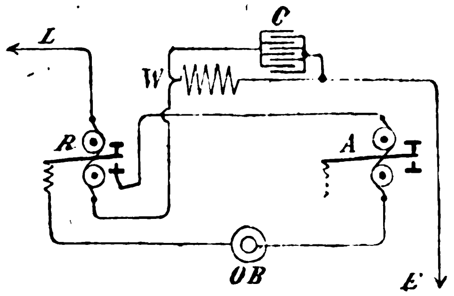



Fig. 1.

ordinary instruments of costly and cumbersome apparatus, fulfilled the desideratum of enabling messages to be transmitted as quickly and clearly as on overhead circuits of equal length. The most efficacious method was considered to be the employment of relays at every 100 or 150 miles, and even then the rate of transmission was considerably less than on overhead lines. Recently an apparatus was devised by Delany, of New York, which, although intended primarily for use on long submarine cables, seemed equally suitable for subterranean work. By means of the Delany key (for full illustrated description, see *The Electrician*, Vol. XXI., p. 242) we can, it is true, send Morse signals much quicker than has hitherto been possible, but it necessitates the employment of complicated apparatus, liable to get out of order. The engineering staff of the German Post Office, therefore, who had been ordered to investigate the practical value of the Delany device, set to work to try and obtain the same result in a simpler manner and without altering the instruments at present in use. Now, augmentation of the speed of transmission depends on realising three conditions: (i) Decrease of battery resistance;

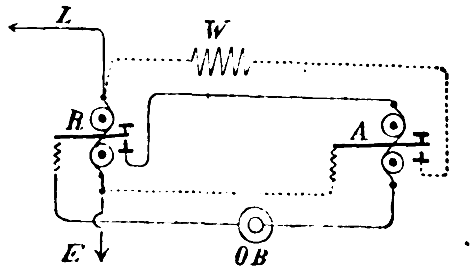



Fig. 2.

(ii) Acceleration of the discharge of the cable; (iii) Compensating the self-induction of the receiving apparatus. It is easy to fufil the first condition, either by arranging the cells in parallel or by using secondary cells. The disturbance produced by self-induction is connected with the effect of the cable discharge. The tongue of a sensitively adjusted relay should fall and close the local circuit as soon as the first part of the current reaches the receiving end; but the release of the tongue is retarded by the discharge current, and this retardation is prolonged by self-induction. To neutralise these effects recourse may be had to an old device proposed by Maxwell.

In this arrangement a resistance W, in shunt with a condenser C, is placed between the receiving relay R and earth E (Fig. 1). The resistance must bear a certain definite relation to the capacity of the condenser, which relation has to be determined by experiment. The installation of a condenser in the first place permits of a more rapid rise of current at the receiving end, since it fulfils during the first instants of charging the functions of an earth. The attraction

* Abstract of a paper read by Herr Grawinkel, chief engineer to the German Post Office, before the Berlin Electro-technical Society.

Digitized by Google

of the tongue of the relay is thus favoured. Moreover, the discharge current of the condenser and the "extra-current" from the line are mutually destructive, and the disappearance of the magnetism is thus accelerated.

In the first experiment with this arrangement the Berlin-Hamburg cables were looped, forming a circuit 272 miles and having a resistance of 5,151ω and a capacity of 150 microfarads. In the second experiment the Berlin-Frankfort cables were looped: length 350 miles, resistance 4,279 ohms, capacity 120 microfarads. The resistance of W was 9,430 ohms, and the capacity of C 20 microfarads. Fifty Tudor accumulators were employed, reinforced by 40 primary cells. In the first case 300 primary cells arranged 100 in series and three in parallel were used.

So far as speed of transmission was concerned these experiments were satisfactory. Representing the ordinary rate of transmission of Morse signals, without translation, by 100, the speed of transmission when a shunted condenser was used was 131, or nearly 30 per cent greater. It must, however, be remembered that the ratio of W to C has to be determined in each individual case, so that the use of this method does not tend to certainty of transmission, and it may derange the working of the line. Attempts were, therefore, next made to attain the same increase of speed without condenser, and this result was finally attained by the very simple arrangement shown in Fig. 2.

In shunt with coils of the relay a variable resistance W is placed, and this resistance only comes into play when the "inker" operates. The effect of this arrangement is to accelerate the discharge of the line. When the current wave at R has attained sufficient strength to work the relay, the Morse recorder A operates. The remainder of the wave then divides, some going to E *viâ* W. The current in R is of course diminished the smaller W is made, and the release of the tongue is thus hastened. The tongue must not, however, be released before a proper Morse signal has been recorded, and the resistance of W must, therefore, be properly proportioned to that of R. It has been found useful to prolong the effect of the shunt circuit, which can be effected by fixing a light spring to the lower end of the "inker" lever so as to hasten the closing of the shunt circuit. If this circuit is of too low resistance the tongue of the relay is released too soon, while if the resistance of W is properly adjusted the current flowing in R, together with the "extra current," act long enough to allow a signal to be produced.

Favourable results have been obtained with this arrangement in transmitting Morse signals without translating devices over a subterranean line connecting Berlin and Frankfort. The relative speeds were: ordinary Morse, 100; condenser and resistance method, 131; arrangement shown in Fig. 2, 145. Further tests of this method on underground lines have shown that Morse signals can be transmitted at the same rate as on overhead circuits up to distances of more than 375 miles, and that on longer an increase of speed of 30 per cent. is obtainable, when compared to the old device of fixing relays at every hundred miles. When a line is more than 625 miles (1,000 kilometres) long it is advisable to instal midway a relay on the shunt principle. One circumstance which contributes in a great measure to acceleration of transmission is that it is no longer necessary to employ such sensitive relays as formerly, sticking of the relay tongue and the consequent blending of signals is thus avoided. Readjustment of the relay is also less frequently needed. Let us hope that this new device may be equally applicable to the transmission of Hughes signals on underground circuits.

## THE OPERATION OF ELECTRIC RAILWAYS.*

In spite of the fact that over 200 electric railroads are to-day in actual operation, comparatively little concerning the practical details of operation has been made known. In the present state of the art railway managers go in for results rather than methods, and in spite of some crudities the results have generally been extremely satisfactory. We have much to learn, however, regarding the true inwardness of electric railway operation. With a view of finding out in a general way as many facts as could be readily obtained with respect to the operation of the modern electric railroad, the *Electrical World* recently sent out to a very large number of electric railway managers a blank containing a list of questions, with the request that the questions be answered and the blank returned. The questions asked were the following:—

1. What system do you use?
2. How many miles of track have you?
3. How many motor cars?
4. What is the average daily mileage per car? Total mileage?
5. What is your steepest grade; does it trouble you in bad weather?
6. What is the total capacity of your dynamos?
7. What is your usual actual station voltage?
8. What is the make and rated horse-power of your engine or engines?
9. Have you tried track or power brakes; if so, with what result?
10. Have you tried cars fitted with a single motor, and with what result?
11. What increase of gross receipts has followed the adoption of electricity?
12. Have the total expenses increased or decreased, and to what extent?
13. What proportion of total expenses is due to repairs on your equipment?
14. What is the average cost of power per car per day?
15. What kind of gearing do you prefer, and what is the usual life of a set of gears?
16. What damage has been done your cars, lines, or stations by lightning?
17. How do the citizens regard the introduction of overhead wires?
18. Do your lines cause trouble with the telephone service, and is the most of it due to earth or to induction?
19. Have any serious shocks been received by *employés* or public?
20. What do you consider the weak point of the particular system which you use?

* From the *Electrical World* of New York.

These last 10 questions were strictly confidential, and consequently in what follows no company or system will be referred to.

Up to date 85 replies have been received from all parts of the country and practically all the systems in use. Eight systems are included in the list of replies; of these 33 were from Thomson-Houston roads, 25 from Sprague, 5 from Rae, 3 from United Electric Traction Company, 2 each from the old Daft and the Short roads, and 1 each from Van Depoele and storage systems. Detailed statements of mileage have been received from 64 roads. Of the figures given the largest was 150 miles per day, reported by two roads. Three others were close behind in the race with 140, and from that the figures run down to as low as 43, most of them, however, ranging between 90 and 100. The two highest figures came from two different systems—one of them a Rae road operating five cars over nine miles of track, the other, a Thomson-Houston road, with 44 motor cars and 25 miles of track. Taking the average of the 64 roads, the mean daily mileage per car is 101. This large figure may be borne in mind with reference to the answers of some of the succeeding questions, as it has an important bearing both on the increased receipts and the occasionally increased expenses.

Eleven per cent. is the heaviest grade reported, though a number of roads are not far in the rear with 10 and 9 per cent. grades. As regards any trouble experienced in running up these heavy grades, the uniform experience has shown that there is very little difficulty encountered, with a judicious use of sand for occasional aid. If we may judge anything by the results obtained with locomotives, the coefficient of adhesion is in excess of 20, although it is quite probable that in a motor car the weight may not always be distributed to the best advantage. At all events, there is every reason to believe that a motor car alone can mount a grade decidedly steeper than any that have yet been attempted. Of course, the use of trailers brings down the maximum possible grade, but the experience of the numerous roads that have reported makes it tolerably evident that 10 per cent. is quite practicable in any ordinary weather.

The total capacity of the dynamos brought out some rather instructive replies, so far as the question of efficiency is concerned. The allowance of power in station capacity per car varied considerably, ranging from less than 10 to over 20 horse-power for each motor car. Roads showing the latter figure might reasonably be expected to show considerable loss in the station from habitual underloading of the dynamos, especially as most of these were rather small roads, where the variations in power are necessarily great and the average load consequently light. Where a small road provides 20 electrical horse-power per car the dynamos are necessarily worked at considerable loss of efficiency. Although the indications thus point to habitual underloading of the dynamos, this state of things is far more noticeable in the matter of engines It is not at all uncommon to find engines reported having a rated capacity 50 per cent. in excess of the full rated capacity of the dynamos. Inasmuch as the full capacity of the engine is usually much greater than its rated capacity—the latter being in general engineering practice based on a cut-off of about one-fourth—it is safe to say that the loss from engine to electrical energy on the line—in other words, loss of efficiency—is much greater than it should be or will be as the real condition of things is better understood.

The prevalence of this state of things is due probably to a large variety of causes. There is a certain feeling that an engine must be big enough to do considerably more work than it will be ever called upon to do, and at the same time it frequently happens that in equipping a power plant allowance is made for the possible contingency of increase in plant at some future time. Under certain circumstances it may be advisable to put in a large engine with this in view, but there are plenty of cases where the increased cost of fuel entailed upon the system by this arrangement would more

than pay for an extra engine. A 50,000-watt dynamo, unless it is the intention to overload it, does not call for an 80 or 90 horse-power engine, provided the latter is properly constructed. The nominal horse-power reckoned as usual at one fourth cut-off, is about the point of maximum efficiency of engines with the steam pressures generally used, and underloading has a worse effect on economy of fuel than overloading. It is safe to say from the figures that have been brought in that the average efficiency of the station, that is, the ratio between the indicated horse-power of the engine and the electrical horse-power of the line, is from 10 to 25 per cent. less than is practicable with a more economical design. Practice is apparently improving, but there is much left to be desired yet. One of the worst cases in the matter of station efficiency was a road operating three motor cars and provided with an engine of 125 horse power. It is safe to say that under these circumstances, particularly as the grades upon the road were light, not more than one-third of the indicated horse-power at the engine appears as electrical energy on the line, and the total efficiency from engine to car wheel cannot well exceed 20 per cent. There are other cases very nearly as bad. A far better specimen of practice is found in several roads that report compound engines of the same rated capacity with the dynamos, and a fine example appears to be under way in a 25-car road having dynamos of a capacity of 420 horse-power operated by a Corliss engine rated at 300. This arrangement means that the full capacity of the engine, assuming the usual standard cut-off, would be very nearly the full capacity of the dynamos, which in a road of that size is certainly good practice.

With reference to the question of track or power brakes no very satisfactory results have appeared.

With regard to question 10, a considerable proportion of the roads that have reported up to date have had some experience with cars deliberately fitted with a single motor, and the general consensus of opinion seems to be that such an arrangement is advantageous where the grades are not heavy. One large Sprague road is fitted entirely with single motors, and reports the best of success. There is every reason to believe, theoretically and practically, that where it is possible to do the work with a single motor the arrangement is most desirable.

Next passing to the second series of questions, there is but one verdict concerning the effect of electricity on the earnings of the road. Of course a considerable number of the systems which replied to the questions were started as electric roads, and consequently could report nothing. But in every case where there was any response from roads which had previously used horses the increase in gross receipts was most marked, ranging from 10 to 500 per cent. Most of the figures showed at least double the traffic that had previously been obtained. This is only what might be expected in view of the very considerable increase in mileage. The adoption of electricity practically doubles the carrying power of a road.

With respect to the total expenses under the electric systems, three or four reports of decrease came in, but the vast majority showed a slight increase. Not enough figures were obtained to permit of a fair average, but 10 per cent. of increase in total expenses would be a fair estimate. To off-set that we have something like 100 per cent. increase in receipts. This is as might be expected; a very great increase in total mileage and carrying capacity is naturally followed by some little increase in wear and tear, and it is not at all remarkable that the cases of actual decrease have been comparatively few. It must be noted, however, that the actual increase in expenses is so small that there is the best of reason to believe that the balance will universally swing the other way as the conditions of economical operations come to be better understood. The increase in net receipts in every case is most marked.

With respect to the cost of power per day, a great many roads were not in a position to give it with any accuracy. Thirty-eight full replies, however, were received covering this point. They ranged from 50 cents per car per day—to which was added the sententious remark, "We burn culm"—to $7 per day in a portion of the country where coal is necessarily very high. The average cost of power per day in 39 electric roads of all sizes, systems, and in all parts of the country, amounts to $2.13 per car per day; and, reducing this to car miles from the figures obtained from these same 39 roads, the average cost of power per car per mile appeared to be 2.024 cents—certainly not an excessive figure.

Comparatively few replies were obtained to question 13, only 20 of the systems giving a definite response. These 20 presented the widest variation, the figures ranging from 1 to 50 per cent. The general average of the 20 indicated that repairs amounted to 18 per cent. of operating expenses.

In the matter of gearing it is only too evident that there is much improvement to be made. All the companies which answered this question at all seemed to be of the opinion that our present system of gearing is not what it should be. Four to six months seemed to be the general life of a set of gears. That stripping has not yet been overcome is evidenced by one remark to the effect that the life of a gear wheel varied from two minutes to a year.

The answers to the 16th question, too, bore on this question of repairs, for a considerable number of reports of serious damage from lightning came in; field coils, motor armatures, and generator armatures share about equally in this particular.

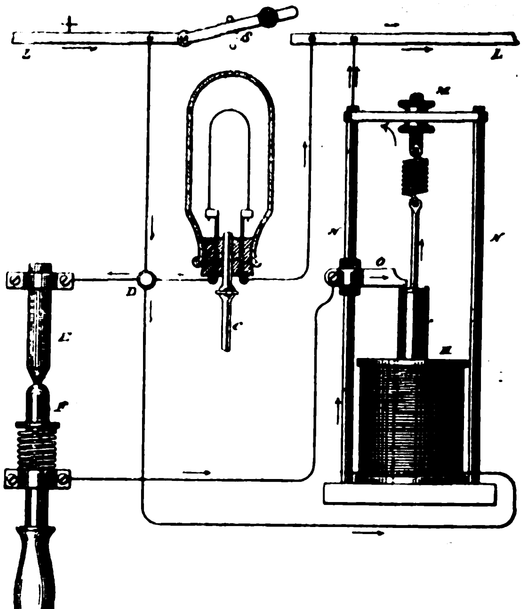
Question 17 was answered favourably in nearly every case. Throughout the country apparently the people are becoming reconciled to the overhead wires, regarding them as certainly desirable in default of any more convenient system of supply.

With respect to the trouble with the telephone service little information was obtained—none of it of value; and the same is true with regard to question 19. No serious results of shock were reported in any case, bearing out the general experience that the current used on street railway lines is not of sufficient voltage to be dangerous.

Question 20 might have been productive of very instructive results, but as a matter of fact the inferences that could be most clearly drawn from the replies received were that the weak point of the modern electric railroad on any and every system is the gearing. In addition to this, there were complaints of badly-constructed armatures and of great susceptibility to the destructive effects of lightning. It is unfortunately only too evident that lightning arresters do not always do their work. The large shunt-wound generators used in railway plants are particularly thin-skinned as regards lightning, so far as we can judge from the results of experience, and arresters which work successfully in other cases often fail here.

## AUTOMATIC FILAMENT-FLASHING APPARATUS.*

The object of the device illustrated in the cuts is to so control the filament flashing process that when the filament reaches the desired resistance it will be automatically cut out of circuit. In using this apparatus, which is the invention of Hermann Lemp of Hartford, Conn., a constant current is employed. A number of the devices for flashing two or more filaments may be therefore arranged at the same time in series.



Referring to the cut, the construction of the device will be readily traced out. The operation of the apparatus is as follows: When the switch S is thrown open, the current splits at D into three portions. One of the portions passes through the carbons E F to the insulated contact-arm O, and thence by way of the core and spring to the frame N, and then to the negative terminal of the line L. This circuit, when intact, is of low resistance. Another portion of the current passes by way of the high-resistance solenoid H, to the frame N to the negative terminal of the main line. The third portion of the current passes through the filament B to the same terminal. The arrows in the figure indicate the paths of the current.

When it is required to flash a filament, the parts are in the position shown in the drawing, an initial filament having been sealed in the globe and a hydrocarbon vapour or liquid passed into the globe through the pipe C. The carbons, E and F, are now separated so as to draw an arc of gradually increasing resistance. This forces the current through the solenoid H, and through the

* From the *Western Electrician*.

Digitized by Google

filament. The latter is now rendered incandescent by the passage of the current and decomposes the hydrocarbon. This action causes a deposit to be made on the filament. The solenoid H also becomes energised, drawing down the core and breaking the contact at O. The continuity of this circuit is thus destroyed, as is the arc between the carbons. The filament at the start being at its highest resistance, causes the greater part of the current to pass through the solenoid and draw the core down to its lowest point. As the deposit upon the filament decreases its resistance and the difference of potential between its terminals also decreases, the core in H will gradually rise until it reaches its highest point. It will then come in contact with the insulated arm O, and automatically shunt the filament, the carbons in circuit having been allowed to assume their normal position after the arc goes out. This operation may be timed by adjusting the apparatus so that the filament will be shunted when it has reached any desired cross-section. The thumb-nut N can be regulated so as to produce this effect, or the solenoid H adjusted for this purpose. It is necessary that the filaments be of a certain standard length; otherwise the variation in length, giving rise to a difference of resistance, would interfere with the successful operation of the apparatus. This method the inventor claims makes the flashing of filaments entirely independent of the pressure of the hydrocarbon gas, its temperature, and the time of flashing.

## SABLE ISLAND.

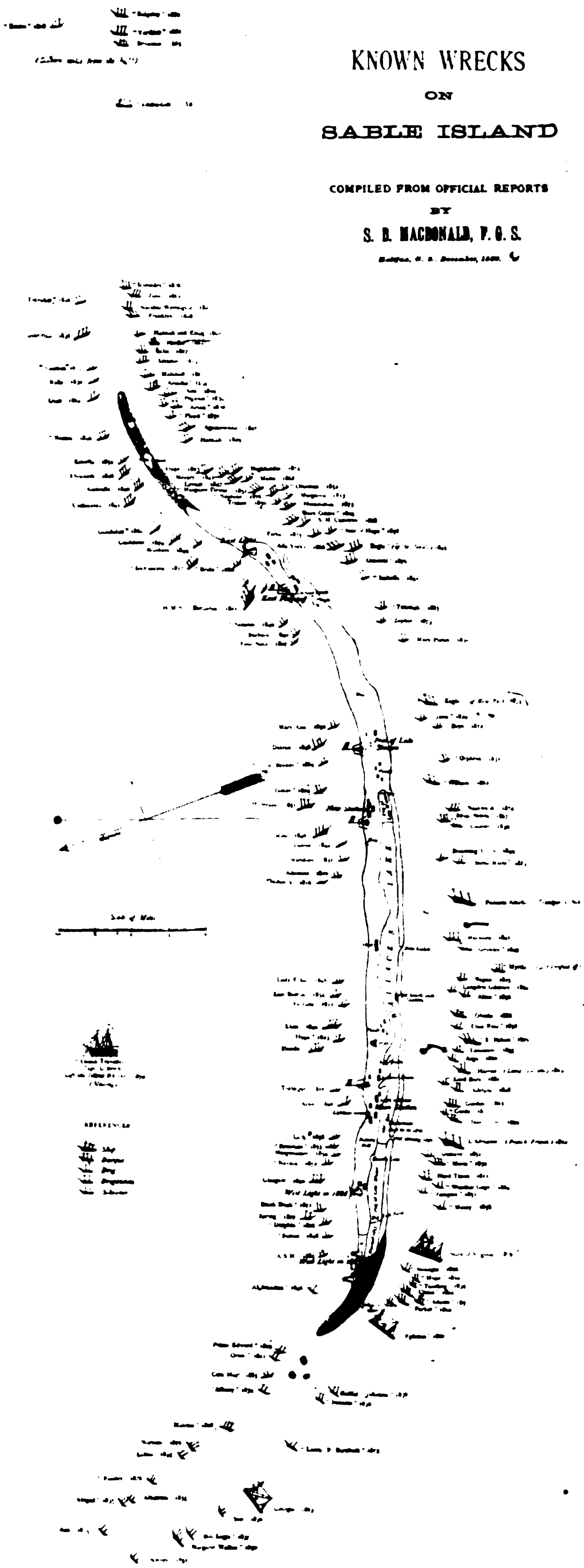
In the course of a review of the telegraph system of Denmark in these columns some months ago, it was pointed out how much credit was due to the Danish Government for connecting the lighthouses and shipping and fishing stations by telegraph and telephone in the interest of the maritime population. We give on the opposite column a sketch of Sable Island, the "graveyard of the Atlantic," showing the various *known* wrecks which have taken place there in past years. Our object in calling attention to the subject at the present time is to urge upon the Imperial and Canadian Governments the desirability, and even necessity, of connecting this dangerous sandbank, for it is little more, with the Government telegraph system, so that help might be promptly despatched to the scene of a wreck or other maritime disaster, in order to effect the saving of life and property when emergencies arise.

The following description of Sable Island has, at our request, been kindly supplied by Mr. F. N. Gisborne, the head of the Canadian Government Telegraph Department, and will be read with interest by many of our readers.

The island is situated in the Atlantic Ocean, about 85 miles from White Head and 150 miles north-eastward of Halifax, Nova Scotia; is a long, narrow, sandy elevation, formed of two nearly parallel ridges, somewhat in the form of a crescent, concave to the northward, and meeting in a point at either end, with sand bars or spits running out from them, over which the sea breaks with great fury during stormy weather. It is about 22 miles in length and scarcely exceeds one mile in width in the widest part. In some places it is wholly or partially covered with coarse grass, in others thrown up into sand hills, none exceeding in height 75ft. above high water. In the middle of it, and between the ridges, there is a long, narrow salt-water lake, about 14 miles long, towards which, on the south side, the sea is gradually encroaching, sweeping, during heavy gales, completely over the bank of sand which separates it from the ocean.

When seen from the north at a distance of ten miles, the island presents the appearance of a long range of sand hills. From the south the range has a more continuous appearance, and on the west sinks very low. The sand hills have in many places formed steep cliffs next the sea; whilst in others they are covered with coarse grass, and are defended by a broad beach which cannot, however, be reached without passing over ridges of sand covered by only a few feet of water. These ridges, which are parallel to the shore at distances not exceeding one-third of a mile, are dangerous to pass in boats when any sea is running. Spring tides rise about four feet, and the ebb sets to the southward at one and a-half to two knots, and the flood at a much less rate in a contrary direction. At each end of the island are dangerous bars, the north-west bar being dry for three-quarters of a mile, succeeded by nine miles of foaming breakers in rough weather, while the north-east bar is dry for four miles, succeeded by 10 miles of breakers.

There being no harbour of any kind around the island, vessels calling anchor one or two miles distant from the shore, and run for shelter to the mainland or out to sea upon the approach of on-shore winds. A reference to the wreck chart will show how the island is gradually wasting away by the action of the sea at the western end, and extending at the eastern end. The average number of ascertained wrecks on Sable Island for some years past have been two annually; but there is frequently sad evidence of additional losses on the bars in the shape of fragments of vessels, or of their cargoes, coming ashore, and many a good ship has come to an untimely end without a soul who was on board surviving to tell the tale.




Two powerful lighthouses have been erected at either end of the island, and at the central station lifeboats, &c., are maintained. A telephone line connects these establishments; but the main desideratum still lacking is a submarine cable connection with Nova Scotia, say 100 miles in length, by means of which timely notice of

Digitized by Google

**wrecks and required assistance could be given, and one or two trips per annum would provide all necessary supplies for the maintenance of the establishment. It is a source of much surprise in the maritime world that such a modern necessity has not already been provided for by the Imperial and Canadian Governments, and should the publicity which the subject is now likely to receive in this country have the desired effect of securing the establishment of the much-needed cable communication, one of the dread dangers of the deep will be minimised.**

**The cost of 100 miles of cable of a type suitable for the somewhat shallow water, manufactured in England, would be about £15,000, and the expense of laying, if a ship were sent specially from this country for the purpose, say, £5,000. If, however, advantage were taken of a vessel proceeding to repair one of the Anglo-American Telegraph or Direct United States Cable Companies' lines in the neighbourhood, the submerging of the cable in question might be effected for £1,500, making a total cost of, say, £16,500.**

**It may be pointed out that submarine cables are becoming much more costly year by year, owing to the great rise in the price of copper as compared with two years ago and the increasing scarcity of gutta-percha, for which, in the manufacture of cables, no substitute has yet been found.**

## THE RONALD'S LIBRARY.

Many of our readers, and some of its members, have never had an opportunity of visiting the habitation of the Institution of Electrical Engineers in Broad Sanctuary. The Sanctuary was one of the privileged precincts. It was under the protection of the abbot and monks of Westminster. Skelton, the satirist, took shelter here from Cardinal Wolsey. The

privilege survived the Reformation, and many of the houses which composed the precinct were not taken down till 1750. The offices of the Institution consist of three rooms, soon to be vacated: the secretary's private room, the Council room, and the Ronald's Library. The library, bearing the name of its founder, consists of a very fine collection of books on electrical science, and was bequeathed to the Institution. The contents are chiefly of historical interest, and the library is not kept up to date with modern books unless they are presented by their authors. Through the courtesy of Messrs. Cassell and Co., we are able to reproduce an excellent engraving of the Library, which appeared in *Cassell's Family Magazine*.

## BOOKS, &c., RECEIVED.

"Calvert's Mechanics' Almanack, 1891." (London.)

"May's Popular Instructor for the Management of Electric Lighting Plant." (Frankfort).

## AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *December* 12, 1890.

**The New York Subways.**—The combat between the City Government and the Consolidated Subway Company, on the one hand, and the electric light companies on the other, continues. At a meeting of the Board of Electrical Control, Dec. 10th, the proposition previously brought forward to turn over the low tension subway construction to a new company was brought up, and a resolution granting the consent of the Board of Electrical Control was presented. Before it came up for consideration the Mayor was served with an injunction obtained in the interest of some of the electric light companies, restraining the Board from making any contract with the new company, or from relieving the old company of any of its obligations, or from making any bargain for subways with any person or corporation engaged in the business of supplying electricity in competition with other companies. This is aimed directly at the Empire Company, which is made up, as was mentioned in my last letter, of people interested in the telephone and telegraph companies. Mayor Grant then arose, and moved to fix a new rental for the subways. This was done, and the expected reduction hardly took the form which was hoped by the electric companies. The proposed prices were for 3in., 2½in., and 2in. ducts respectively, at $900, $800, and $700 per month. This proposition is equivalent to continuing the old oppression that has been so bittterly complained of in the past. The municipal authorities have peremptorily refused the bids for city lighting offered by the various companies; they seem to think that they will be able to force by various oppressive regulations the furnishing of light at the same price as before the wires were put underground. If free permission had been granted to the illuminating companies to do their own subway construction, it might have been possible to furnish light at the old prices; but with the ring and the Subway Company united to extort every possible dollar for conduit rents, there is little prospect of any such peaceable settlement. The whole matter will go before the courts for decision, and with a promise of bitter and prolonged litigation.

**Decline in Price of Electrical Stocks.**—Just at the present time there is a serious decline in the price of electrical stock. Large companies and small alike are included in this unhappy movement, and rumoursare flying about that at least one of the important companies is in a very tight place financially. In spite of the good prices obtained for electrical machinery, reckless competition has reduced the funds available for carrying on business. It is an open secret that sales are frequently made on the basis of not more than 25 per cent. in cash, the remainder being taken in bonds of the company to which the apparatus is furnished. This sort of thing cannot go on indefinitely without causing trouble, which has apparently come already.

**The Rochester (N.Y.) Power Station.**—One of the largest power stations in use to-day is that of the Electric Railway Company in Rochester, N.Y., now rapidly approaching completion. The road is operated on the Short overhead system, and the generating station is equipped with machinery of the same make. The building is a colossal one, the dynamo room being over 200ft. in length; it will contain 17 80-kilowatt generators, driven by seven engines, and will furnish power both to railway and to stationary motors. The Short system originally entered the field as an exponent of series traction, but this feature of its work has practically been abandoned, so that at the present time its cars are operated on the parallel system of distribution, like those of all the other American tramway systems.

## VIENNA NOTES.

(FROM OUR OWN CORRESPONDENT.)

VIENNA, *December* 20, 1890.

The International Electrical Company of Vienna opened its new central station on November 14th, and current is now supplied every day from 4 o'clock until the morning. The dynamo at work is one of Messrs. Ganz and Company's type A 7 machines, and has a maximum capacity of 200 kilowatts, at 2,000 volts pressure. The other dynamos which are to be put up are of type A 8 of 400 kilowatts. The exciters are also made by Messrs. Ganz and Company, they run at 375 revolutions, and give 150 amperes at 180 volts pressure. The exciters are driven by and coupled direct to Westinghouse engines. The boilers are by Messrs. Steinmüller, and have 243 square metres heating surface. The central station, when completed, will have a capacity of 6,000 kilowatts.

As I have already reported, the Imperial Palace is to be lit by electricity. This will be a very large installation, as the palace contains altogether 93 halls and rooms, of which 52 are to be completed by the end of this year. Glow lamps only are to be used, and they are to be so arranged that all the present costly fittings will be utilised. The lamps are to be so arranged as to look like wax lights. They will be smaller than is customary, and fitted to white wooden stands. Some 5,250 glow lamps will be used for the 93 halls and rooms, and their total candle-power will be 30,000. One hall alone, the Knights' Hall, will be lit by 1,836 lamps.

The Anglo-Austrian Bank have been negotiating with Messrs. Siemens and Halske about taking over all their works in Austro-Hungary. These negotiations are said to be completed, and the Bank proposes forming two companies, one to work Messrs. Siemens and Halske's works and installations in Austria, and one to take over their business in Hungary, specially their electric railway in Budapest.

The town of Trient has a large electric light installation. The power is derived from turbines, the dynamos being coupled direct to them. The installation was put down by Messrs. Siemens and Halske, and it supplies 4,150 glow lamps and 44 arc lamps. The streets are lit by 550 glow and 22 arc lamps. The power being so cheap, it is no wonder that the electric current is being largely used for motors. One mill is being driven by an electromotor of 50 horse-power, and many motors of 2, 1, and even $\frac{1}{10}$th and $\frac{1}{20}$th horse-power are in use.

## CORRESPONDENCE.

### SECONDARY BATTERIES, POSITIVE AND NEGATIVE PLATES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Will you allow me to call attention to the confusion that arises from the use of the words positive and negative, in reference to the plates of a secondary battery. Strictly speaking, the peroxide plate is the positive plate in the charge and the negative plate in the discharge; and similarly, the grey plate is negative in the charge and positive in the discharge. Hence there is a certain inconvenience in calling either plate by the name of positive or negative, since it is sometimes entitled to the one name and sometimes to the other.

This inconvenience, however, might be borne if all writers used these names in the same way. But such is not the case. Messrs. Ayrton and Perry, for example, in their excellent and valuable Paper, which has lately appeared in your journal, speak of the peroxide plate as positive, and of the grey plate as negative; whereas, Messrs. Gladstone and Tribe, in their no less admirable little manual, do just the reverse. With them the peroxide plate is negative, and the grey plate positive. Sir David Salomons, if I remember rightly, follows the same usage as Messrs. Ayrton and Perry; but he feels called on, now and then, to interpose an explanation which only adds to the confusion. Referring, for instance, to the "negative plate," he throws in the remark, "That is, the one that is really positive."

No doubt a careful reader can generally gather from the context in each case which plate the writer means to speak of. But all readers are not careful; and even if they were, lucidity of style is still an important quality in scientific writing, and the words used ought, as far as possible, to declare their own meaning. My suggestion would be to call the peroxide plate the *brown* plate, and the other the *grey* plate. These names explain themselves, and do not tend to confuse our ideas of positive and negative: they leave us free to conceive the brown plate as positive in the charge and the grey plate as positive in the discharge, which, I submit, is the true way to conceive them.—Yours faithfully, GERALD MOLLOY.

Catholic University of Ireland, Dec. 19, 1890.

[The difficulty is very similar to that of naming the north and south poles of a magnet. Some teachers try to avoid it by speaking of red and blue poles. The difficulty, like that of the knights and the shield, simply depends on the point of view. We decidedly adhere to the names as well as to the reasons given in our note last week.—ED. *E.*]

### GAS AND ELECTRIC LIGHTING AND VENTILATION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the article under this heading (extracted from the *Journal of Gas Lighting*) in your issue of the 19th inst., there appears the following: "Instead of a closed room and a constant quantity of oxygen, any desired supply of the latter may be had from outside. Besides, it is not only a question of the inlet of a current of fresh air for the lights, but this must be done in any case for the human occupants of the room. So that it is only a matter of degree whether oxygen has to be supplied for both purposes or for only one. It is therefore possible to say that the method by which a public hall is lighted cannot make much difference to the fundamental obligation to ventilate it with due regard to the health and comfort of the people who use it."

I think that the fallacy involved in the concluding sentences of the above should not pass unnoticed. It is true "that it is only a matter of degree whether oxygen has to be supplied for both purposes or for only one," but the whole difficulty of ventilating a room efficiently turns upon this question of degree. In order to ventilate a room, a certain interchange must take place between the inner and the outer air. The rate at which this should take place will depend upon the degree of vitiation of the internal air. The difficult problem (so unhappily left unsolved in many cases) is to admit air at such a rate as to effect the necessary interchange without producing draughts. The difficulty increases with the number of persons in the room, and also, but in a greater degree, with the number of gas-jets.—Yours truly, GEO. FLETCHER.

School of Science, Derby, December 22, 1890.

### THE CHEMISTRY OF THE SECONDARY CELL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Allow me to make two very necessary corrections in the "authorised abstract" of the observations I made at the last meeting of the Institution of Electrical Engineers. The formulæ

$$(PbO_2)_{10}\,(H_2O)_5\,PbSO_4 = (H_2Pb_2O_5)_5\,PbSo_4$$

express not "the chemical changes produced by electrolysis," but the composition of a certain sample of lithanode, which I was inclined to regard as a type of the active material in the negative element of a lead secondary battery. The former of the two expressions is the empirical and the latter the theoretical formula. The second correction is that I have not yet obtained a discharge of two amperes per lb. gross weight of cell for two hours. This is what I am *trying* to get, but one and a-half amperes for the two hours is what I have actually obtained.—Yours, &c., DESMOND G. FITZGERALD.

### SELENIUM.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: May I be allowed to correct a few inaccuracies in your account of my recent communication to the Physical Society? (See p. 213, *ante.*)

*Paragraph 1 of the Report.*—I began with some remarks on three of the allotropic modifications of selenium. (1) the black amorphous, or vitreous; (2) the red amorphous, a finely divided powder; (3) the crystalline or metallic. Se-

Digitized by Google

lenium in the crystalline form is obtained by keeping amorphous selenium at a temperature of from 100 degrees to 200 degrees for a sufficient length of time, which varies with circumstances, but is generally only a few minutes. Amorphous selenium is a non-conductor. Crystalline selenium conducts, but not well. The specific resistance of a piece which was cast in a glass mould and annealed *out of contact with any metal* was 2,500 megohms.

*Para. 2.*—I showed a simple cell formed by imbedding two short lengths of copper wire in a piece of crystalline selenium, and stated its resistance to be several megohms. I made no reference to Graham Bell's photophone cells. Their resistance was in point of fact only a few hundred ohms, though in respect of sensitiveness to light they were far inferior to my own. *Each* wire of my cells makes twenty turns to the inch, so that the distance between the two electrodes is less than one-fortieth of an inch. *Para. 3.*—I said that the cell should be kept for some time at a temperature a few degrees *below* 217 (which is the melting point of crystalline selenium). After long heating and slow cooling, the resistance of a cell with a surface of 10 sq. cm· is generally about 50,000 ohms.

*Para. 5.*—I did not attribute the fall of the resistance of Prof. Adams's pieces of selenium to the formation of copper selenide, but said that "it would be of great interest to know the cause." Adams's electrodes were invariably formed of platinum wire. (I have discussed the fall of the resistance of Adams's selenium in *Phil. Mag.*, Aug. 1885, pp. 183, 184.)

*Para. 6.*—For "selenide of copper" read "metallic selenide." *Para. 8.*—In the second line, delete the comma after "expected." *Para. 9.*—Here I was completely misunderstood. The following is an extract from my notes, which I have tried to make a little clearer:—"In the discussion which followed the reading of my former Paper, the late Mr. J. W. Clark took exception to a hypothesis therein put forward as to the probable action of the selenides formed in selenium cells [an action which would involve the partial decomposition of the selenides by a current] on the ground that selenide of copper conducted metallically [*i.e.*, without decomposition] and not electrolytically [as I assumed it did]. This he stated to have been proved experimentally by Hittorf. But if the amorphous selenium surrounding the anode in the present case [*i.e.*, in the case of the cell referred to in paras. 7 and 8, and submitted to the meeting] was formed otherwise than by electrolysis, it is difficult to imagine why it should be confined to the anode [as was seen to be the fact] and did not extend also to the kathode and other portions of the cell." The inference, of course, is that J. W. Clark was mistaken, and that copper selenide does conduct electrolytically.

*Para. 10.*—This also may be best amended by an extract. "In the illustration of lectures it is often desirable to be able to exhibit experiments in a striking and attractive manner. The movements of a spot of light upon a scale may be convincing, but they are hardly impressive. Yet the resistance of sensitive selenium cells is so high that the variation [under the influence of light] of currents passing through them cannot easily be demonstrated to an audience in any other manner than by their action upon a reflecting galvanometer. With sufficient battery, however, they may be made to work a delicate relay, and thus to produce indirectly a great variety of startling effects." Some of which were shown.—Yours faithfully,

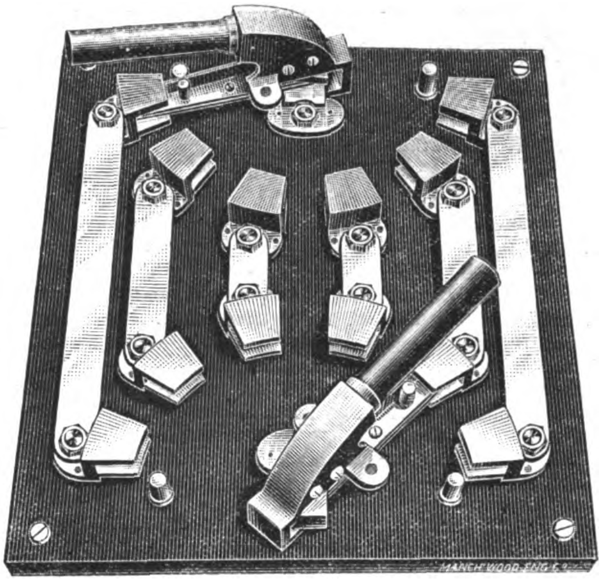
SHELFORD BIDWELL.

Riverstone Lodge, Southfields, S.W.,
December 20, 1890.

## TRADE NOTES AND NOTICES.

THE ARCHER PIPE COMPANY (LIMITED).—We have received from this company a fully illustrated catalogue of their manufactures. The catalogue gives full particulars of the well-known Archer patent lined joint. Instructions how to lay the Archer pipes are given, and a list of the places where the Archer patent jointed stoneware pipes have been put down accompanies the catalogue. Testimonials from users of the pipes are given, including some from electrical firms, a section of the catalogue being devoted to illustrating the suitability of the Archer pipe for electrical purposes.

MESSRS. DORMAN AND SMITH.—The accompanying illustration shows a patent regulator for varying the number of cells in circuit on charging or discharging. This accumulator switch is manufactured by Messrs. Dorman and Smith, of Manchester. The



distance between the jaws connected with the several cells is so arranged as to prevent short circuiting, and a change of circuit from one cell to another is conveniently obtained, regardless of the speed at which the handle is moved.

MESSRS. ENGELBERT AND CO.—We have received from this firm a very useful sheet calendar for 1891 and 1892, copies of which can be obtained on application.

THE DIRECT UNITED STATES CABLE COMPANY.—This company have sent us a neat calendar with space above each day for memoranda.

## PATENT RECORD.

### APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

December 5, 1890.

19,842. W. H. STURGE and J. GRUBB. Birmingham. Improvements in roses for ceilings and wall connectors, for electrical purposes.

19,856. T. J. MURDAY. Newcastle-on-Tyne. A thermo-electric firedamp detector and alarm for use in mines.

19,865. M. A. DAVELUY, Junior. London. Improvements in electric arc lamps.

19,883. L. CAPOCCI, C. PICONE, and A. SPACAGNA. London. Improvements in or relating to self-controlling electrical signals for the prevention of railway accidents.

December 6, 1890.

19,894. S. F. PREST and J. STATTER. London. A new or improved magnetic separator.

19,942. W. P. THOMPSON. Liverpool. Improvements in galvanic batteries, and in the electro-chemical formation of chlorine and chlorine compounds applicable for such batteries and other purpose (F. Marse, Germany).

December 8, 1890.

20,006. C. HUELSER. London. Protective and insulating boxes for subterraneous telegraph conduits (H. Paradies, Germany).

December 9, 1890

20,019. H. W. SABOLD. London. Improvements in circuits for electric railways.

20,043. G. L. ANDERS and C. H. ELLIOT. London. A combination of telephones and mechanical signals.

20,053. P. JENSEN. London. Improvements in and relating to electric signals for engines (H. G. Underwood, United States).

20,062. S. D. WILLIAMS. Newport. An improved perforator for automatic telegraphy.

20,063. S. D. WILLIAMS. Newport. Improved apparatus connected with column printing, telegraphically and otherwise.

Digitized by Google

20,088. L. B. ATKINSON. London. Improvements in the method of driving certain types of percussive rock drills and other tools by electric power.
20,094. M. W. DEWEY. London. Improvements in electric traction increasing system for railways.
20,099. J. E. KINGSBURY. London. Improvements in telephone exchange apparatus (The Western Electric Company, United States).
20,100. P. W. WILLANS. London. Improved means for controlling the supply of electric current to electric mains from a dynamo or dynamos.
20,102. A. S. BAXENDALE. London. An improvement in dynamo-electric and electro-dynamic machines.
20,111. H. H. LAKE. London. Improvements in apparatus for use in the electrolytic decomposition of metallic salts (J. L. Roberts and T. H. McGraw, United States).

December 10, 1890.

20,126. C. E. DUTTON, jun. Washington, United States. Improvement in galvanic batteries.
20,134. W. P. J. FAWCUS and E. W. COWAN. Chester. Improvements in suspending electric light and other cables from a carrying wire.
20,146. G. S. RAM. London. An improved electric lamp.
20,169. A. H. Howard. London. An improved mode of effecting electrical distribution.
20,175. A. FRAGER. London. Improvements in electric meters.
20,204. J. ASHCROFT. Liverpool. Improvements in billiard table electric light and other like reflector shades.

## COMPANIES' MEETINGS & REPORTS.

### Reuter's Telegram Company (Limited).

An extraordinary general meeting of the Company was held at the offices, 24, Old Jewry, on the 23rd inst., when the subjoined resolutions, which were duly passed at a special meeting held on the 6th inst., were submitted for confirmation as special resolutions:—

1. That the capital of the Company be increased to £100,000 by the creation of 2,500 new shares of £8 each, and that the Directors be forthwith authorised, under the provisions of Clause 26 of the Articles of Association of the Company, to issue such shares.

2. That subject to the provisions of the Companies (Memorandum of Association) Act, 1890, the provisions of the Memorandum of Association of the Company, with respect to the objects of the Company, be altered as follows, that is to say, by expunging sub sections 2 and 3 of Clause 3 of the Memorandum of Association, and by inserting in lieu of the sub-sections so expunged the following sections:—

(2.) To carry on and extend the said business, and generally to carry on, acquire, obtain, and supply telegraphic, telephonic, or other news and intelligence, and to issue, publish and circulate, and otherwise utilise, with a view to the profit or advantage of the Company, the same news and intelligence.

(3.) To carry on in the United Kingdom, and in any part of the world, the business of general advertisement contractors and advertising agents in all its branches.

(3a.) To construct, purchase, hire, or otherwise acquire, or work, telegraphs and telephones for any of the purposes hereinbefore mentioned.

Admiral the Right Hon. Sir J. C. Dalrymple Hay, Bart., K.C.B., presided.

The SECRETARY (Mr. Walter F. Bradshaw) read the notice convening the meeting.

On the motion of the CHAIRMAN, seconded by Baron DE REUTER, the resolutions were unanimously confirmed, and the proceedings, which were purely formal, then terminated.

### The Phonopore Syndicate (Limited).

A meeting of this Syndicate was held on Monday, at Winchester House, E.C., Mr. E. H. Pollard presiding.

The CHAIRMAN said the shareholders were aware that the Company was as yet practically a developing Company. They had had many obstacles to encounter, a great many of which had been successfully overcome, while the others were in a fair way of being surmounted. The obstacles were not in any way connected with their patents, or with the value of the invention, but with its development and introduction into general commercial use. This new system had, of course, to some extent, to fight against systems already in use; but the main feature that the Directors had tried to impress on the heads of Government departments, and other departments, and on private individuals was, that the wires at present in use could be used over again for the working of this invention. Thus this invention would give an additional service for the transmission of messages without interfering with the use of the same wires by the telegraph instruments now at work. It was not absolutely necessary, either for the progress of the invention, for the value of the invention, or for their receiving dividends, that they should entirely substitute their instrument for that of the telegraph. It would be quite sufficient to give them a very large income if they could once satisfy the public that it would increase the telegraph transmitting power without the cost of putting up new wires or requiring any special class of operators; a boy who had been operating for a few months with the ordinary telegraph instrument could just as easily work the phonopore. The Chairman concluded by remarking that the great value of the invention had been fully proved to the satisfaction of experts, and it was now only a question of manufacture. He moved the adoption of the report and accounts.

Mr. HENRY KIMBER, M.P., seconded the motion, which was carried unanimously.

The retiring members of the committee, Mr. Kimber and Major-General Shaw Stewart, were re-elected on the motion of the CHAIRMAN, seconded by Mr. DICKSON; and Messrs. Boyce and Ramsay were reappointed the auditors.

Major STEWART moved that Mr. M. I. Brown be elected a member of the committee, and the motion was agreed to after a discussion.

---

The meeting then became special for the consideration of the following resolution:—

"*That the capital of the syndicate be increased by an issue of 10,000 ordinary shares of £1 each, and that the committee be empowered to issue such shares in such manner and on such terms as they may deem best.*"

The CHAIRMAN moved the adoption of this resolution, and said it was a matter of necessity that the Committee should have further funds at its disposal, in order to carry on the manufacture of the instruments and to push the sale. It was proposed, he said, to give the debenture-holders power to turn their debentures into shares within three years, or at an earlier period, if any of the Company's rights were parted with, and this the Directors could not do unless they took the power they now asked. The Directors only took the power to increase the capital in order to comply with the option to convert, if the shareholders decided to give that option. With regard to the Debentures, the Directors had not yet subscribed, because of a rumour that they were going to take them all among themselves; but a considerable number of applications were being held back until the option was sanctioned.

PATENT
SILICIUM BRONZE AND SILICIUM COPPER WIRE.
The best for overhead Telephone and Telegraph Lines,
AND ALL ELECTRICAL PURPOSES.
Hard Drawn High Conductivity Copper Wire.
ROLLED AND DRAWN PHOSPHOR BRONZE.
PHOSPHOR BRONZE VULCAN PHOSPHOR DURO METAL
PHOSPHOR BRONZE BEARINGS, BUSHES, AND OTHER PARTS OF ELECTRICAL MACHINERY.
SOLE PROPRIETORS of the British, Indian and Colonial Patents,
THE PHOSPHOR BRONZE COMPANY (Limited),
87, Sumner Street, Southwark, London, S.E.
WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

Digitized by Google

Mr. A. B. ISAAC seconded the motion, which, after a further discussion, was carried *nem. con.*

The proceedings closed with a vote of thanks to the Chairman for his conduct in the chair.

## NEW COMPANIES REGISTERED.

**ALICE-STREET FOUNDRY (LIMITED).**—Registered by Kerr and Lanham, 3, Chichester-rents, Chancery-lane, with a capital of £20,000, in £10 shares. Object: To carry into effect an agreement made between W. S. Llewellyn and Samuel Cartwright, to carry on the business of iron and brass founders, mechanical engineers, &c. The registered office is in Hope-street, Cardiff.

**AVON INDIARUBBER COMPANY (LIMITED).**—Registered by Robinson, Preston and Stow, 35, Lincoln's Inn-fields, with a capital of £50,000, in £5 shares. Object: To acquire the freehold properties and goodwill of the business of indiarubber manufacturers carried on by E. G. W. Browne and J. C. Margetson, in partnership, under the style of the Avon India-rubber Company, at Melksham, Wiltshire.

**ELECTRIC STORES (LIMITED).**—Registered by G. D. Freeman, 103A, Paul-street, Finsbury-square, with a capital of £15,000 in £1 shares. Object: To carry on as principals or agents the business of electrical stores. Registered without Articles of Association.

**JAMES KIDD AND CO. (LIMITED).**—Registered by Rye and Eyre, 16, Golden-square, with a capital of £3,000 in £1 shares. Object: To carry on the business of gas and lighting engineers, fitters, and manufacturers of every kind of apparatus used in connection with lighting.

**LACTITE (LIMITED).**—Registered by Charles Doubble, 14, Serjeants'-inn, Temple, with a capital of £30,000, in £1 shares. Object: To acquire an invention of a new and improved process for the manufacture of a new material designed to serve as a substitute for bone or celluloid.

**PRACTICAL ELECTRO-PLATING AND ENAMELLING COMPANY (LTD.).** Registered by Waterlow and Sons (Limited), London Wall, with a capital of £2,000 in £5 shares. Object: To acquire the above-named business, carried on at Warwick-lane, Coventry. Registered without Articles of Association.

**PURDON-WALTERS' MOTOR SYNDICATE (LIMITED).**—Registered by Wynne and Co., 40, Chancery-lane, with a capital of £10,000 in £10 shares. Object: To acquire, on such terms as the Directors think fit, and to work and vend, any patents and licences under patents.

## CITY NOTES, &c.

**AFRICAN DIRECT TELEGRAPH COMPANY (LIMITED).**—The coupons on this Company's Four per Cent. Mortgage Debentures to bearer, due January 1st next, will be paid on and after that date at the Alliance Bank, Bartholomew-lane, London, E.C. Coupons must be left at the Alliance Bank three clear days for examination.

**ALLCHIN, LINNELL, AND COMPANY (LIMITED).**—A petition for the winding-up of this Company of electrical engineers came before Mr. Justice Kekewich on Saturday. Mr. Eve, in support, said that a provisional official liquidator had been appointed, and it was now asked to continue him until the appointment of an official liquidator. The business was a going concern, and the provisional liquidator had had power given to him by the Court to advance or raise £250 at 5 per cent. interest, for the purpose of carrying on current contracts. It was now asked that he might advance a further sum for the purpose, among others, of paying the workmen's wages. The assets of the Company were of great value, consisting chiefly of the goodwill of the business, the fixed machinery, plant, stock, and also current contracts, in respect of which moneys were daily being received. After some discussion the petition was ordered to stand over, and in the meantime the petitioner would have liberty to advance a sum not exceeding £400, on the same terms as before.

**ANGLO-PORTUGUESE TELEPHONE COMPANY (LIMITED)**.—Coupons No. 6 of the First Mortgage and No. 1 of the Second Mortgage Debentures of this Company will be paid, less income-tax, by the Alliance Bank, Bartholomew-lane, on and after the 1st proximo.

**BRAZILIAN SUBMARINE TELEGRAPH COMPANY.**—The receipts of this Company for the week ended December 19th amounted to £6,118. The coupons on this Company's second issue of Five per Cent. Debentures due 31st inst., will be paid on and after that date at the Alliance Bank Bartholomew-lane, London, E.C. Coupons must be left at the Alliance Bank three clear days for examination.

**COWLES SYNDICATE (LIMITED).**—A private meeting of this syndicate was held at Winchester House on Friday last.

**ELECTRICAL AUTOMATIC DELIVERY BOX COMPANY (LIMITED).**—Mr. F. G. Painter (of the firm of Tribe, Clarke, Painter, and Co., of 19, Coleman-street, E.C.), the official liquidator of this Company, will, with the sanction of Mr. Justice Kekewich, forthwith pay 20s. in the £ to all creditors who have proved their claims.

**ELMORE'S FOREIGN AND COLONIAL COPPER DEPOSITING COMPANY (LIMITED).**—The following circular has been issued by the above Company:—"The first annual ordinary general meeting of this Company will be held at the offices of the Company, 64, Cannon-street, London, E.C., on Monday, the 29th day of December, 1890, at 12 o'clock noon, to transact the ordinary business of the Company and, if thought fit, to pass the following resolution:—'*That once at least in every year the Board of Directors shall lay before the Company, in general meeting, a statement of the income and expenditure for the past year, made up to the 31st of December then last past, instead of to the 31st of March as provided in clause 113 of the Company's Articles of Association.*' It is obligatory to hold the above general meeting this year, but, in the event of the foregoing resolution being passed, the second annual ordinary general meeting will be held at the earliest possible date in January next to receive the Directors' report and accounts of the Company, made up to the 31st inst. Notice of the second general meeting, together with a copy of the Company's accounts, will issue in due course. The shareholders will, therefore, understand that it is not important for them to attend the first meeting here on the 29th inst.—By order of the Board, J. SHURMER, Secretary."

**EXCELSIOR COPPER COMPANY (LIMITED).**—At an extraordinary general meeting of the shareholders, held on Friday, Colonel Malleson in the chair, resolutions were passed voluntarily winding up and reconstructing the Company.

**HENLEY'S ELECTRIC LIGHT AND POWER COMPANY (LIMITED).**—A private meeting of this Company was held on Friday at the offices, 27, Martin's-lane, London, E.C.

**HENLEY'S TELEGRAPH WORKS (LIMITED).**—A private meeting of this Company was held on Friday at the offices, 27, Martin's-lane, London, E.C.

**MANITOBA ELECTRIC AND GAS LIGHT COMPANY.**—Messrs. Robert A. McLean and Co. will, on and after January 1st next, pay the half-year's interest, due on that date, on the Six per Cent. First Mortgage Debentures of this Company.

**WEST AFRICAN TELEGRAPH COMPANY.**—The Directors of this Company announce an interim dividend for the first half of the current year of 4s. per share, payable on the 22nd inst.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY.**—The traffic receipts of this Company for the week ending December 19, 1890, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £4,815.

**WHITE'S ASBESTOS COMPANY v. HOARE.**—The hearing of this case, in which the Company sued the defendant for calls, and the defendant, on the other hand, by counterclaim, sought rescission of the contract to take shares, on the ground of misrepresentation in the prospectus, was resumed on Friday before Mr. Justice Day, and resulted in a verdict for the defendant both on the claim and the counterclaim, with costs.

THE NON-CONDUCTOR OF ELECTRICITY.

VULCANISED FIBRE,

PATENTED.

This new material is supplied in two qualities, Flexible and Hard.

The FLEXIBLE is a substitute for Leather, Rubber, Gutta Percha, &c., and is extensively used by Brass Founders, Axle Makers, Hydraulic, Sanitary, and other Engineers, Pump Makers, Carriage Builders, &c.

It makes the best Hot and Cold Water Packings, and for Axle Washers of all kinds it is unequalled.

The HARD is a substitute for Metals, Hard Wood, Ivory, Vulcanite, Ebonite, &c., and is a good Insulator.

Sold in sheets, 5ft. 6in. by 3ft. 6in., varying in thickness from 1-50in. to 1in.

FLEXIBLE, 2/- per lb.; HARD, 2/3 per lb.

MOSSES & MITCHELL, 70, Chiswell-st., London, E.C.

WAREHOUSE.

FACTORY.

Digitized by Google

## COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name. | Previous Week's Price, Dec. 17. | | Price Monday, Dec. 22. | | Rate per Cent. Yielded. | Dividend Due. | Business Done During Week Ending Dec. 22. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **TELEGRAPHS.** | | | | | £ s. d. | | | |
| £1,381,380 | Stock | 15/0 | Anglo-American | 48½ | 49½ | 48½ | 49½ | 5 16 2 | Jan., Apr., July, Oct. | 49½ | .. |
| £2,809,310 | Stock | 30/0 | Do. Preferred | 84½ | 85½ | 84½ | 85½ | 6 14 6 | " " | 85½ | 85 |
| £2,809,310 | Stock | .. | Do. Deferred | 13¼ | 13¾ | 13¼ | 13¾ | .. | .. .. | .. | .. |
| £250,000 | £100 | 4% | African Direct, 4 per Cent. Debentures | 98 | 101 | 98 | 101 | 3 19 3 | January and July .. | .. | .. |
| £130,000 | 10 | 6/0 | Brazilian Submarine | 11¼ | 11¾ | 11¼ | 11¾ | 6 7 8 | Mar., June, Oct., Dec. | 11⅝ | 11¼ |
| £84,500 | 100 | 5% | Do. 5 per Cent. Bonds | 101 | 103 | 101 | 103 | 4 17 1 | January and July .. | .. | .. |
| £75,000 | 100 | 5% | Do. 5 per Cent. Bonds (2nd Series, 1906) | 104 | 108 | 104 | 108 | 4 12 7 | June and December | .. | .. |
| $7,216,000 | $100 | $1½ | Commercial Cables | 104 | 106 | 104 | 106 | 5 13 2 | April and October .. | 105½ | .. |
| £16,000 | £10 | 8/0 | Cuba Submarine | 11½ | 12 | 11½ | 12 | 7 1 8 | February and August | .. | .. |
| £6,000 | 10 | 10% | Do. Preference 10% | 17 | 18 | 17 | 18 | 5 11 1 | " " | .. | .. |
| £12,931 | 5 | 2/4½ | Direct Spanish (£4 paid) | 3¾ | 4¼ | 3¾ | 4¼ | 5 12 11 | April and October.. | .. | .. |
| £6,000 | 5 | 10% | Do. Preference 10% | 9 | 10 | 9 | 10 | 5 0 0 | " " | .. | .. |
| £60,710 | 20 | 3/6 | Direct United States | 10¼ | 10⅜ | 10⅜ | 10⅝ | 6 15 0 | Jan., Apr., July, Oct. | 10⅝ | 10⅜ |
| £100,000 | 10 | 2/6 | Eastern | 13⅞ | 14⅛ | 13⅞ | 14⅛ | 4 12 0 | " " | 14 | 13 13/16 |
| £70,000 | 10 | 6% | Do. 6 per Cent. Preference | 14¾ | 15¼ | 14¾ | 15¼ | 3 18 8 | " " | 15½ | 15 |
| £1,200,000 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock | 104 | 107 | 104 | 107 | 3 14 9 | May and November | 105¼ | .. |
| £200,000 | £100 | 5% | Do. 5 per Cent Debentures, 1899 | 106 | 109 | 106 | 109 | 4 11 9 | February & August | .. | .. |
| £250,000 | 10 | 2/6 | Eastern Extension | 14 | 14¼ | 14 | 14¼ | 4 18 3 | Jan., Apr., July, Oct. | 14⅛ | 14 1/16 |
| £320,000 | 100 | 6% | Do. 6 per Cent. Debentures, 1891 | 101 | 103 | 101 | 103 | 5 16 6 | February & August | .. | .. |
| £91,800 | 100 | 5% | Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900 | 102 | 105 | 103 | 106 | 4 14 4 | January and July .. | .. | .. |
| £145,300 | 100 | 5% | Eastern & S. African 5 per Cent. Mor. Deb., 1900 | 102 | 105 | 102 | 105 | 4 15 3 | " " | .. | .. |
| £180,227 | 10 | 1/9 | Globe Telegraph and Trust | 8¾ | 9 | 8¾ | 9 | 5 8 4 | Jan., Apr., July, Oct. | 9 | 8¾ |
| £180,042 | 10 | 6% | Do. 6 per Cent. Preference | 14½ | 14¾ | 14½ | 14¾ | 4 1 4 | " " | 14½ | .. |
| £150,000 | 10 | 5/0 | Great Northern | 16 | 16½ | 16 | 16½ | 4 10 11 | Jan., April, and July | 16¼ | .. |
| £15,000 | 100 | 5% | Do. 5 per Cent Debentures, 1881 | 101 | 104 | 101 | 104 | 4 16 2 | January and July .. | .. | .. |
| £130,000 | 100 | 5% | Do. 5 per Cent. Debentures, 1883 | 104 | 107 | 104 | 107 | 4 13 6 | March & September | 106 | .. |
| £17,000 | 25 | 12/6 | Indo-European | 35 | 37 | 35 | 37 | 6 15 2 | May and November | .. | .. |
| £38,348 | 10 | 4/0 | London Platino-Brazilian | 6 | 7 | 6 | 7 | 5 14 4 | " " | .. | .. |
| £100,000 | 100 | 6% | Do. 6 per Cent. Debentures | 106 | 109 | 106 | 109 | 5 10 1 | March & September | .. | .. |
| £9,000 | 8 | 4/0 | Reuter's | 8½ | 9 | 8½ | 9 | 5 11 1 | April and October.. | .. | .. |
| £3,381 | £100 Cert. | 6% | Submarine Cables Trust | 108 | 112 | 108 | 112 | 5 7 2 | " " | 112 | .. |
| £15,609 | £10 | 6/6 | West African | 8½ | 9½ | 8½ | 9½ | 5 5 3 | January and July .. | .. | .. |
| £290,000 | 100 | 5% | Do. 5 per Cent. Debentures | 98 | 101 | 98 | 101 | 4 19 0 | March & September | .. | .. |
| £30,000 | 10 | 3/0 | West Coast of America | 2 | 4 | 2 | 4 | .. | January and July .. | .. | .. |
| £150,000 | 100 | 8% | Do. Debentures 8% | 101 | 106 | 100 | 105 | 7 12 5 | June and December | .. | .. |
| £38,321 | 10 | Nil. | West India and Panama | 2⅞ | 3⅛ | 2⅞ | 3⅛ | .. | .. | 3 | 2⅞ |
| £34,563 | 10 | 6/0 | Do. 1st Preference 6% | 11¼ | 11¾ | 11¼ | 11¾ | 5 2 2 | May and November | 11½ | 11¼ |
| £4,669 | 10 | £3 | Do. 6 p. c. 2nd Pref. | 11 | 12 | 10½ | 11½ | 5 4 4 | " " | 11 | .. |
| £34,174 | 15 | 6/0 | Western and Brazilian | 10¾ | 11¼ | 10¾ | 11¼ | 5 6 8 | " " | 11 | .. |
| £27,873 | 7½ | 6/0 | Do. 5 per Cent. Cumulative Preferred | 6¼ | 6¾ | 6¼ | 6¾ | .. | — | 6⅝ | .. |
| £27,873 | 7½ | 4/6 | Do. 5 per Cent. Deferred | 4½ | 5 | 4½ | 5 | .. | .. | .. | .. |
| £200,000 | 100 | 6% | Do. 6 per Cent. Debs., Series "A" | 103 | 106 | 103 | 106 | 5 13 2 | February & August | .. | .. |
| £250,000 | 100 | 6% | Do. 6 per Cent. Mort. Debs., Series "B" | 103 | 106 | 103 | 106 | 5 13 2 | " " | .. | .. |
| $1,336,000 | $1,000 | 7% | Western Union 7 per Cent. 1st Mortgage | 120 | 125 | 120 | 125 | 5 12 0 | May and November | .. | .. |
| £175,100 | £100 | 6% | Do. 6 per Cent. Sterling Bonds | 99 | 103 | 99 | 103 | 5 16 0 | March & September | .. | .. |
| | | | **TELEPHONES.** | | | | | | | | |
| £224,850 | 14/0 | 0/4½ | Consolidated Telephone Const. & Maintenance. | 7/16 | 9/16 | ½ | ⅝ | .. | May and November | .. | — |
| £220,000 | £1 | 3% | Oriental (11s. paid) | ⅛ | ⅜ | ⅛ | ⅜ | 4 8 3 | Yearly | .. | — |
| £438,984 | 5 | 3/0 | National xd | 4⅜ | 4⅝ | 4⅜ | 4⅝ | 5 18 11 | June and December | 4 9/16 | 4⅜ |
| £15,000 | 10 | 6/0 | Do. 6 per Cent. Cumulative 1st Pref. xd | 12 | 12½ | 12 | 12½ | .. | " " | .. | .. |
| £15,000 | 10 | 4/9½ | Do. 6 per Cent. Cumulative 2nd Pref. (£8 pd) xd | 9¾ | 10¼ | 9¾ | 10¼ | 5 17 1 | " " | .. | .. |
| £209,750 | 1 | ½% | South of England, Ordinary | ⅛ | ⅜ | ⅛ | ⅜ | .. | — | .. | .. |
| £20,000 | 5 | 2/1 | Do. 6 per Cent. Cumulative Pf. (£3 10s. pd) | 2½ | 3 | 2½ | 3 | .. | .. | .. | .. |
| £58,000 | 5 | 1/0 | United River Plate | 3 | 4 | 3 | 4 | .. | January and July .. | .. | .. |
| £146,128 | Stock | 5% | Do. 5 per Cent. Debenture Stock | 90 | 95 | 90 | 95 | 5 5 3 | .. | .. | — |
| £3,200 | 100 | 7% | Do. 7 per Cent. Debentures | .. | | .. | | .. | — | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | | | |
| £200,000 | £5 | .. | London Electric Supply | 1¾ | 2 | 1¾ | 2 | .. | — | .. | .. |
| £13,900 | 10 | .. | Metropolitan Electric Supply (£8 paid) | 7½ | 8 | 7½ | 8 | .. | — | .. | .. |
| £12,853 | 5 | .. | Westminster Electric Supply (£3 paid) | 2¼ | 2¾ | 2½ | 3 | .. | — | .. | .. |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | | | |
| £63,416 | 3 | .. | Brush Electrical Engineering | 1¼ | 1¾ | 1¼ | 1¾ | .. | .. | 1½ | .. |
| £63,416 | 2 | 0/10 | Do. 6 per Cent. Preference | 1½ | 2 | 1½ | 2 | 6 0 0 | June and December | 1½ | .. |
| £20,000 | 5 | 7% | Crompton and Co., 7 per Cent. Pref. Shares | 5½ | 5¾ | 5½ | 5¾ | 6 1 9 | January and July .. | .. | — |
| £17,139 | 5 | .. | Edison and Swan United | .. | | .. | | .. | .. | .. | — |
| £45,000 | 10 | 6% | Electric Construction xd | 7 | 7½ | 7 | 7½ | 8 0 0 | .. | 7⅛ | — |
| £70,000 | 2 | 10/0 | Elmore's Patent Copper Depositing | 3¼ | 3¾ | 4¼ | 4¾ | .. | .. | 5 | 3⅜ |
| £20,000 | 5 | .. | Fowler-Waring Cables (£4 paid) | 2½ | 3½ | 2½ | 3½ | .. | .. | .. | .. |
| £41,600 | 10 | 10/0 | India Rubber, Gutta Percha & Telegraph Works | 18½ | 19½ | 18½ | 19½ | 5 2 7 | February & August | 18⅞ | 18 |
| £200,000 | 100 | 4½% | Do. 4½ per Cent. Debentures, 1896 | 100 | 102 | 100 | 102 | 4 8 3 | March & September | .. | .. |
| £78,949 | 5 | 10% | Swan United (£3. 10s. paid) ..10% for year | 4½ | 5 | 4½ | 5 | 6 19 10 | May and November | 5 | 4⅞ |
| £37,350 | 12 | 12/0 | Telegraph Construction and Maintenance | 43 | 45 | 43 | 45 | 5 6 8 | March and July | 44⅞ | 44⅛ |
| £150,000 | 100 | 5% | Do. 5 per Cent. Bonds, red. 1894 | 100 | 102 | 100 | 102 | 4 18 0 | January and July .. | .. | .. |


JABLOCHKOFF'S DISTRIBUTION PATENT

(BEING A PATENT FOR "PRODUCING AND DIVIDING ELECTRIC LIGHT," No. 1996 of 1877.)

THE ELECTRICAL ENGINEERING CORPORATION, LIMITED,

(STATTER'S) Are Proprietors of the above Patent, and Warn the Public against Infringement. (UNITED).

*The following are Licensees:—*

Brush Electrical Engineering Company, Limited.
Crompton & Co., Limited.
S. Z. de Ferranti.—London Electric Supply Corporation, Limited.
W. T. Goolden & Co.
Hammond & Co.
Wilson Hartnell.
Johnson & Phillips.
Laurence, Paris & Scott, Limited.
Malder Brothers & Co.
Paterson & Cooper.
Ernest Scott & Co.
Siemens Brothers & Co., Limited.

3, Prince's Mansions, Victoria Street, Westminster.

PERCY E. SCRUTTON, *Secretary.*


Digitized by Google

# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 659.—Vol. XXVI. FRIDAY, JANUARY 2, 1891. Price Fourpence.

## NOTES.

Our readers will notice that we begin the year by publishing the first of a new series of articles from the pen of Mr. Oliver Heaviside. Although much of Mr. Heaviside's previous contributions to *The Electrician* appealed to a rather limited class of readers, both from the nature of the work and its treatment, we believe that as time goes on it will be found that this work possessed highly valuable and original qualities, and that he was one of the first to appreciate the importance of certain matters which are now being forced very strongly on the attention of those he calls "practicians." In particular, his work on the flow of alternating currents in conductors and sundry questions connected with that complex subject has yet, we think, to receive the appreciation it merits. Dr. Fleming calls attention this week to an important paper of Mr. Heaviside's in the *Philosophical Magazine*, which deserves study by those who are now busy with some difficult and unexpected effects in tubular conductors, since a considerable amount of information concerning these phenomena may be gathered by a careful study of Mr. Heaviside's paper. Mr. Heaviside promises to make the present series of articles, as far as possible, intelligible to readers who do not possess a very copious armoury of mathematical weapons, and we doubt not that a good deal can be accomplished in the cause of truth by a little common algebra *plus* a great deal of common sense.

A simple formula, embodying the results of Ewing's researches on the waste of energy due to hysteresis, is certain of a warm welcome among electrical engineers, as it must prove of great service in the determination of transformer losses. It is this want which Mr. Charles Steinmetz has endeavoured to supply, and we reproduce in this issue the result of his efforts. Starting with the assumption that the loss of energy varies as some power of the density of magnetic lines B, Mr. Steinmetz has found, with the aid of mathematical analysis, that the value of B, raised to the power 1·6, most nearly coincides with the numbers actually obtained from Prof. Ewing's observations. The agreement is so close as to fully justify the original assumption, and although the formula has only been verified with reference to tests made on an iron wire, there seems little reason to doubt its general application. We have taken the liberty of altering some of the symbols employed, as they were already in use with other meanings, and were thus liable to create confusion.

Mr. Steinmetz applies his formula to the case of a transformer, and finds that the watts wasted per cubic inch of iro are given by the formula $1{\cdot}67 \times 10^{-10} \times n\,M^{1{\cdot}6}$, where $n$ is the frequency of the alternate current, and M is the magnetic density in C.-G.-S. lines per square inch. It is unfortunate to have a mixture of three systems of units in a single formula, although it is almost necessary, since the answer to be useful must be expressed in watts, and magnetic densities are generally given in C.-G.-S. measure, as no recognised unit on the "practical" system exists. The word *volt-line* might be used as a provisional name for the practical unit of lines of force. A volt-line is equal to $10^8$ C.-G.-S. lines, and is such that if a wire of length $l$ be moving with a velocity $v$ across the lines of force in a field traversed by $n$ volt-lines per unit area, the voltage induced in the wire is $n\,l\,v$. The above expression for the watts lost per cubic inch becomes $1055\ n\ M^{1{\cdot}6}$, if M is expressed in volt-lines per square inch.

A novel method of investigating the motion of atoms in electric discharges has recently been employed by Mr. John Trowbridge. It depends on what is known as its velocity. It is well known that the note given out by the whistle of a railway engine rises in pitch as well as in amplitude as the train approaches the observer, and falls in pitch as it recedes. A similar effect happens in light when the luminous body is in rapid motion, and the velocity of approach or recession of certain stars has been estimated from the shifting of the lines in its spectrum due to this cause. It occurred to Mr. Trowbridge that if the electric spark consists of a convective discharge accomplished through the agency of swiftly-moving charged atoms, it should be possible to prove it in a similar manner. One of Prof. Rowland's highly dispersive concave gratings was at his disposal, and in consequence he could arrange the apparatus so as to be sensitive enough to detect any such effect if it occurred. The oscillating spark produced by a Leyden jar discharge was passed between two iron terminals, one of which being hollow permitted the axis of the spectroscope to point along the line joining the terminals. The light given out by the approaching atoms would cause a displacement of the lines in one direction, while the receding atoms would yield a dispersion spectrum displaced the other way. No such displacement was detected, the inference being that in spark discharges electrical oscillations do not carry the atoms of metals with them. The electrical waves pass by the atoms, merely causing in them subsidiary heat vibrations.

Digitized by Google

General Webber, in his letter which appears in our correspondence columns as a reply to the article on "Shaking the Foundations of Science," makes a much better case for the proposed railway than might have been expected, but he altogther fails to convince. It is true that the words of Prince Albert have been partially realised, though a good deal of the space in the "vast quadrangle" is now occupied by a partly-finished building which, whether it is to be public or not, connected with Science and Art or not, or, indeed, useful or not, is somewhat doubtful. "When the Royal Albert Hall was first projected," says General Webber, a pneumatic railway formed part of the original scheme. Practical knowledge of pneumatic railways has not advanced very materially since the date of the Royal Charter of the Commissioners; indeed, they were then considerably more talked about than at present. Physical science, on the other hand, has made great strides, and physical laboratories, which were then practically unheard of, have sprung into existence, and are so important, both scientifically and commercially, that the railway, if it is to inconvenience them, should give way.

Whatever may have been the original objects of the Commissioners of 1851; whatever may have been done in sundry observatories and private laboratories; and, indeed, whatever may have been the wisdom of planting the Central Institution in a locality so widely different from that of the older establishment at Finsbury, we sympathise with the instruction of students, and feel that the good work which is at last being done at South Kensington should not be lightly set aside.

That the permanent galleries of South Kensington are attracting less visitors than formerly is to be regretted, but is there reason to suppose that this is due to want of facilities of access? When were they better than now, if the brief opening of the subway be omitted? Might not a little be done to attract the public? We visited the Science Collection on a recent Bank Holiday morning, with the intention of experimenting *in corpore vili* at the Anthropometrical Laboratory. There was a thick fog, and the gallery was in utter darkness, the anthropometrician was away, and the solitary occupant, a policeman, who emerged from the gloom, informed us in reply to inquiries, that there was neither gas nor electric light, but that the gallery was not closed, and he could not stop us, if we desired to grope among the shadowy cases and their invisible contents.

There is a not uncommon misapprehension as to the legal status of the candle-power of glow lamps. Every one knows that the candle-power of gas is as strictly defined as was possible at the time, by the parliamentary candle which is supposed to burn 120 grains of spermaceti in an hour, with any dodging of the wick that circumstances may dictate. Moreover, it is no secret that medical students and others can earn £100 a year with no very arduous labour, though during somewhat inconvenient hours, by performing the nightly duties of gas inspector. But the *Journal of Gas Lighting*, in common with many other people, appears to think that the supply companies or the Board of Trade, or "somebody," should take care that when we ask for a sixteen-candle lamp we should "see that we get it." In the United States some companies supply light, ours have plenty to do in confining themselves to the supply of electrical energy. Our contemporary is mistaken in supposing that the recently-appointed committee can deal with this matter in any way except indirectly by the establishment of a decent standard of light, and they are in error in supposing that the introduction of cheap inefficient lamps will injuriously affect the profits of the supply companies. It will, indeed, put a stop to contracts at per lamp, but these are happily giving way to the more satisfactory method of charging by meter.

According to the leading electrical journal of Chicago, electrical circles in that progressive city are much agitated by a question which is being discussed at the present moment by the Committee on Electricity of the "World's Columbian Exposition." Is the electrical department to be organised now or next year? The general consensus of outside opinion is that the department should be organised as soon as practicable, that "dilatory tactics" should not be allowed to prevail, and that the process of "prodding" electrical manufacturers at home and abroad should be immediately commenced. This sudden solicitude as to foreign exhibits is somewhat strange in the citizens of a Republic which, as is well-known, is the universe in miniature. The electrical Chicagoans have, however, temporarily abandoned this belief, and now consider that if their "exposition" is to be representative, it must be international; and they are, consequently, exceedingly anxious that the Briton, the Gaul, and the Teuton should, in spite of their "inborn conservatism," be invited without further delay to forget the McKinley Bill and the four thousand miles that separate them from Chicago, and "expose" their electrical decadence to the eyes of progressive Western electricians.

The attitude which will in all probability be adopted by the majority of European electrical firms in regard to the Chicago Exhibition, is that of the gentleman connected with the Allgemeine Elektricitäts Gesellschaft, who, according to the article in our Chicago contemporary, displayed "the most profound and startling indifference to the World's Fair and the electrical department." His company, he said, would make an extensive exhibit at the electrical exhibition at Frankfort-on-the-Main, but, *horribile dictu*, "as for Chicago, he knew nothing about its fair, and he cared less." This, says our contemporary, "was an expression of opinion from a foreigner who had visited the country several times, could speak its language, and, what is still more important, he had quite a large sum of money invested in electrical industries in the United States." Sentiment has but a small place in business affairs, and yet it would be little else than sentiment for a European firm to send its wares several thousand miles across the sea to such an electrically self-sufficient country as the United States of America.

Apart from the question of patents, the telephone seems likely to prove a fruitful source of legal decisions. Some few months ago the validity of contracts made by telephone was

Digitized by Google

called into question in the United States, and the decision arrived at was one eminently characteristic of the legal mind. Contracts by telephone were held to be valid, but as the same rules of evidence were required in telephonic contracts as in contracts made in the ordinary manner, what the law gave with one hand it took away with the other. More recently the right of electric tramways to the use of "earth" has been hotly contested by American telephone companies, and the dispute has given rise to a fine crop of conflicting pronouncements from the bench. The latest point raised is whether registration by telephone is legal? A voter at Macon, Ga., rang up the Town Clerk of that town, and demanded to be registered. The clerk was familiar with the voter's voice, knew that his taxes had been paid; but as the law requires a voter to apply in person, the clerk is said to have his doubts as to legality of the whole proceeding.

**Brussels.**—The municipality has definitely decided not to grant electric lighting concessions, but to undertake the lighting itself.

**Gravesend.**—The opinion of the burgesses of Gravesend has been taken on the electric lighting question, and they have decided in favour of the light.

**A Correction.**—We are informed that the remarks in the authorised abstract of the discussion on Prof. Ayrton's Paper on "The Chemistry of Secondary Cells," attributed to Mr. E. A. Hall, were made by Mr. H. C. Hall.

**The Telegraph in the United States.**—The telegraph system in the West (says Reuter's New York correspondent) has almost completely collapsed owing to the heavy storms and fogs which are prevalent throughout the country.

**Obituary.**—We regret to announce the death, on the 27th ult., of Mr. George Crabtree, who has been in the service of the Eastern Telegraph Company since its formation, and was for some years Superintendent of the Tripoli Station.

**Village Lighting.**—The colliery village of Abercanaid, near Merthyr Tydvil, was lighted for the first time last week by electricity. The same plant supplies current to the Abercanaid Pit, and electrical haulage in the colliery is contemplated.

**The "Electrical Review," New York.**—The London offices of this journal have been removed from Bridge House, 181, Queen Victoria-street, E.C., and all papers and communications should be sent to Mr. Charles Ffrench, the London editor and manager, at the Hotel Victoria, Charing Cross.

**Buckingham.**—We learn that upon the winding-up of the Buckingham Electric Light and Power Company the plant was purchased by Mr. A. C. Rogers, of Prebend House, Buckingham, who is carrying on the lighting. Water power is used, and we understand that the plant is likely to be shortly much increased.

**Society of Arts.**—The following are some of the Papers to be read at the meetings of the Society of Arts, after the Christmas recess:—Prof. William Robinson, "The Use of Petroleum in Prime Motors;" and Mr. H. Newman Lawrence and Dr. Arthur Harries, "Electricity in Relation to the Human Body."

**The School of Electrical Engineering, Hanover-square.**—In connection with the sad death of Mr. Lant Carpenter, to which we refer in another column, we understand that this school will go on, as before, under the management of Mr. Léon Drugman, who, during Mr. Carpenter's illness—that is, since last spring—has been sole manager.

**Interruption of Telegraphic Communication.**—In consequence of a fire at a rag warehouse at Woodbridge (Suffolk), on Monday morning, telegraphic communication between England and India and the Continent was stated to have been interrupted for about six hours. We learn, however, on the best authority, that only four wires out of 50 were damaged.

**Central Station Statistics.**—The Electrical Trades Section of the London Chamber of Commerce have issued the two forms relating to the interchange of statistics which were published in our issue of November 14th. We hope that the scheme will be heartily taken up by the managers of supply companies.

**Weaving by Electricity.**—Herr Lembcke, the Director of the School of Weaving in Crifeld, reports that satisfactory trials have recently been made in the working of silk weavers' looms by electric motors in their own houses. The working of the looms by electrical power from a central station is found to be more satisfactory than the working by means of gas engines.

**St. Thomas' Charterhouse Schools.**—The Clothworkers' Technical Scholarship (value £240) has again been taken by a pupil (aged 13) of these schools. The subjects of examination were mathematics, drawing, science, and the usual English subjects. Recently also 3 out of 4 scholarships offered by the City and Guilds Technical Institute were won by scholars of these schools.

**Bacup.**—At a recent meeting of the Town Council a letter was read from the Board of Trade calling attention to the provisions of section 10, sub-section 1, of the Electric Lighting Order, 1890, and requesting that the Board should be informed what system of electric supply the Corporation proposed to adopt, and stating that it was necessary to obtain the approval of the Board before the work was commenced.

**The London and Paris Telephone Trunk Wire.**—A report having appeared in daily papers that the Government telegraph steamer "Monarch" had arrived at Calais with the telephone cable which is to be laid across the English Channel, and that in the course of the next few days the cable would be laid, we may state that the "Monarch" is at Charlton, and that the cable in question is lying peacefully in Siemens' works.

**Electricity in Railway Shops.**—In the new engineering shops of the Union Pacific Railroad, at Cheyenne, Wyo., one of the most important improvements, says the *Western Electrician*, is a 50-ton electric travelling crane. Five motors are used, one for the crane as a whole, and two for each trolley. The transfer table between the erecting and boiler shops is operated by electricity, and the transfer table for the car shops will also be run in the same manner.

**Postal Telegraph Revenue.**—The receipts from the telegraphic department of the Post-office for the quarter ending December 31, 1890, amount to £615,000, as against £590,000 for the corresponding quarter of 1889, an increase of £25,000 or 4·2 per cent. The receipts for the unexpired portion of the year ending March 31, 1891, amount to £1,840,000, as compared with £1,735,000 for corresponding period of the previous financial year, an increase of £105,000, or 6 per cent.

**The French Elmore Company.**—"In France," says the *Bulletin International de l'Electricité*, "the Société Elmore will be in a somewhat difficult situation, at least at the commencement of its career, owing to the existence of a concern which M. Secretan once knew well, a concern which is in possession of a *clientèle*, and which does not lack means of action. The Société des Métaux, even in the hands of a liquidator, is not an adversary to be neglected, and the Elmore patent is perhaps not the only one possessing the virtues commonly attributed to it."

**The Electric Registration of Meteorological Phenomena.**—The installation of the electrical devices for recording the indications of the meteorological instruments installed at the summit of the Eiffel Tower is now in working order, and on November 25th M. Mascart, says *La Lumière Electrique*, was able to announce to the Académie des Sciences that the velocity of the wind at the top of the Tower that morning was 300 *metres per second*. As this is equivalent to a velocity of about 672 miles per hour, and a pressure of more than one ton per square foot, we think a decimal point must be wanting somewhere.

**The Postal Revenue.**—A Parliamentary return, prepared at the instance of Mr. Shaw-Lefevre, has been issued, giving the

Digitized by Google

gross and net revenue and expenditure of the Post Office for each year for the last 21 years. Every year of the series, with the exception of the years 1872 and 1876, shows, alike in gross and net revenue, a substantial increase over the record of its predecessor. Twenty-one years ago the postal revenue from all sources amounted to £5,074,336, and the expenditure to £3,669,450, leaving a net yield of £1,404,886. In 1889 the revenue reached the total of £9,721,481, and the expenditure had risen to £6,275,085, the net yield being returned at £3,446,396.

**Technical College, Finsbury.**—The autumn courses of Special Lectures at the Technical College have been attended by very large numbers of students. That on Indiarubber, by Mr. T. Bolas, attracted many outside the ranks of ordinary chemical students. The lectures on Electricity Meters, by Prof. Silvanus Thompson, which were concluded in November, are now being revised for publication. Mr. O'Keefe has since been lecturing on Arc Lamps. When the classes re-assemble in January, Prof. Thompson will lecture on Dynamo-machines, on Monday evenings, and on Magnetism on Wednesdays. Prof. Perry continues his lectures on the Applications of the Differential and Integral Calculus to Engineering Topics.

**Gouraud v. Fitzgerald and Others.**—The following letter has been sent us for publication :—

"SIR : As you inform us that passages in the reports prepared by us in the year 1884, in reference to the Consolidated Telephone Company and its associated companies, have given rise to incorrect impressions adverse to yourself, we beg to say that we have since ascertained that, in the hurry of issuing the reports, some inaccuracies occurred in them. In the passages referred to we did not intend to convey that you had been guilty of a breach of duty as a Director of any of the companies mentioned in them, and we regret if any such incorrect impression should have been produced by our reports.—Your obedient servants,

"C. L. W. FITZGERALD,
"A. H. BAKER,
"HENRY GREWING.

"Col. G. E. GOURAUD, Little Menlo, August 6, 1890."

**Institution of Civil Engineers.**—This institution was founded on January 2, 1818, so that it has reached its seventy-third anniversary. Amongst its presidents have been Thomas Telford, Sir John Rennie, James Meadows Rendel, Robert Stephenson, George Parker Bidder, Sir John Hawkshaw, Sir John Fowler, Bart., K.C.M.G. ; Charles Blacker Vignoles, Thomas Hawksley, George Robert Stephenson, John Frederic La Trobe Bateman, Lord Armstrong, C.B. ; Sir Joseph William Bazalgette, C.B. ; Sir Frederick Joseph Bramwell, Bart. ; and Sir George Barclay Bruce. The present president is Sir John Coode, K.C.M.G. The numbers of the various classes now on the books comprise 1,700 members, 2,880 associate members, 427 associates, 19 honorary members, and 927 students—together, 5,953.

**St. Pancras Vestry.**—At the meeting of this Vestry on December 22nd, the Electricity Committee reported that they had inspected the works at the Stanhope-street station, and found the progress in every way satisfactory. With reference to the other works, all of which were being carried out, the engineer had reported that he had tested the boilers of the Babcock and Wilcox Company at Glasgow, and that everything was satisfactory, and the work in a forward state. It was also reported that the engines and dynamos were well advanced. The Electrical Construction Corporation had raised some questions as to the limit of time for their works, and this had been arranged by the engineer, and it was now understood that the station would be ready for them to proceed with their work on April 15th next, and their work was to be completed within two months from that date. In accordance with the terms of the St. Pancras Order, plans of the mains had been deposited with the London County Council and the General Post Office, and one month's notice had been given, as required, to the Gas, Water, and Tramways Companies. The Committee had, therefore, every confidence in informing the Vestry that the whole of the works were progressing satisfactorily.

**Paris.**—Yesterday an important addition was made to the Paris central lighting stations by the coming into operation of the central station of the Edison Company in the Avenue Trudaine. This station, like the others of the same company, is on the three-wire system, and is connected to the station in the Faubourg Montmartre. Its present capacity is 24,000 eight candle-power lamps, but ultimately it will be able to supply twice this number. When complete the plant will comprise six Belleville boilers, and eight Weyher and Richemond engines, coupled direct to eight-pole Edison dynamos, each having an output of 800 amperes and 125 volts at 135 revolutions. The cables are run on porcelain insulators placed in concrete troughs.—The Minister of Commerce has presented a Bill to the Chamber of Deputies, authorising the lighting by electricity of all the Government offices in Paris.—The results of installing letter-boxes on the cars of the Tramways-Sud have proved so satisfactory that the postal authorities extended the system, on New Year's Day, to the cars of the Tramways-Nord. During September, 12,000 telegrams, postcards, and letters were transmitted in this manner from the suburbs to the chief offices in Paris, and in October and November the figures were 15,000 and 17,000 respectively.

**The South Kensington and Paddington Subway Railway.**—The promoters of this scheme, which was withdrawn in the early part of last session, have re-deposited their Bill, with important amendments, in the Private Bill Office of the House of Commons. The first Directors of the proposed Company are the Earl of Kilmorey, Baron Sudeley, the Hon. Edward Spencer Churchill, Sir John Henry Puleston, Mr. John Irving Courtenay, Mr. Samson Fox, Mr. George Newman, Mr. Edward Power, and Major-General Charles Edmund Webber. Power is sought to construct a subway of a little over $1\frac{3}{4}$ miles in length, commencing at a point near the Exhibition-road, Kensington, and terminating in Paddington at the western end of the Bishop's-road bridge over the Great Western Railway. A capital of £276,000 is to be raised, in respect of which the Company will be empowered to borrow an additional sum of £92,000. Power is sought to enter into agreements with the Great Western Railway Company for connecting the subway by junctions with their system at Paddington, whilst several widely permissive clauses are inserted in the Bill, empowering public bodies and the Metropolitan District Railway Company to undertake the construction of this subway alone or jointly, or to subscribe towards the capital of the Company, or guarantee the payment of dividends. The public bodies mentioned are the County Council, the Royal Commissioners of the Exhibition of 1851, the Corporation of the Hall of Arts and Sciences (Albert Hall), the Commissioners of Woods, the Commissioners of Works, and "any vestries or vestry."

**The Influence of the Electric Spark and of the Surrounding Gas on the Rate of the Electric Discharge.**—In a recent number of the *Journal of the Physico-Chemical Society of Russia*, M. P. Bakhmetieff states that he has repeated the experiments of M. Naccari on the loss of charge undergone by an electrified body when close to an electric spark, placing the whole arrangement under a bell-glass and filling it with different gases. Generally speaking the electric spark accelerated the discharge, but charges of positive sign were the more rapidly dissipated in carbonic acid, and in coal gas, while negative electrification disappeared the more rapidly in air, hydrogen, and oxygen. M. Bakhmetieff attributes these results to an unstable molecular allotropic modification of the gases by the electric spark which renders them conducting, but only to electricity of one particular sign. M. A. Nacarri, in the *Atti della R. Accademia delle Scienze di Torino*, Vol. XXV., states, with reference to some further experiments of his, that the influence of the electric spark on the rate of discharge of an electrified body is much diminished by the presence of vapour of water, alcohol, essence of turpentine, ether, and petroleum. He further calls attention to the fact that the presence of a piece of phosphorus near an electrified metal ball causes it to rapidly discharge. This phenomenon is, he says, apparently closely connected with phosphorescence, since it only takes place if the phosphorus emits a glow reaching to the electrified body. The phenomenon ceases in the presence of bodies, like essence of turpentine, which cause phosphorescence to disappear.

Digitized by Google

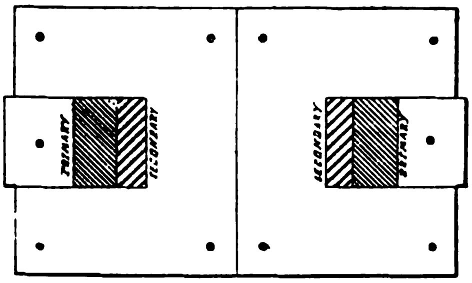
## ELECTRICAL DISTRIBUTION BY TRANSFORMERS FROM CENTRAL AND ECCENTRIC STATIONS.*

BY DR. J. A. FLEMING, M.A.

*(Continued from page 197.)*

Various devices have been invented by Prof. Elihu Thomson for preventing, by any possible chance, the connection of the primary high potential circuit with the secondary. In 1885 he took out a patent for a "Sheath" protective device, in which a copper strip or divided plate connected to the earth is interposed between primary and secondary windings. Another device is to ground one end of the secondary circuit, as described in Prof. Thomson's United States Patent Specification, No. 322,138,

Fig. 10.



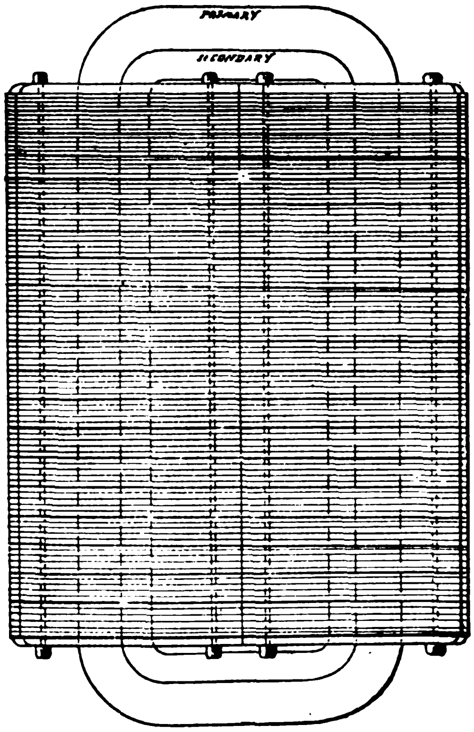



Fig. 12. Fig. 11.

of 1885;† the latest arrangement, however, is the application of the film cut out (described further on in connection with the series socket) to automatically ground the secondary circuit in case the high potential reaches it.

The objection to the film device is that it is apt to be broken down in case of a lightning discharge reaching the line before the lightning arresters have a chance to operate. On underground circuits the film device can be used without any such risk.

Figs. 10, 11, 12, 13, 14 show the various forms of cores which have been used in these transformers. Figs. 10 and 11 showe a type in which the coils are wound about two cores of similar shape, placed back to back, and each built up of C-shaped laminæ. Laminated plugs are driven into the openings over the coils, and the whole securely fastened together with bolts. In this form it will be noticed that the break in the continuity of the iron core is not such as to offer air resistance to the lines of force, its plane being parallel to the plane of those lines.

Fig. 13 shows another form of core in which the coils are wound on formers and then driven over a tongue projecting from a core built of "E"-shaped laminæ. Laminated plugs are driven into the openings over the coils. This is the type of core employed in the type "E" transformer shown in its box in Fig. 8.

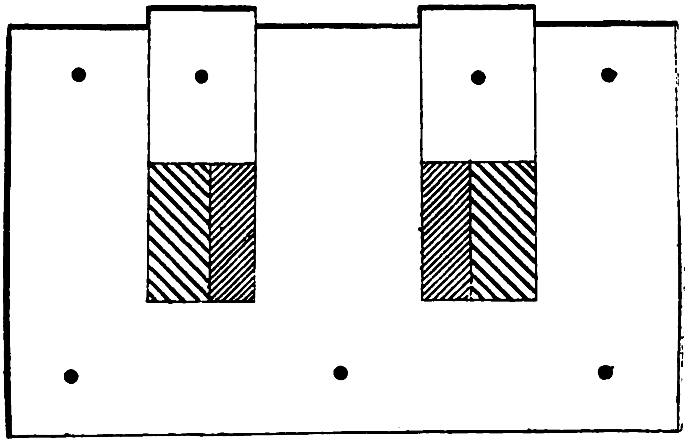


Fig. 13.

Fig. 14 shows the latest form of core. A plug of laminated iron is placed in the centre of a transformer coil, and sheets of iron cut in the form of a hollow rectangle are placed about the coil. These squares fit the plug very closely, and render the magnetic contact very perfect.

No insulating sheets are used between the laminæ of the transformer cores, the oxide of iron formed on the sheets during the annealing process being considered to be sufficient insulation for eddy currents.

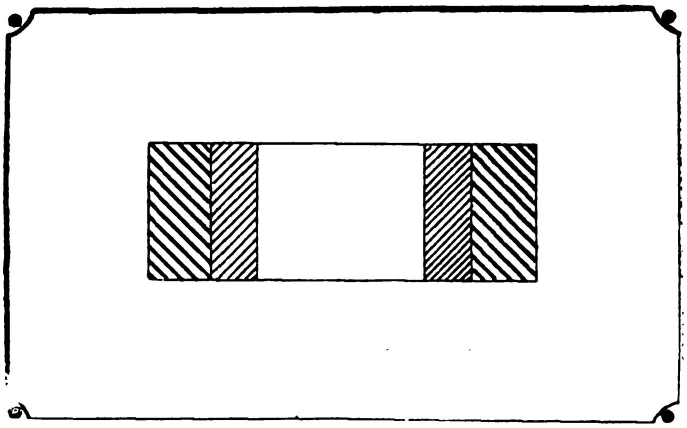


Fig. 14.

A novel device due to Prof. Thomson is employed in the transformers for maintaining the induction of the cores in the plane of the laminæ; zinc sheets, equal in thickness to two or three laminæ are introduced in the core at intervals of five sheets of iron. The magnetic resistance of these sheets prevents any distortion of the lines of induction, and serves materially to increase the efficiency of the apparatus. These sheets are shown by the heavy lines in Fig. 11 of the transformer. The primary and secondary fuses are contained in the ends of the iron cases, access being obtained by lids which can be screwed down. The primary fuses are mounted on ebonite, and the secondary on porcelain bases. It is remarkable to note how short these primary fuses are. The possibility of using such short fuse wires is dependant on the use of a dynamo of high self induction.

* All rights are reserved.

† See letter in *Electrical Review*, Sept. 26, 1885, by J. A. Fleming, and subsequent correspondence.

Digitized by Google

*Constant-Current Transformer*—Figs. 15 and 16 show two forms of transformer adapted for transforming from a constant potential primary current to a secondary current of constant strength, the potential of the secondary varying with the number of lamps in circuit.

Fig. 15 shows a type in which the coils are wound about opposite ends of a peculiarly-shaped soft iron laminated core. This core is designed so that the magnetism induced by the primary is partially carried through that part of the core enclosed by the secondary circuit, and partly through the air space "A." The transformer core is properly formed and proportioned, so that any decrease in the number of lamps on the secondary circuit by decreasing the secondary circuit resistance

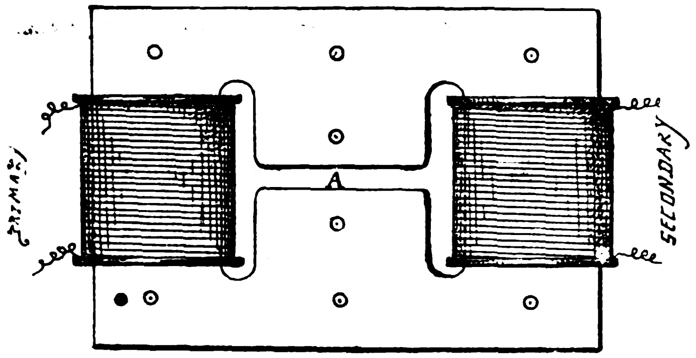



Fig. 15.—Constant-Current Thomson-Houston Transformer.

increases the reaction of the same on the primary, and causes a greater leakage of magnetism across the air space "A." This cuts down the induction in the secondary and increases the self-induction of the primary, thus proportionally decreasing its current.

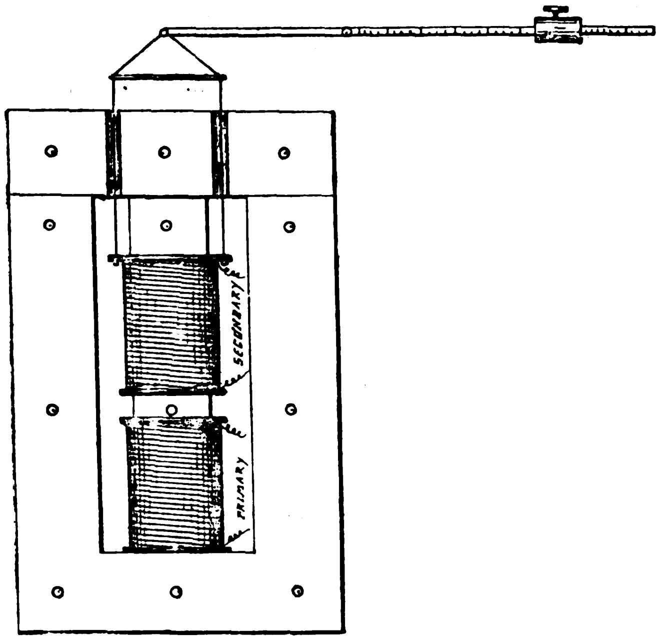



Fig. 16.—Constant-Current Thomson-Houston Transformer.

Fig. 16 shows an ingenious device invented by Prof. Thomson, for maintaining a constant secondary current. It is upon the same principle as the arrangement often used in laboratory experiments, consisting of a secondary coil balanced on a scale arm over a primary coil, the secondary being connected in series with an incandescent lamp. When an alternating current is sent through the induction coil the lamp coil is repelled, and adjusts its height above the primary induction coil, in accordance with the induction in itself,and maintains the current in itself constant even for varying primary current by its changing distance.

The secondary coil of the transformer in question is movbale on the core, and is supported by a rod from a lever bearing an adjustable counter-balance. At full load the counter-balance is so placed as to allow the secondary to lie close to the primary. If the secondary resistance be decreased its current increases momentarily enough to cause the secondary coil to be repelled from the primary and to assume some position above the latter at which point its reaction is the same as before, and its current again becomes normal.

A third device used for the same purpose as the above, but of a different nature, is shown in Fig. 17. A reactive coil, as is shown in Fig. 18, and explained under the head of regulating devices, is connected in the circuit of lamps in series on a constant potential system. Its sheath is counter-balanced by the weight P, and the weak spring S holds the sheath over the coil under normal load. On the extinction of a lamp in the circuit the reaction of the sheath on the coil increases and the

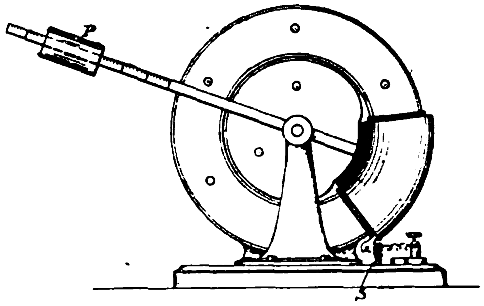



Fig. 17.—Balanced Reactive Coil.

sheath is repelled, thus increasing the self-induction of the coil and reducing the lamp current to its proper amount.

*Regulating Devices.—Reactive Coil or Dimmer.*—This is a device used in alternating current work to serve the same ends as rheostats in direct current plants. They are used in central stations for adjusting the potential of the feeders, and in theatres for controlling the candle power of the lamp.

They are, in principle, choking coils in which the winding is about a laminated soft iron ring, and in which a heavy envelope of copper adjusts, by its position as regards the coil, the self-induction exerted by it.

Fig. 18 shows the general form of the reactive coil. A winding of well insulated copper wire of comparatively few turns surround one part (about one-eighth of the circumference) of a laminated iron ring. Inside the ring is a laminated iron

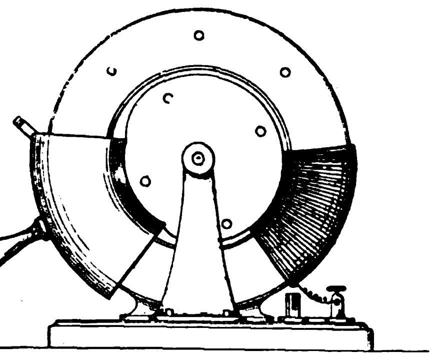


Fig. 18.—Reactive Coil or Dimmer.

drum, supported in bearings and fitting the inside of the ring very closely. A copper sheath is fastened to this drum, and is rotated about with it. When it is over the coil, its width is just sufficient to completely cover it. This sheath mounted upon the drum forms a closed coil, of very large section, about the ring, and fits so closely to it as to leave but a small air space inside or out.

The action of the dimmer will be evident from what has been said of its construction. When the sheath is over the coil, the latter is in the same condition as the primary of a short circuited transformer, and offers but slight resistance to the flow of current. In some dimmers the coil is short-circuited when the sheath is in this position. When the sheath is rotated away

Digitized by Google

from the coil its reactive effect is diminished, and the self-induction of the coil is increased; when it is in its furthest position from the coil the magnetic field of the latter is closed through the drum-shaped core and its self-induction is very great.

This same device, of a movable secondary having but one turn of heavy metal, is used as a transformer for electric welding work. In this case the sheath is not a closed circuit, its terminals being connected to the pieces to be welded.

The principle which underlies this instrument is simply that the presence of a closed secondary circuit near to a primary coil greatly reduces the inductance of that primary, and has the effect of decreasing the impedance of the primary circuit in question. When the sheath is directly over the primary it is traversed by very heavy induced currents, and hence there is a certain waste of energy in employing such an apparatus; but it has great advantages over a simple graded choking coil, in that the impedance can be varied continuously and without breaking circuit.

(*To be continued.*)

## ELECTROMAGNETIC THEORY.—I.

BY OLIVER HEAVISIDE.

§ 1. *Preliminary Remarks.*—The main object of the series of articles of which this is the first, is to continue the work entitled "Electromagnetic Induction and its Propagation," commenced in this journal on January 3, 1885, and continued to the 46th Section in September, 1887, when the great pressure on space and the want of readers appeared to necessitate its abrupt discontinuance. (A straggler, the 47th Section, appeared December 31, 1887.) Perhaps there were other reasons than those mentioned for the discontinuance. We do not dwell in the Palace of Truth. But, as was mentioned to me not long since, "There is a time coming when all things shall be found out." I am not so sanguine myself, believing that the well in which Truth is said to reside is really a bottomless pit.

The particular branch of the subject which I was publishing in the summer of 1887 was the propagation of electro-magnetic waves along wires through the dielectric surrounding them. This is itself a large and many-sided subject. Besides a general treatment, its many-sidedness demands that special cases of interest should receive separate full development. In general, the mathematics required is more or less of the character sometimes termed transcendental. This is a grandiloquent word, suggestive of something beyond human capacity to find out; a word to frighten timid people into believing that it is all speculation, and therefore unsound. I do not know where transcendentality begins. You can find it in arithmetic. But never mind the word. What is of more importance is the fact that the interpretation of transcendental formulæ is sometimes very laborious. Now the real object of true naturalists, in Sir W. Thomson's meaning of the word, when they employ mathematics to assist them, is not to make mathematical exercises (though that may be necessary), but to find out the connections of known phenomena, and by deductive reasoning, to obtain a knowledge of hitherto unknown phenomena. Anything, therefore, that aids this, possesses a value of its own wholly apart from immediate or, indeed, any application of the kind commonly termed practical. There is, however, practicality in theory as well as in practice. The very useful word "practician" has lately come into use. It supplies a want, for it is evident the moment it is mentioned that a practician need not be a practical man; and that, on the other hand, it may happen occasionally that a man who is not a practician may still be quite practical.

§ 2. Now, I was so fortunate as to discover, during the examination of a practical telephonic problem, that in a certain case of propagation along a conducting circuit through a conducting dielectric, the transcendentality of the mathematics automatically vanished, by the distorting effects on an electromagnetic wave, of the resistance of the conductor, and of the conductance of the dielectric, being of opposite natures, so that they neutralised one another, and rendered the circuit non-distortional or distortionless. The mathematics was reduced, in the main, to simple algebra, and the manner of transmission of disturbances could be examined in complete detail in an elementary manner. Nor was this all. The distortionless circuit could be itself employed to enable us to understand the inner meaning of the transcendental cases of propagation, when the distortion caused by the resistance of the circuit makes the mathematics more difficult of interpretation. For instance, by a study of the distortionless circuit we are enabled to see not only that, but also *why*, self-induction is of such great importance in the transmission of rapidly varying disturbances in preserving their individuality and preventing them from being attenuated to nearly nothing before getting from one end of a long circuit to the other; and *why* copper wires are so successful in, and iron wires so prejudicial to effective, long distance telephony. These matters were considered in Sections 40 to 45 (June, July, August, 1887) of the work I have referred to, and Sections 46, 47 contain further developments.

§ 3. But that this matter of the distortionless circuit has, directly, important practical applications, is, from the purely scientific point of view, a mere accidental circumstance. Perhaps a more valuable property of the distortionless circuit is, that it is the Royal Road to electromagnetic waves in general, especially when the transmitting medium is a conductor as well as a dielectric. I have somewhat developed this matter in the *Phil. Mag.*, 1888-9. Fault has been found with these articles that they are hard to read. They were harder, perhaps, to write. The necessity of condensation in a journal where space is so limited and so valuable, dealing with all branches of physical science, is imperative. What *is* an investigator to do, when he can neither find acceptance of matter in a comparatively elementary form by journals of a partly scientific, partly technical type, with many readers, or, in a more learned form, by a purely scientific journal with comparatively few readers, and little space to spare? To get published at all, he must condense greatly, and leave out all explanatory matter that he possibly can. Otherwise, he may be told his papers are more fit for publication in book form, and are therefore declined.

There is a third course, of course, viz., to keep his investigations to himself. But that does not answer, in a general way, though it may do so sometimes. It is like putting away seed in a mummy case, instead of planting it, and letting it take its chance of growing to a useful plant. There is nothing like publication and free criticism for utility. I can see only one good excuse for abstaining from publication when no obstacle presents itself. You may grow your plant yourself, nurse it carefully in a hot-house, and send it into the world full-grown. But it cannot often occur that it is worth the trouble taken. As for the secretiveness of a Cavendish, that is utterly inexcusable; it is a sin. It is possible to imagine the case of a man being silent, either from a want of confidence in himself, or from disappointment at the reception given to, and want of appreciation of, the work he gives to the world; few men have an unbounded power of persistence; but to make valuable discoveries, and to hoard them up as Cavendish did, without any valid reason, seems one of the most criminal acts such a man could be guilty of. This seems strong language, but as Prof. Tait tells us that it is almost criminal not to know several foreign languages, which is a very venial offence in the opinion of others, it seems necessary to employ strong language when the criminality is more evident. (*See*, on this point, the article in *The Electrician*, November 14, 1890. It is both severe and logical.)

§ 4. I had occasion, just lately, to use the word "naturalist." The matter involved here is worthy of parenthetical consideration. Sir W. Thomson does not like "physicist," nor, I think, "scientist" either. It must, however, be noted that the naturalist, as at present generally understood, is a student of living nature only. He has certainly no exclusive right to so excellent a name. On the other hand, the physicist is a student of inanimate nature, in the main, so that he has no exclusive right to the name, either. Both are naturalists. But their work is so different, and their type of mind also so different, that it seems very desirable that their names should be differentiated, and that "naturalist," comprehending both,

Digitized by Google

should be subdivided. Could not one set of men be induced to call themselves organists? We have organic chemistry, and organisms, and organic science; then why not organists? Perhaps, however, organists might not care to be temporarily confounded with those members of society who earn their living by setting a cylinder in rotatory motion. If so, there is another good name, viz., vitalist, for the organist, which would not have any ludicrous association. Then about the other set of men. Are they not essentially students of the properties of matter, and therefore materialists? That "materialist" is the right name is obvious at a glance. Here, however, a certain supposititious evil association of the word might militate against its adoption. But this would be, I think, an unsound objection, for I do not think there is, or ever was, such a thing as a materialist, in the supposed evil sense. Let that notion go, and the valuable word materialist be put to its proper use, and be dignified by association with an honourable body of men.

Buffon, Cuvier, Darwin, were typical vitalists.

Newton, Faraday, Maxwell, were typical materialists.

All were naturalists. For my part I always admired the old-fashioned term "natural philosopher." It was so dignified, and raised up visions of the portraits of Count Rumford, Young, Herschel, Sir H. Davy, &c., usually highly respectable-looking elderly gentlemen, with very large bald heads, and much wrapped up about the throats, sitting in their studies pondering calmly over the secrets of nature revealed to them by their experiments. There are no natural philosophers nowadays. How is it possible to be a natural philosopher when a Salvation Army band is performing outside; joyously, it may be, but not most melodiously? But I would not disparage their work; it may be far more important than his.

§ 5. Returning to electromagnetic waves. Maxwell's inimitable theory of dielectric displacement was for long generally regarded as a speculation. There was, for many years, an almost complete dearth of interest in the unverified parts of Maxwell's theory. Prof. Fitzgerald, of Dublin, was the most prominent of the very few materialists (if I may use the word) who appeared to have a solid faith in the electromagnetic theory of the ether; thinking about it and endeavouring to arrive at an idea of the nature of diverging electromagnetic waves, and how to produce them, and to calculate the loss of energy by radiation. An important step was then made by Poynting, establishing the formula for the flow of energy. Still, however, the theory wanted experimental proof. Three years ago electromagnetic waves were nowhere. Shortly after, they were everywhere. This was due to a very remarkable and unexpected event, no less than the experimental discovery by Hertz, of Karlsruhe, (now of Bonn), of the veritable actuality of electromagnetic waves in the ether. And it never rains but it pours; for whilst Hertz with his resonating circuit was working in Germany (where one would least expect such a discovery to be made, if one judged only by the old German electro-dynamic theories) Lodge was doing in some respects similar work in England, in connection with the theory of lightning conductors. These researches, followed by the numerous others of Fitzgerald and Trouton, J. J. Thomson, &c., have dealt a death-blow to the electrodynamic speculations of the Weber-Clausius type (to mention only the first and one of the last), and have given to Maxwell's theory just what was wanted in its higher parts, more experimental basis. The interest excited has been immense, and the theorist can now write about electromagnetic waves without incurring the reproach that he is working out a mere paper theory. The speedy recognition of Dr. Hertz by the Royal Society is a very unusual testimony to the value of his researches.

At the same time I may remark that to one who had carefully examined the nature of Maxwell's theory, and looked into its consequences, and seen how *rationally* most of the phenomena of electromagnetism were explained by it, and how it furnished the only approximately satisfactory (paper) theory of light known; to such a one Hertz's demonstration came as a matter of course—only it came rather unexpectedly.

§ 6. It is not by any means to be concluded that Maxwell spells Finality. There is no finality. It cannot even be accurately said that the Hertzian waves prove Maxwell's dielectric theory completely. The observations are very rough indeed, when compared with the refined tests in other parts of electrical science. The important thing proved is that electromagnetic waves in the ether at least approximately in accordance with Maxwell's theory are a reality, and that the Faraday-Maxwellian method is the correct one. The other kind of electrodynamic speculation is played out completely. There will be plenty of room for more theoretical speculation, but it must now be of the Maxwellian type, to be really useful.

§ 7. In what is to follow, the consideration of electromagnetic waves will (perhaps) occupy a considerable space. How much depends entirely upon the reception given to the articles. Mathematics is at a discount, it seems. Nevertheless, as the subject is intrinsically a mathematical one, I shall not scruple to employ the appropriate methods when required. The reader whose scientific horizon is bounded entirely by commercial considerations may as well avoid these articles. Speaking without prejudice, matter more to his taste may perhaps be found under the heading TRADE NOTICES. *Sunt quos curriculo.*

I shall, however, endeavour to avoid investigations of a complex character; also, when the methods and terms used are not generally known I shall explain them. Considering the lapse of time since the discontinuance of E.M.I. and its P. it would be absurd to jump into the middle of the subject all at once. It must, therefore, be gradually led up to. I shall, therefore, in the next place make a few remarks upon mathematical investigations in general, a subject upon which there are many popular delusions current, even amongst people who, one would think, should know better.

(*To be continued.*)

## ON THE PROPAGATION OF ALTERNATING CURRENTS THROUGH CONCENTRIC CABLES.

BY DR. J. A. FLEMING, M.A.

Attention having been drawn of late to interesting phenomena in connection with the Ferranti trunk mains, it may be of utility to furnish very briefly the results of some measurements on these cables, reserving further facts for another occasion, and to point out how far these facts fit in with existing theoretical investigations. Particularly also to refer readers of *The Electrician* to some work of Mr. Oliver Heaviside, which will be found to contain a good deal which is pertinent to questions now being discussed. The employment of conductors having quite sensible, even if not very considerable electrostatic capacity in conjunction with alternators and transformers, brings into prominence phenomena which may be broadly called resonance effects, and which need careful study to avoid serious practical mistakes in laying out large systems of electrical distribution. It is convenient to adopt a telephonic nomenclature, and to speak of the alternator or transformer, or both together, placed at the generating end of a trunk main as the Transmitter, and to call the transformer at the distribution end the Receiver.

Let us consider a simple generating and pressure reducing plant consisting of a transmitter, concentric conductor, and receiver. The transmitter and receiver may be considered to be transformers. There are then seven quantities which may be supposed to be given constants. The ohmic resistances of the transmitter, receiver, and conductor; the inductances at given loads of the same three; and the electrostatic capacity of the cable. First, let us consider the cable, supposed to consist of two concentric conductors separated by a tubular dielectric sheath. The capacity C, a length $l$, of such a cable is capable of being calculated from the well-known formula,

$$C = \frac{R\,l}{2 \log_\epsilon \frac{R_3}{R_2}},$$

where $R_2$ is the half-diameter of the outside of the inner conductor, and $R_3$ is the half-diameter of the inside of the outer conductor, and R is the specific inductive capacity of the

dielectric. For the Ferranti mains, the ratio $R_3 : R_2$ is about 2·27, and it appears that the specific inductive capacity of the compressed waxed paper of which the dielectric is formed is nearly 3·5. The experimentally measured capacity of one length of Ferranti cable of about one mile and a-third showed that the capacity of the cable as laid is ·367 of a microfarad per mile.

The self-induction of a concentric cable of this type can be accurately calculated from a formula given by Lord Rayleigh in the *Philosophical Magazine* for May, 1886, and which is given in the form

$$\frac{L}{l} = 2 \log \frac{R_3}{R_2} + \frac{2}{R_2^2 - R_1^2}\left(\frac{R_2^2 - 3R_1^2}{4} + \frac{R_1^4}{R_2^2 - R_1^2} \log \frac{R_2}{R_1}\right)$$
$$+ \frac{2}{R_4^2 - R_3^2}\left(\frac{R_3^2 - 3R_4^2}{4} + \frac{R_4^4}{R_4^2 - R_3^2} \log \frac{R_4}{R_3}\right)$$

in which L is the inductance of a length $l$ of the cable and $R_1$, $R_2$, $R_3$, $R_4$ are the half-diameters of inside of inner, outside of inner, inside of outer, and outside of outer copper conductor. From the carefully measured dimensions of the Ferranti cable I find that

$$L = 1{\cdot}7755\, l.$$

Since one mile = 160931·5 centims., it follows that the self-induction of one mile of the Ferranti cable is ·0002857 henrys The measured ohmic resistance of the copper conductor, taking both inner and outer together, is ·324 legal ohms per mile run of the cable at 0°C.

The frequency $n$ or number of complete periods in the current used has been hitherto 67. If we take $p$ as usual to represent $2\pi n$, we have then

$$n = 67,\ p = 421,\ p^2 = 177220.$$

Let R be the ohmic resistance, C the electrostatic capacity, and L the self-induction of the cable, all per mile run, then,

$$R = {\cdot}324 \text{ ohm.} \qquad R^2 = {\cdot}1049.$$
$$L = {\cdot}000286 \text{ henry.}$$
$$pL = {\cdot}1204. \qquad p^2 L^2 = {\cdot}0145.$$

also $R^2 + p^2 L^2 = {\cdot}1194 = I^2$, and $\sqrt{R^2 + p^2 L^2} = {\cdot}3455$ ohms = I, or the impedance per mile, and I exceeds R by about 7 per cent. Also $C = {\cdot}367$ microfarads $= \frac{367}{10^9}$ farads, and we can calculate from the values above given other important quantities, such as

$$Cp = \frac{1545}{10^7}$$

and
$$P^2 = \sqrt{R^2 + p^2 L^2} - pL = {\cdot}00001738,$$
$$Q^2 = \sqrt{R^2 + p^2 L^2} + pL = {\cdot}00003597\ ;$$

thus
$$P = {\cdot}004 \qquad Q = {\cdot}006,$$

and
$$\frac{P^2 + Q^2}{I^2} = \frac{447}{10^6} \quad (2PR + 2QLp) = {\cdot}00415$$

and
$$(2PLp^2 - 2QpR) = -1{\cdot}216.$$

These numerical quantities are required in calculating the current at the far end of the cable.

Let us first examine the simple case of a condenser of capacity C, of which the terminals are short-circuited by an inductive resistance of inductance $l$ and resistance $r$, and let another inductive resistance L, R connect the terminals of the condenser with a source of simple periodic alternating electromotive force (*see* Fig.) E of frequency $n$.

If $v_1$ and $v$ are the potential differences at any instant of the generator and condenser ends of the line $L_1$ R, and if $V_1$ and V are the maximum values of these potentials, it is not difficult to show that

$$\frac{V_1^2}{V^2} = (A^2 + B^2) + (1 - Cp^2)\frac{R^2 + p^2 L^2}{r^2 + p^2 l^2} + \frac{2Llp^2}{r^2 + p^2 l^2} + \frac{2Rr}{r^2 + p^2 l^2}$$

where $A = 1 - CLp^2$ and $B = CRp$, and $p$, as usual, $= 2\pi n$.

This equation gives us the ratio of the potential differences at the generator and condenser end of the inductive line L, R. Let us examine some particular cases.

(i.) Let $r^2 + p^2 l = \infty$, that is if there is no shunt, then

$$\frac{V_1}{V} = \sqrt{A^2 + B^2} = \sqrt{(1 - CLp^2)^2 + C^2 R^2 p^2}.$$

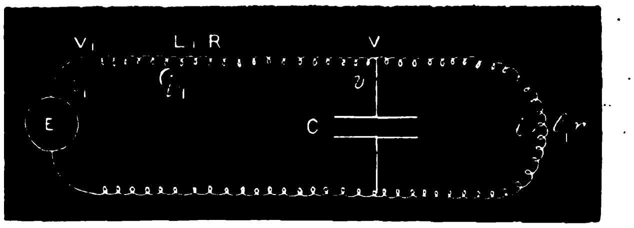
If the values of $C_1$ $L_1$ R and $p$ are such as to make the quantity under the radical less than unity, then V is greater than $V_1$; that is, there is a rise of pressure as we proceed away from the generator end. This reduced case was first treated by Dr. Hopkinson long ago (see *Proc. Institution of Electrical Engineers*, 1884, p. 513. It is easy to see that C, L, R, and $p^2$ may have such values that $V_1$ is greater, equal to or less than V.

(ii.) If $L = 0$, $l = 0$, $r = \infty$;

then
$$\frac{V_1}{V} = \sqrt{C^2 R^2 p^2 + 1}.$$

This case, when there is no inductance and no shunt, is treated by Mr. Blakesley ("Alternating Currents," p. 32, second edition), and since $C^2 R^2 p^2 + 1$ is always greater than unity, $V_1$ in this case is always greater than V; that is, there can be no rise of pressure, but only a fall as we pass from the generator end to the condenser end of the line.

(iii.) Returning to the general case, it is easy to see that whatever be the values of $(1 - CLp^2)$ and $CRp$ it is possible to have such a small value for the impedance $(\sqrt{r^2 + p^2 l^2})$ of the shunt, that V must be less than $V_1$, and hence the pressure less




at the condenser end than at the generator end. This investigation (given only in sketchy outline here) shows fully what takes place when an alternator is connected with a line, ending in such a short-circuited condenser, it indicates that the potential difference of the terminals of the condenser may be very much greater than that of the terminals of the generator. By trying different values of L, C, R, and $p^2$, we can see generally what the result is. We see at once that if $l$ and L are both zero, and $r = \infty$, that V must be less than $V_1$, but that for certain critical values of L, C, R, and $p^2$, we may have V many times greater than $V_1$, as first shown by Dr. Hopkinson.

The general case of a line having capacity, resistance, and self-induction having a transmitting apparatus, having inductance and resistance at one end, and a receiver having the same qualities at the other end, has been very fully and ably treated by Mr. Oliver Heaviside in the *Philosophical Magazine* for 1887 (Vol. XXIII., p. 21, January, 1887). If $L_0$ $R_0$ be the inductance and resistance of the transmitter apparatus, and $L_1$ and $R_1$ that of the receiver, and if L, R, and C be the inductance, resistance, and capacity of the line per unit of length, Mr. Heaviside has given the equation for the amplitude of the current $C_0$ at the receiver end of the line, when a periodic electromotive force of amplitude $V_0$ acts at the transmitter end. The cable having resistance R, inductance L, and capacity C per unit of length, and the transmitter apparatus having inductance $L_0$ and resistance $R_0$, and the receiver apparatus having inductance $L_1$ and resistance $R_1$. The equation for the current amplitude (leaving out of account for the present dielectric conductivity in the cable) is

$$C_0 = V_0 \frac{2\sqrt{Cp}}{(R^2 + p^2 L^2)^{\frac{1}{4}}} \left[G_0 G_1 e^{2Pl} + H_0 H_1 e^{-2Pl} - 2(G_0 G_1 H_0 H_1)^{\frac{1}{2}} \cos(2Ql + 2\theta)\right]^{-\frac{1}{2}}.$$

Digitized by Google

In this equation $p$ stands $2\pi$ times the frequency, or for $2\pi n$, P and Q are given by $P^2 = \left(\frac{pC}{2}\sqrt{R^2+p^2L^2} - Lp\right)$ and $Q^2 = \frac{pc}{2}\sqrt{R^2+p^2L^2} + Lp$, $G_0$, $H_0$ are certain complicated functions of the inductances, resistances, and capacity of the cable and of the transmitter apparatus, and $G_1$, $H_1$ the same for the receiver apparatus, and $\theta$ is likewise a function of all these quantities, whilst $l$ stands for the length of the cable. This equation may be looked upon as a kind of glorified Ohm's law, by means of which the current $C_0$ at the far end of the cable may be calculated from the given constants and the volts $V_0$ at the home end. For further information readers must consult Mr. Heaviside's Paper in the *Phil. Mag.* for January, 1887. Moreover, when we have the value of $C_0$, we have only to take the product of $C_0$ and $\sqrt{R_1^2+p^2L_1^2}$ to get the potential difference of the cable ends at the receiver end, and comparing this with the value of $V_0$ we are able to see if the pressure is greater at the receiver end than at the transmitter end. Not to take up more space, I may say that I have attempted to get the necessary values of all these constants to test this theory in the case of the Ferranti mains. Taking it to be, as I think we may, correct, it is easy to employ it to calculate the rise of pressure at the receiver end in various cases. Thus, suppose a lamp of 10 ohms resistance and negligible inductance is placed at one end of five miles of the Ferranti cable, and an alternator of 10 ohms resistance and negligible inductance at the other end. Let the potential difference at the transmitter end of the cable be $V_0$, required to find the potential difference $V_1$ at the terminals of the lamp at the receiver end. It is not difficult to show that in this case $V_1$ should be *less* than $V_0$ in the ratio of 400 to 583.

If, however, the alternator has a resistance of 10 ohms and an inductance of ·1 henry, and the receiver is a non-inductive resistance of 100 ohms, the cable being the same, then it appears there will be a *rise* in pressure, and that the potential difference at the receiver end will be greater than that at the transmitter end in the ratio of 100 to 70. I hope to treat this matter more fully on another occasion.

## THE RISE OF POTENTIAL DIFFERENCE IN THE DEPTFORD MAINS.

BY W. E. AYRTON.

I am glad to see, from Mr. Glazebrook's article in *The Electrician* for December 26th, that he holds the same view as that given by me to my students some little while ago on this sub-

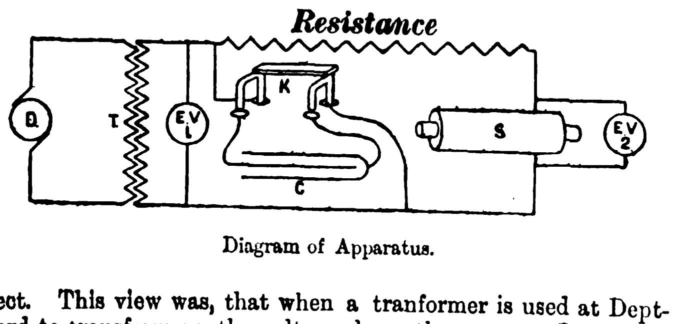



Diagram of Apparatus.

ject. This view was, that when a tranformer is used at Deptford to transform up the volts and another one at London to transform them down, the mere fact that the cable connecting these transformers had capacity was sufficient to cause the potential difference at London to be higher than the potential difference at Deptford. In connection with this suggestion some of the students at the Central Institution made a number of experiments last term under the superintendence of Dr. Sumpner and Mr. Mather. The annexed figure explains the arrangement of apparatus used by them for one set of tests, and with a certain rate of alternation, &c., they found on pressing down the double key, K, by its wooden-cross bar so as to connect the two coatings of the condenser with the two terminals of the secondary coil of the transformer, that while the potential difference measured by voltmeter $E_1V$ (volts at Deptford) went up about 1 per cent., the potential difference measured by the voltmeter $E_2V$ (volts at London) went up over 5 per cent. On raising the key, the potential difference at each end of the circuit went back to its original value, showing that the effect observed in this experiment was solely due to the addition of capacity to the mains.

As the secretaries of the Physical Society tell me that they intend devoting one meeting early this next year *exclusively* to the subject of transformers, I will confine myself on the present occasion to the above brief description of this one experiment.

## ALTERNATE CURRENT CONDENSERS.

BY J. SWINBURNE.

The following explanation of the "Ferranti Effect," due to Mr. Swinburne, formed the latter half of his Paper on "Alternate Current Condensers" recently read before the Physical Society, and a brief abstract of which appeared in our issue of December 19, 1890. As the subject is attracting so much attention, we give this portion of the paper in full.

Loss of power in dielectrics is not confined to condensers; it may be very serious in cables. A condenser that heated excessively was made like the Deptford mains. The dielectric was very much thinner in proportion to the pressure, and allowing the loss per cubic centimetre to vary as the square of the pressure on its sides, a Deptford main would have a loss of, very roughly, 7,000 watts in the dielectric. It does not follow that this is the exact loss in a Deptford main. Very small differences in the constitution of the dielectric cause large variations in the power wasted. The loss may, therefore, be very much greater, or very much less. Taking the specific inductive capacity of the dielectric as 2, a seven mile main has a capacity of 2 microfarads. With 10,000 volts at a frequency of 80, this takes 10 amperes, and 100,000 "apparent" watts; 7,000 watts is only a small percentage of this.

Another unexpected effect has occurred at Deptford. There is an extraordinary rise of pressure. No authoritatively accurate accounts have been published, so it is difficult to say what has happened; but it is said that when the mains are put on the pressure rises. This is generally explained by saying the mains have capacity, and there is self-induction in the circuit, and the capacity and self-induction have a period which corresponds with the frequency of the dynamo, so that the system sympathises, or acts as a sort of electric resonator, thus giving abnormally high pressure. A little consideration will show that this theory is untenable. With such a capacity as that of the Deptford cables the self-induction would have to be enormous.

Let the capacity of the cable be K, and the self-induction of the circuit L, in farads and henrys or quadrants. Call E and C the electromotive force and current respectively. Then,

$$E = L\frac{dC}{dt}$$

and

$$C = -K\frac{dE}{dt}.$$

Combining these equations,

$$\frac{d^2E}{dt^2} = -\frac{E}{KL};$$

so,

$$\frac{dE}{dt}\frac{d^2E}{dt^2} = -\frac{E}{KL}\frac{dE}{dt},$$

and integrating

$$\left(\frac{dE}{dt}\right)^2 = -\frac{1}{KL}(E^2+a)$$

where $a$ is a constant,

or, $$\frac{dE}{dt} = -\frac{1}{\sqrt{KL}} \sqrt{(E^2+a)}.$$

so $$\frac{\sqrt{KL}\,dE}{\sqrt{E^2+a}} = -dt$$

and integrating $$\sqrt{KL} \cos^{-1}\frac{E}{a} = t,$$

therefore, $$E \propto \cos\frac{t}{\sqrt{KL}},$$

and $$T = 2\pi\sqrt{KL}.$$

When a charged condenser is short-circuited through a circuit with self-induction only, oscillation is produced, the current and pressure both varying harmonically with a frequency of $1/2\pi\sqrt{KL}$.

In the Deptford case, with a capacity of two microfarads and a period of 0·0125 the self-induction needed would be half a henry. A choking coil with such a coefficient of self-induction wound to carry 250 amperes, which, I understand, is the load of one main, would take 64,000 volts to get the current through. A transformer only acts on the circuit as a choking coil to the small extent due to the waste induction in it. If built on the lines of commercial transformers this one would have to be large enough to give an output of hundreds of millions of watts to produce a resonator effect. Moreover, a slight alteration in the speed of the dynamo would throw it "out of tune" with the resonator, so that the effect would disappear. For instance, a 5 per cent. variation of speed would alter the pitch of the dynamo nearly a semitone.

It has been stated that there is a difference of apparent ratio in the Deptford transformer when the main is in circuit, that is to say, that though it generally transforms four to one, when the main is on it transforms about 4½ or 5 to one. I would suggest this is impossible. There is always a "drop" in transformers due to waste field. In a transformer for 10,000 volts and 250 amperes if properly designed, it would be well under 1 per cent., probably about one-tenth per cent. In order that an oscillatory current should be confined to the line side by the waste induction which causes a drop of 1 per cent. and 80 periods per second, the frequency would have to be enormous. Such an oscillatory current would also be excluded from the secondary at the London end. Any effect which does not involve enormous frequencies must show on both sides of the tranformers. It might be said that the "drop" of the transformers in the circuit would give enough self-induction to produce a frequency corresponding to an upper partial of the note of the dynamo. If the dynamo E.M.F. does not vary harmonically such an effect might be produced, but it would show on the voltmeters at both ends. To give an increase of 15 or 20 per cent. effective pressure, with a total transformer drop of 1 per cent., the frequency would be, roughly, 1,000, and the effective pressure of the oscillatory component 6,000 volts. This would give 72 amperes, and the "skin effect" would absorb a great deal of power.

There is, however, a simpler explanation. The cables have considerable capacity, and take an appreciable current. This "leads" relatively to the electromotive force, so the capacity current passes in the armature coils when they are just in the position to magnetise the fields more strongly. The fields cannot follow each pulsation of excitation so produced, but are affected by it. Their average excitation is increased. I have tried putting a condenser on one of the old Gramme alternators, which have rather weak fields, and a large number of armature ampere turns. The pressure ran up and burned the voltmeter. I have already gone fully into the action of leading and lagging currents on dynamo fields elsewhere, so the subject need not be pursued here. It would, no doubt, be possible to make an alternator excite itself like a series machine by putting a condenser on the terminals instead of exciting the fields by a direct current machine. Such an arrangement seems scarcely commercial, though interesting.

## NOTE ON THE LAW OF HYSTERESIS.*

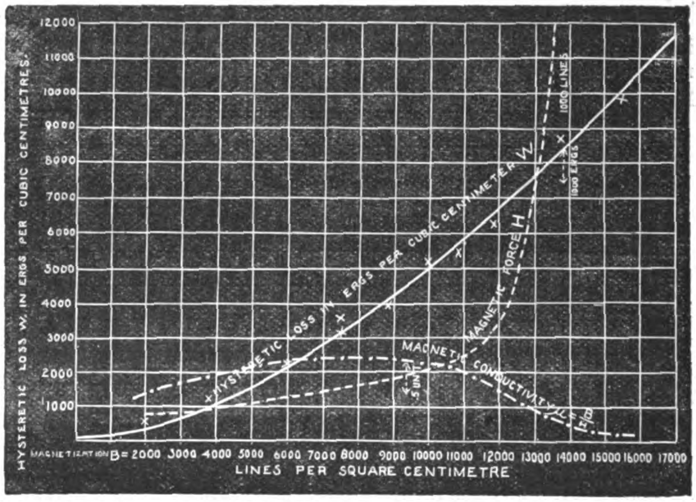
BY CHAS. STEINMETZ.

The magnetism of a magnetic circuit will vary periodically, if subjected to a periodically varying magneto-motive force. The variations of the magnetism, however, will not be simultaneous with the variations of the magneto-motive force, but show a certain lag, so that the curve of magnetism, as a function of the magneto-motive force, forms a kind of loop, the well-known curve of hysteresis.

This phenomenon proves that in the production of the magnetic circuit by the conversion of electric energy into magnetic energy, and in the destruction of the magnetic flow by its reversion into electric energy, a certain amount of energy has been lost, that is, converted into heat.

The amount of energy converted into heat by hysteresis in a full magnetic cycle depends on the maximum magnetisation. It increases with increasing magnetisation, but faster than the magnetisation, so that, when for magnetisation of B = 3,000 (3,000 lines of magnetic force per square centimetre), the loss by hysteresis amounts to 736 absolute units or ergs per cubic centimetre ($10^7$ ergs = 1 watt-second); for four times as high a magnetisation, or B = 12,000, the loss is 6,720, that is, more than nine times as high. On the other hand, the loss increases more slowly than the square of the magnetisation, because the square law would require a loss of 11,776 for B = 12,000.

A great number of experimental researches on the loss of energy due to hysteresis, with different magnetisations, have been made by Ewing; but that law of nature is still unknown, which gives the dependence of the hysteresis upon the magnetisation.




Loss by Hysteresis at Different Degrees of Magnetisation.

In trying to find at least a clue to this law, I subjected a very complete set of Ewing's observations on the hysteric energy, *made on a soft iron wire*, and consisting of 10 tests from a magnetisation of 1,974 lines of magnetic force per square centimetre, up to 15,560 lines per square centimetre, to an analytical treatment by the method of least squares, to ascertain whether the losses due to hysteresis are proportional at all to any power of the magnetisation, and which power this is.

The results of this calculation seem to me interesting enough to publish, in so far as all those observations fit very closely the calculated curve, within the errors of observation, and the exponent of the power was so very nearly 1·6, that I can substitute 1·6 for it, and combine those observations of Ewing in the formula

$$W = \cdot 002\, B^{1\cdot 6},$$

where W is the waste due to hysteresis, in ergs per cubic centimetre ($=10^{-7}$ watt-second) per cycle, and B, the maximum magnetisation (number of lines of magnetic force per square centimetre).

In Table I., in the first column, are given the values of the magnetic force H in absolute units; in the second column is given the maximum magnetisation or induction, B, in lines per square centimetre; in the third column the magnetic conductivity $\mu = \frac{B}{H}$; in the fourth column the hysteretic loss E, in ergs per cubic centimetre, as observed by Ewing, but in the fifth column the hysteretic loss calculated by the formula:

$$W = \cdot 002\, B^{1\cdot 6}.$$

* From the *Electrical Engineer* of New York

Digitized by Google

The sixth column gives the differences of the observed and the calculated values, $E - W$; the seventh column gives these differences in per cents. of $E$.

In the diagram these calculated values, $W$, of hysteretic loss are shown in the curve; the black crosses show the values of hysteretic loss $E$ observed by Ewing.

For comparison there are shown, in dotted lines, the curves of magnetic force $H$ and of magnetic conductivity $\mu = \frac{B}{H}$, as functions of the magnetisation $B$.

It will be seen that the observed values of hysteretic loss are very near the calculated curve through the whole range of observation, and do not show any tendency to deviation, which justifies my considering this coincidence as something more than a mere accident, and, indeed, as an indication of a general law, although certainly this law might be more complicated than the formula.

In Table II, are given the values of hysteretic loss, calculated by the formula:

$$W = \cdot 002\ B^{1 \cdot 6}.$$

To one interesting fact I wish to draw attention: The hysteretic loss seems to be independent of the magnetic force $H$, and only dependent upon the magnetisation $B$; it therefore shows no special singularity at the point of the beginning of magnetic saturation, but increases in the last two observations in Table I., which, for an increase of $B$ by 3,500, require an increase of $H$ by 68, showing high saturation, according to the same rule as in the first eight observations, where $B = 12{,}000$ corresponds to $H = 7$. Therefore the "knee" of the magnetic curve or "characteristic,"

$$B = f(H)$$

is no singular point of the curve of hysteresis $W = \cdot 002\ B^{1 \cdot 6}$, as the diagram shows.

From this formula we get the loss due to hysteresis per cubic inch of soft iron and for the maximum magnetisation of $M$ lines of magnetic induction per square inch, when $n$ = the number of complete periods of the exciting alternate current:

$$W = \tfrac{5}{3} \times 10^{-10}\ n\ M^{1 \cdot 6} \text{ watts.}$$

Table I.

Comparison of Ewing's observed values of $E$, the energy consumed by hysteresis in soft iron, with the values calculated by the equation:—

$$W = \cdot 002\ B^{1 \cdot 6}.$$

| H | B | $\mu$ | E | W | E - W | Difference in percentage. |
|---|---|---|---|---|---|---|
| 1·50 | 1,974 | 1,330 | 410 | 375 | 35 | 8·5 |
| 1·95 | 3,830 | 1,964 | 1,160 | 1,082 | 58 | 5·0 |
| 2·56 | 5,950 | 2,324 | 2,190 | 2,190 | 0 | ·0 |
| 3·01 | 7,180 | 2,385 | 2,940 | 2,956 | - 16 | - ·5 |
| 3·76 | 8,790 | 2,340 | 3,990 | 4,080 | - 90 | - 2·3 |
| 4·96 | 10,590 | 2,133 | 5,560 | 5,510 | 50 | ·9 |
| 6·62 | 11,480 | 1,734 | 6,160 | 6,260 | - 100 | - 1·7 |
| 7·04 | 11,960 | 1,700 | 6,590 | 6,690 | - 100 | - 1·5 |
| 26·5 | 13,700 | 517 | 8,690 | 8,310 | 380 | 4·4 |
| 75·2 | 15,560 | 207 | 10,040 | 10,190 | - 150 | - 1·5 |

Table II.

Energy consumed by hysteresis, in absolute units ($=10^{-}$ watt-seconds) per cycle and per cubic centimetre soft iron, for the induction of $B$ lines of magnetic forces per square centimetre, calculated by the equation:—

$$W = \cdot 002\ B^{1 \cdot 6}$$

| B | W | B | W |
|---|---|---|---|
| 1,000 | 126 | 11,000 | 5,850 |
| 2,000 | 382 | 12,000 | 6,720 |
| 3,000 | 736 | 13,000 | 7,640 |
| 4,000 | 1,160 | 14,000 | 8,600 |
| 5,000 | 1,658 | 15,000 | 9,610 |
| 6,000 | 2,220 | 16,000 | 10,660 |
| 7,000 | 2,840 | 18,000 | 12,870 |
| 8,000 | 3,520 | 20,000 | 15,230 |
| 9,000 | 4,240 | 25,000 | 21,760 |
| 10,000 | 5,020 | 30,000 | 29,280 |

## PROVISIONAL ORDERS AND LICENCES GRANTED BY THE BOARD OF TRADE DURING 1890.

### PROVISIONAL ORDERS—Metropolitan.

| Title of Order. | To Whom Granted. | Area covered by Order. |
|---|---|---|
| City of London Electric Lighting (Brush) Order ...... | Brush Electrical Engineering Company, Limited | Portion of the City of London. |
| Crystal Palace and District Electric Lighting Order. | Electric Installation and Maintenance Company, Limited | Portions of following Districts, viz., Parishes of Lambeth and Camberwell, District of Lewisham District Board of Works, and of Beckenham Local Board. |
| Lambeth Electric Supply Order ........................... | House-to-House Electric Light Supply Company, Limited | Portion of the Parish of St. Mary, Lambeth. |
| North London Electric Supply Order ...................... | Ditto | The Parish of Islington. |
| Wandsworth District Electric Supply Order ........... | Ditto | The District of the Wandsworth District Board of Works. |
| City of London (East District) Electric Lighting Order | Laing, Wharton and Down Construction Syndicate, Limited | Portion of the City of London. |
| London Electric Supply Corporation Electric Lighting (Metropolitan) Order | London Electric Supply Corporation, Limited | The Parish of St. George the Martyr, Southwark and a portion of the Parish of Camberwell. |
| Metropolitan Electric Supply Company (Paddington) Lighting Order. | Metropolitan Electric Supply Company, Limited | The Parish of Paddington. |
| St. James' Electric Lighting Order ....................... | St. James' and Pall Mall Electric Light Company, Limited | The Parish of St. James', Westminster. |

Provisional Orders (Provincial) is given on next page.

### LICENCES—Provincial.

| Title of Licence. | To Whom Granted. | Area covered by Licence. |
|---|---|---|
| Bath Electric Lighting Licence ........................ | Mr. H. G. Massingham ................. | Portion of the City of Bath. |
| Chelmsford Electric Lighting Licence.................. | Messrs. Crompton and Co., Limited ... | Municipal Borough of Chelmsford. |
| Dublin Electric Lighting Licence (Private)............ | Corporation of Dublin .................... | City of Dublin. |
| Newcastle and District Electric Lighting Company's Licence | Newcastle and District Electric Lighting Company, Limited | City of Newcastle. |
| Newcastle-upon-Tyne Electric Supply Company's Licence | Newcastle-upon-Tyne Electric Supply Company, Limited | City of Newcastle. |
| Northampton Electric Lighting Licence (Provisional Order subsequently granted, when powers under Licence ceased) | Northampton Electric Light and Power Company, Limited | Municipal Borough of Northampton and portions of the Rural Sanitary Districts of the Northampton and Hardingstone Unions. |
| Southampton Electric Lighting Licence .................. | Southampton Electric Light and Power Company, Limited | Municipal Borough of Southampton. |

Digitized by Google

Provisional Orders.—Provinces.

| Title of Order. | To Whom Granted. | Area covered by Order. |
|---|---|---|
| Aberdeen Electric Lighting Order | The Town Council of Aberdeen | The City and Royal Burgh of Aberdeen. |
| Accrington Electric Lighting Order | The Corporation of Accrington | The Municipal Borough of Accrington. |
| Ashton-under-Lyne Electric Light and Power Order | Municipal Electric Light and Power Corporation (Limited) | The Municipal Borough of Ashton-under-Lyne. |
| Ayr Burgh Electric Lighting Order | The Town Council of Ayr | The Municipal Burgh of Ayr. |
| Bacup Electric Lighting Order | The Corporation of Bacup | The Municipal Borough of Bacup. |
| Barnsley Electric Lighting Order | The Corporation of Barnsley | The Municipal Borough of Barnsley. |
| Bedford Electric Lighting Order | The Corporation of Bedford | The Municipal Borough of Bedford. |
| Belfast Electric Lighting Order | The Corporation of Belfast | The City of Belfast. |
| Birkenhead Electric Lighting Order | The Corporation of Birkenhead | The Borough of Birkenhead. |
| Blackburn Electric Lighting Order | The Corporation of Blackburn | The Municipal Borough of Blackburn. |
| Blackpool Electric Lighting Order | The Corporation of Blackpool | The Municipal Borough of Blackpool. |
| Bognor Electric Lighting Order | The Electric Trust (Limited) | The Local Board District of Bognor. |
| Bournemouth Electric Supply (Brush) Order | Brush Electrical Engineering Company (Limited) | The District of the Bournemouth Improvement Commissioners, and a portion of the District of the Poole Urban Sanitary Authority. |
| Bournemouth Electric Supply (House to House) Order | South of England House-to-House Electricity Company (Limited) | The Urban Sanitary District of Bournemouth. |
| Burnley Electric Lighting Order | The Corporation of Burnley | The Municipal Borough of Burnley. |
| Burton-upon-Trent Electric Lighting Order | The Corporation of Burton-upon-Trent | The Municipal Borough of Burton-upon-Trent. |
| Bury Electric Lighting Order | The Corporation of Bury | The Municipal Borough of Bury. |
| Cambridge Electric Lighting Order | The Corporation of Cambridge | The Borough of Cambridge. |
| Chatham, Rochester, and District Electric Lighting Order | Chatham, Rochester, and District Electric Lighting Company (Limited) | Portions of the Urban Sanitary Districts of the City of Rochester, Chatham Extra, and Gillingham. |
| Cheltenham Electric Lighting Order | The Corporation of Cheltenham | A portion of the Municipal Borough of Cheltenham. |
| Chester Electric Lighting Order | The Corporation of Chester | The Urban Sanitary District of the City of Chester. |
| Coatbridge Electric Supply Order | Scottish House-to-House Electricity Company (Limited) | The Burgh of Coatbridge. |
| Darlington Electric Lighting Order | The Corporation of Darlington | A portion of the Municipal Borough of Darlington. |
| Derby Corporation Electric Lighting Order | The Corporation of Derby | The Municipal Borough of Derby. |
| Dover Electric Lighting Order | The Corporation of Dover | The Borough of Dover. |
| Dundee Electric Lighting Order | The Gas Commissioners of Dundee | Portion of the Parliamentary Burgh of Dundee. |
| Eastbourne Electric Supply Order | Eastbourne Electric Light Company (Limited) | The Municipal Borough of Eastbourne. |
| Fleetwood Electric Lighting Order | The Fleetwood Improvement Commissioners | The Urban Sanitary District of Fleetwood. |
| Galway Electric Lighting Order | Galway Electric Company | The District over which the Galway Town Improvement Commissioners are the Urban Sanitary Authority. |
| Glasgow Corporation Electric Lighting Order | The Town Council of Glasgow | The City and Royal Burgh of Glasgow. |
| Great Yarmouth Electric Lighting Order | The Corporation of Great Yarmouth | The Borough of Great Yarmouth. |
| Hastings and St. Leonards-on-Sea Electric Supply Order | Hastings and St. Leonards-on-Sea Electric Light Company (Limited) | The Borough of Hastings. |
| Hastings (Public Purposes) Electric Lighting Order | The Corporation of Hastings | The Borough of Hastings. |
| Hove Electric Lighting Order | The Hove Commissioners | The Town and District of Hove. |
| Huddersfield Electric Lighting Order | The Corporation of Huddersfield | The County and Municipal Borough of Huddersfield. |
| Kelvinside Electric Lighting Order | Kelvinside Electricity Company (Limited) | The District of Kelvinside. |
| Kingston-upon-Hull Electric Lighting Order | The Corporation of Kingston-upon-Hull | The County Borough of Kingston-upon-Hull. |
| Lancaster Electric Lighting Order | The Corporation of Lancaster | The Municipal Borough of Lancaster. |
| Leicester Electric Lighting Order | The Corporation of Leicester | The Municipal County Borough of Leicester. |
| Malvern Electric Lighting Order | The Local Board of Malvern | The Local Government District of Malvern. |
| Manchester Electric Lighting Order | The Corporation of Manchester | Portion of the City of Manchester. |
| Morecambe Electric Light and Power Order | Messrs. T. R. Andrews and T. Preece | The District of the Morecambe Local Board. |
| Moss Side and Stretford Electric Lighting Order | Manchester House-to-House Electricity Company (Limited) | The Local Board Districts of Moss Side and Stretford. |
| Northampton Electric Lighting Order | Northampton Electric Light and Power Company (Limited) | The Municipal Borough of Northampton, and portions of the Rural Sanitary Districts of the Northampton and Hardingstone Unions. |
| Nottingham Electric Lighting Order | The Corporation of Nottingham | The Borough of Nottingham. |
| Oldham Electric Lighting Order | The Corporation of Oldham | The Borough of Oldham. |
| Oxford Electric Lighting Order | Electric Installation and Maintenance Company (Limited) | The Urban Sanitary District of Oxford. |
| Plymouth Electric Lighting Order | Devon and Cornwall Electricity Supply Company (Limited) | The County Borough of Plymouth. |
| Portsmouth Electric Lighting Order | The Corporation of Portsmouth | The Municipal Borough of Portsmouth. |
| Preston Electric Lighting Order | National Electric Supply Company (Limited) | A Portion of the Borough of Preston. |
| Preston and Fulwood Electric Lighting Order | Lancashire and Cheshire House-to-House Electricity Company (Limited) | The County Borough of Preston and the District of the Fulwood Local Board. |
| Salford Electric Lighting Order | The Corporation of Salford | The Municipal County Borough of Salford. |
| Sevenoaks Electric Lighting Order | The Electric Trust (Limited) | The Local Board District of Sevenoaks. |
| Stafford Electric Lighting Order | The Corporation of Stafford | The Municipal Borough of Stafford. |
| Stockton-on-Tees Electric Lighting Order | The Corporation of Stockton-on-Tees | The Municipal Borough of Stockton-on-Tees. |
| Tiverton Electric Lighting Order | The Corporation of Tiverton | A portion of the Municipal Borough of Tiverton. |
| Tunstall Electric Lighting Order | The Electric Trust (Limited) | The Local Board District of Tunstall. |
| Walsall Electric Lighting Order | The Corporation of Walsall | The Borough of Walsall. |
| Wigan Electric Lighting Order | The Corporation of Wigan | The Borough of Wigan. |
| Windsor Electric Supply Order | Windsor and Eton Electric Light Company (Limited) | The District of the New Windsor Urban Sanitary Authority and a portion of the District of the Eton Rural Sanitary Authority. |
| Woking Electric Supply Company Order | Woking Electric Supply Company (Limited) | The Parish of Woking. |
| Wolverhampton Electric Lighting Order | The Corporation of Wolverhampton | The Municipal Borough of Wolverhampton. |
| Worcester Electric Lighting Order | The Corporation of Worcester | The City of Worcester. |
| Wrexham Electric Light and Power Order | Wrexham and District Electric Supply Company (Limited) | The Municipal Borough of Wrexham. |
| York Electric Lighting Order | The Corporation of York | The City of York. |

Digitized by Google

# The Electrician.

**Published every Friday, Price Fourpence; Post Free, Fourpence Halfpenny.**
**Editorial, Publishing, and Printing Offices:**
**SALISBURY COURT, FLEET ST., LONDON, E.C.**
*Telephone No.* 2714. *Telegrams:* "ELECTRICIAN NEWSPAPER, LONDON."

*All Letters relating to Subscriptions, Advertisements and other business matters should be addressed to the Publisher,* "THE ELECTRICIAN," *Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to* "THE ELECTRICIAN" *Printing and Publishing Company, Limited, and be crossed* "*Coutts and Co.*" *All other letters to be addressed to the Editor.*
*All letters intended for insertion in* "THE ELECTRICIAN," *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

"THE ELECTRICIAN" *is published every Friday morning, in time for the morning mails. Subscribers should receive their copies by the first post on Friday morning.*
"THE ELECTRICIAN" *is on sale at the railway bookstalls throughout the Kingdom on Friday morning, and can be obtained of all Booksellers and Newsvendors; or direct from the Publishing Offices as above.*
*New Volumes of* "THE ELECTRICIAN" *commence in May and November.*

SUBSCRIPTION RATES.

The rates for Subscriptions to "THE ELECTRICIAN" are as follows:—

| | 3 months. s. d. | 6 months. s. d. | 12 months. s. d. |
|---|---|---|---|
| For the United Kingdom | 5 0 | 10 0 | 19 6 |
| For Foreign Parts and Colonies:— | | | |
| Within Postal Union | 6 6 | 12 6 | 24 0 |
| Aden Borneo, Ceylon, China, India, Japan, Java, Labuan, Mozambique, New Caledonia, Persia, Philippine Islands, Siam, Transvaal, and Zanzibar | 7 6 | 14 6 | 28 0 |



TO ADVERTISERS.

"THE ELECTRICIAN" *offers exceptional advantages to Advertisers.*
**It has by far the largest circulation of any English Electrical paper, and circulates all over the World.**
*Particulars relating to Advertisements will be promptly forwarded on application to the Offices as above.*
TRADE ADVERTISEMENTS *intended for the current issue must reach the Offices not later than First Post on Thursday morning. Renewals of expiring advertisement orders and alterations to standing advertisements should be in the Publisher's hands by Wednesday at latest. No alteration can be made in Wrapper advertisements after Wednesday evening.*
SMALL PREPAID ADVERTISEMENTS *(for Rates see page xvii.) are accepted up to 4 p.m. on Thursday.*

TECHNICAL PRINTING.

"THE ELECTRICIAN" PRINTING AND PUBLISHING COMPANY (LIMITED) *inform Electricians, Electric Light Engineers, &c., that they make a specialty of Technical Printing, and have a large Staff thoroughly acquainted with Electro-Technology. They can, therefore, promise Accuracy and Despatch in the Printing of Electro-Technical Literature, &c.*

**"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.** (Royal 8vo.)

*Early in each year is issued* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. *The* DIRECTORY *was established in 1883, and the 1890 Edition consisted of about 850 pages of printed matter. The names and addresses of all persons engaged in the Electrical Industries at home and abroad may be relied upon as accurate. Useful Tables and Electrical Formulæ, and information specially compiled for this work are given, together with popularly-written Biographical Notices of the leading Electricians, Electrical Engineers, &c., accompanied in many cases by Portraits.*
*The 1891 Edition is now actively preparing, and Subscription and Advertisement Orders, New Names, Corrections, &c., can be received.*

ELECTRICAL BOOKS AND PUBLICATIONS.

*All Books, Newspapers, and other publications, dealing with Electrical and kindred subjects, can be ordered direct of* "THE ELECTRICIAN" *Printing and Publishing Company, who are proprietors of the well known* "ELECTRICIAN" *Series of Standard Electrical Works, and are agents for all the leading publishing houses at home and abroad.*


## CONTENTS OF THE CURRENT NUMBER.


NOTES ... 251
Electrical Distribution by Transformers from Central and Eccentric Stations. By Dr. J. A. Fleming, M.A. Illustrated. Continued ... 255
Electromagnetic Theory. By Oliver Heaviside ... 257
On the Propagation of Alternating Currents through Concentric Cables. By Dr. J. A. Fleming, M.A. Illustrated ... 258
The Rise of Potential Difference in the Deptford Mains. By W. E. Ayrton. Illustrated ... 260
Alternate Current Condensers. By J. Swinburne ... 260
Note on the Law of Hysteresis. By Chas. Steinmetz. Illustrated ... 261
Provisional Orders and Licences granted by the Board of Trade during 1890 ... 262
**1890** ... 264
OBITUARY.
William Lant Carpenter ... 266
The National Telephone Company ... 267
Inductance and its Proposed Unit the Henry. By A. E. Kennelly. Illustrated ... 267
Electro-Magnetic Mechanisms. By Prof. S. P. Thompson, D.Sc., B.A. Illustrated. Continued ... 269
Summary of Electrical Events for 1890 ... 271
Central Lighting Stations of the United Kingdom ... 274
Electric Railways and Tramways in the United Kingdom ... 276
Electric Lighting Notices for 1891 ... 276
Electric Traction Notices for 1891 ... 277
New Companies of 1890 ... 277
Public Companies wound up in 1890 ... 278
American Notes ... 278
Scandinavian Notes ... 278
CORRESPONDENCE—
The Determination of Inductance—Chas. Steinmetz ... 279
Permanent Magnet Voltmeters—Edward F. Colby ... 279
"Shaking the Foundations of Science."—C. E. Webber, Major-General ... 280
Electrical Treatment of Sewage—F. G. Worth ... 280
Compound Dynamos — W. Brew. Illustrated ... 280
Drum Winding—Charles A. Parsons ... 281
Trade Notes and Notices ... 281
Books Received ... 282
PATENT RECORD ... 282
COMPANIES' MEETINGS, &c.—
Elmore's Foreign and Colonial Patent Copper Depositing Company (Limited) ... 282
New Companies Registered ... 283
City Notes, &c. ... 283
Companies' Share List ... 284


# 1890.

Though not marked by any occurrences of startling novelty, the year 1890 has been an interesting and, from some points of view, an eventful one. The devotees of pure science will remember it as the year in which EWING enunciated his molecular theory of induced magnetism, and the Royal Society elected Sir WILLIAM THOMSON as its President. To the practical man the past twelve months will be memorable, inasmuch as they have witnessed the realisation of FERRANTI's bold conception of supplying central London with current generated at Deptford, the establishment on a firm basis, in the heart of the Metropolis, of a widespread system of electric supply, and the opening of the City and South London Railway. Even the telephone engineer and the electrical litigant will have cause to remember 1890; the one by reason of the expiry a few weeks ago of the Bell patent, and the various signs that seem to portend a period of sharp competition for the leading telephone company of the United Kingdom; the other, by reason of the final invalidation of the Gaulard-Gibbs transformer patent, and the second pronouncement in the Scotch courts to the effect that there was nothing in BRUSH's so-called compound-winding patent No. 2,003 of 1878 which was not to be found in VARLEY's patent No. 4,905 of 1876.

In the Metropolis the past year has been one of steady progress. Mains have been laid, central stations taken over from the contractors, and customers connected up. Twelve months ago there were thirteen central lighting stations in

Digitized by Google

the Metropolis supplying electricity under statutory powers, to-day there are seventeen; and the laying of mains and the connecting up of customers has been carried out with such an amount of vigour that when the year closed nearly 120 miles of conductors had been buried beneath the streets of London, and some 200,000 lamps were dependent upon public companies for their current. It was not to be expected that so much would be achieved without rebuffs, but fortunately for the other supply companies the demon of mischief seems to have been attracted by Mr. FERRANTI'S engineering audacity, and the numerous mishaps inevitable in every novel enterprise have in consequence been focussed upon the London Electric Supply Corporation's system. First of all, the ratio of transformation of the transformers at the Grosvenor Gallery sub-station was found to be distorted, and 8,500 volts at Deptford apparently became 10,000 in London. The large electrostatic capacity of the Ferranti mains, and the inductance of the "step-up" transformer at Deptford were "reasonably suspected," and the phenomenon was no sooner made public than explanations of it were forthcoming, some of which are appearing in these columns. The next phenomenon was a disaster, namely, the burning out of the Grosvenor Gallery transformer sub-station on November 15th, and this was followed on December 3rd by the complete breakdown of the bank of hastily-repaired converters. The London Company then wisely determined to shut down until everything, both at Deptford and in Bond-street, was in thorough order, and it is to be hoped that when the supply is recommenced this company's system will not again be the target for "the slings and arrows of outrageous fortune." In the Provinces, apart from municipal enterprise, there has been comparatively little electric lighting work. At Newcastle the two supply companies have prospered, and Fareham, Lynmouth, Weybridge, and Woking have been added to the list of towns in which central stations are in operation.

Encouraged by the Board of Trade, and, in most instances, by the ratepayers, local authorities have been peculiarly active during the past year in the matters of electric lighting. In August, 43 Provisional Orders out of a total of 74 were granted to municipalities; towns as diverse as Birkenhead and Cheltenham, Dover and Glasgow, Portsmouth and York being equally eager to dabble in municipal lighting. Moreover, the tide shows no signs of slackening, since only ten days ago out of 70 memorials deposited at the Board of Trade, no less than 37 emanated from local authorities. The question of interest to electrical engineers is what the local authorities propose to do with the Orders they obtain, and so far, it must be confessed, the future is not very clear. In some towns absolutely no steps have been taken to carry out statutory obligations, in others the report stage is within sight, in others the stage of visiting the central lighting stations of the Metropolis has been reached, while in two cases, those of Brighton and St. Pancras, whose Orders date from 1883, money has been voted, a foundation-stone has been laid, and a well-considered scheme is in process of execution. Corporations are, however, notoriously slow-moving bodies, but the Board of Trade is evidently determined, if we may judge by its recent polite inquiries at Dundee, Bacup, and elsewhere, that Orders shall not, for one thing, be used by local authorities merely for purposes of obstruction. While some municipal authorities have elected to secure electric lighting powers and to do nothing, others have preferred the reverse process. Since the beginning of 1890 the streets of Bath, Chelmsford, and Fareham have been lighted by electricity, and similar contracts have been entered into by the Corporation of the City of London and by Swansea.

From the point of view of increase in mileage, electric traction cannot be said to have witnessed any important development in the United Kingdom during the year which has just elapsed. If, however, we look somewhat more closely into the matter, we find that distinct advances have been made. The Central London Railway Bill, although ultimately rejected by the Upper House, served a purpose. It drew attention to the marvellous progress of electric traction across the Atlantic, and it gave the public an idea of the many advantages attendant on the use of electricity as a motive power. But in the opening on December 18th of the City and South London Railway a still more tangible step forward was taken. In a few months' time, when the minor defects which at present militate in some degree against the success of this line have disappeared, the Select Committees, who will then once more be considering the Central London Railway Bill, will have an opportunity of seeing for themselves that electric traction is an actuality and not some "wild cat" idea from across the ocean. With prejudices and doubts once removed, electric traction may be trusted to rapidly make its way. Mention must also be made of the steady service which has been maintained during the past year by the accumulator cars on the Barking-road line, and of the fact that the West Metropolitan Tramway Company has at last extorted the permission of the Hammersmith Vestry to lay down between Uxbridge-road and Kew a line on Mr. LINEFF'S ingenious closed-conduit system. Across the Atlantic electric traction continues to gain ground in spite of the strenuous opposition of the telephone companies, and in many instances also of the town authorities, to the single-trolley system.

The lapse on December 9th of the Bell patent, and the approaching expiration of the important transmitter patent has given rise to considerable agitation in the usually quiet telephonic world. The National Telephone Company, threatened with competition, has announced a wholesale reduction of rentals in the provinces, and in London it has promised complete metallic circuits. The National Company has also continued to strengthen its position by trunk wire extensions, and on October 19th the line connecting London with the North was at last opened to the public. As to whether or not the Post Office intends to depart from its attitude of "armed neutrality" it is difficult to say, but there can be no doubt that it might without entering into direct competition with the National Company render considerable service to the public by making use of the telephone as a feeder to its magnificent system of telegraphs. In submarine cable circles the chief events of note have been the International Telegraph Conference, which was held at Paris in May, one of the principal results being the adoption of an authorised vocabulary for code messages on the European régime, and the question of the reduction from 9s. 4d. to 4s. per word of the Australasian tariff under a guarantee by some of the Australasian Colonies to the cable companies concerned of half the loss involved. It is expected that the negotiations will be speedily concluded, and the new rates brought into operation at an early date. A few new cables, such as the Halifax-Bermuda and that along the West Coast of South America, have been laid, but as a rule the companies have been content with multiplying existing lines, the principal instance being that of the Eastern Telegraph Company's quadruplicate Red Sea cable.

Although eventful in other respects, the year 1890 cannot be said to have produced many new types of heavy electrical engineering machinery, the most novel development being, perhaps, the Westinghouse arc-light alternator. It may, therefore, be considered that the art of dynamo making has

Digitized by Google

attained a very satisfactory stage of completeness. Inventive stagnation does not mean commercial stagnation, and the balance-sheets of manufacturing companies and the reports which other firms have sent us have shown that the electrical trade has been very active. One new company naïvely informs us, indeed, that it "has been engaged in the arduous task of establishing a reputation;" but there are many who will this year be gratified in a more substantial manner by good solid profit on the hard work that has been done during the past twelvemonth. However, the elder branches of heavy electrical engineering may slacken in their development of novelties, electric welding, electric tanning, electric bleaching, and the electrical purification of sewage, are evidences that the entire field is not yet exhausted. Electric welding, while coming into extensive use in the United States, does not make much headway with us; on the other hand, tanning by electricity has so far advanced in this country as to occupy a place in the law list, an unmistakable sign of commercial vitality. Electric bleaching continues to make steady progress, both in Europe and America, and the possibilities of purifying sewage on a large scale by means of electricity will soon be settled one way or the other by the report which will shortly be made on the subject to the Corporation of Salford.

Papers read before the Institution of Electrical Engineers are not for the most part of a very startling character, but have a flavour of hard work and practical experience, and the papers read during the past twelve months have not proved exceptions to this rule. Following Dr. Hopkinson's Presidential Address on "Magnetism," we had a paper from Mr. Swinburne on "The Theory of Armature Reactions in Dynamos and Motors," and another covering much the same ground, though in a very different style, by Mr. Esson, on "Some Points in Dynamo and Motor Design," which was deservedly awarded the Institution premium. These two able papers brought out for the first time the points of difficulty which crop up in the construction of large central station dynamos, and they gave rise to an interesting and at times animated discussion extending over several evenings. In April Dr. Lodge, nothing daunted by Mr. Preece's assertion that the lightning protectors at present in use were the acme of cheapness and reliability, and that consequently there was no need for a new one, read a paper on an ingenious form of lightning guard which he had devised. At the Edinburgh meeting of the Institution Prof. Ayrton read a valuable paper on "The Working Efficiency of Secondary Cells," and followed it up in November by another on "The Chemistry of Secondary Cells." These two papers resulted in a long and practical discussion, extending over three evenings. At the meeting of the British Association in Leeds the papers of interest were of the pure science order. Mr. R. T. Glazebrook read a paper before Section A, in which he tabulated the various determinations of the ohm, and described the different methods which had been employed, and concluded by stating that in his opinion the resistance of a column of mercury of 1 sq. mm. section and 106·3 cms. long was the nearest approximation to the true ohm. This value was ultimately adopted by the Electrical Standards Committee of the British Association, and will probably shortly be legalised by Act of Parliament. A most brilliant paper was communicated to the meeting by Prof. J. A. Ewing, in connection with his molecular theory of induced magnetism. The mutual action of a group of magnetised needles has often been examined, but it was left to Prof. Ewing to see in it the representation of the intermolecular forces at work in a bar of iron. He has thus been able to coherently explain the general characteristics of the process of magnetisation, and has advanced the theory of magnetism in a most marked manner.

The year 1890 has, therefore, been fruitful both in brilliant theoretical speculation and in solid practical progress, and we have every reason to hope that when, twelve months hence, the time again comes round for taking a retrospective glance, the record will be equally encouraging.

## OBITUARY.

### WILLIAM LANT CARPENTER.

We regret to have to record the sad death, at his residence at Harlesden, on the morning of Tuesday, December 23rd, of Mr. William Lant Carpenter, one of the managers of the School of Electrical Engineering, Princes-street, Hanover-square. Mr. Carpenter had been in failing health for some time past, but recently had become so much better that it was hoped he would be able to return to his work in the spring.

Mr. Carpenter was born in 1841, and was the eldest son of the late Dr. W. B. Carpenter, C.B., F.R.S. He was educated at University College School—where he held a scholarship for five years, and gained numerous prizes—and at University College. He took Bachelor's degrees in Arts and in Science, with honours, in the University of London in 1860 and 1861. For several years in early manhood he resided in Bristol, as one of the partners in a large manufacturing business, involving a considerable knowledge of industrial chemistry and physics. During this period he was one of most active promoters of the movement that led to the foundation of University College, Bristol, on the Council of which he sat for some years as the nominee of the Vice-Chancellor of London University. He was local secretary at the Bristol (1875) meeting of the British Association, and took a leading part in all movements for the promotion of science, and especially physical science, in the West of England, where he was well known as a lecturer on such subjects. He was in charge of the chemical and part of the physical investigations of the deep-sea explorations of H.M.S. "Porcupine" of 1869 and 1870, his report on which was printed in the *Proceedings* of the Royal Society. Having determined to devote himself entirely to scientific pursuits, he removed to London in 1881, and was employed by the Gilchrist Educational Trust in delivering popular lectures to very large artisan audiences upon experimental physics, and mainly upon electricity. One set of such courses, intended specially as a popular exposition of the doctrine of the Conservation of Energy, was published in book form, under the title of "Energy in Nature." He also lectured to large audiences in America, Australia, and New Zealand.

Mr. Carpenter was known as a zealous advocate of the introduction of a proper system of teaching elementary science into primary schools, a subject on which he wrote and lectured a good deal, before the Society of Arts and the managers of London Board Schools.

Together with the late Prof. Balfour Stewart he contributed several Papers to the Royal Society on the periodic changes of sun-spots and their connection with terrestrial and magnetic phenomena. He was on the British Association Committee for considering the best means of comparing and reducing magnetic observations. He took a very active part in the Committees of Convocation of the University of London (*e.g.*, on the subject of degrees in engineering). He was member of the Chemical and Physical Societies and of the Institution of Electrical Engineers, and was joint manager with Mr. L. Drugman of the Hanover-square School of Electrical Engineering, which he thoroughly reorganised and brought into line with the leading institutions of the kind in the country.

No one who had the good fortune to be personally acquainted with Mr. Lant Carpenter is likely to soon forget his sympathy with those struggling to the front, and his unvarying courtesy and ever ready assistance to all who came to him. His death will leave a great void in the ranks of the not too numerous army of popular exponents of orthodox science.

Digitized by Google

## THE NATIONAL TELEPHONE COMPANY.

As a result of the amalgamation of the three principal British Telephone Companies—the National, United, and Lancashire and Cheshire—the Directors of the combined undertaking have had under consideration for some time past various arrangements for the improvement and extension of the telephone service throughout their system.

The London service is so extensive, and some sections are so distant from others, that in order to obviate the faults which have arisen, the Directors of the Company some time back decided to loop the wires, and have also substituted throughout the Metropolitan system improved appliances. The process of looping the wires has also been extended to the outlying districts, and will be gradually brought into use over the entire undertaking. This looping constitutes practically a duplication of the wires, and raises a serious objection where these wires are overhead, and in order to overcome the objection, the Company have decided to petition the local authorities for the necessary permission to place their wires underground where necessary. It will be remembered that many representatives of the London Vestries gave evidence before the Telephone Committee of 1885, and recommended that the telephone trunk wires should be taken underground, and suggested that a combined underground and overhead system would best suit the requirements of the Metropolis. Notwithstanding this, the Company has not been uniformly successful in obtaining the consent of the Vestries to this course, one important Vestry having already declined to act upon the suggestion. The reason assigned for this action by the Vestry in question was that they declined to enter into arrangements with a Company having no statutory authority, and the Directors of the National Company feel strongly that no permanent advance can be made in the telephonic service until the Company is provided by Parliament with statutory powers similar in character to those now enjoyed by railway, tramway, electric lighting, gas, and water companies.

The all-important question of wayleaves is so intimately associated with the granting of statutory powers to the Company, that the Directors are of opinion that unless they are thus enabled to enter into arrangements of a permanent character, their efforts to promote the extension, efficiency, and reliability of the telephone will be greatly hampered. At present their greatest source of anxiety, labour, and expense is the constant withdrawal of wayleaves, and the consequent reconstruction of the routes. It is certainly difficult to see how the Company are to satisfactorily do all that is required to put their service into an efficient state so long as the whole of its construction rests upon the basis of sufferance. The time has, therefore, clearly come when the Company should have its operations facilitated and controlled by statutory powers. The National Company's predecessors, the United Company, applied for statutory powers, but their Bill was, for a variety of reasons, opposed by the Post Office authorities. Now that the Post Office has abandoned for the present the idea of purchasing the telephones, it seems to us that the Department would best serve the public interest by facilitating the progress through Parliament of the Company's Bill, at all events so far as underground wires and the vestries are concerned.

The National Company has already connected up many of the principal Northern and Midland towns with London by telephone trunk wires (at present used from a call office at Oxford-court, Cannon-street, E.C.), and arrangements are in progress to facilitate the use of these wires from subscribers' offices.

So far as the Metropolitan service is concerned, the question of cost is not, perhaps, so much to be considered as the establishment of an efficient, rapid, and reliable service, and we are, therefore, glad to learn that the Company contemplate a very heavy outlay on their London system in the immediate future as an equivalent for the large reductions of rentals announced in the provinces.

The overhead wires originally selected for the telephonic service were of galvanised wire, and weighed 224lb. to the mile, or 12lb. to the span of 100 yards; but this has now been entirely replaced by silicium bronze wire, weighing only 36lb. to the mile, or 2lb. per span of 100 yards. The advantages arising from the use of the lighter wires will be readily appreciated by everyone who considers the effect of a snowstorm upon wires weighing 12lb. per 100 yards.

In view of the competition with which the Company is threatened, and the improvements in telephonic apparatus which the expiry of the master patents may be expected to bring about, it will be interesting to watch the steps taken by the Directors of the National Company to secure themselves in the strong position which they unquestionably occupy.

## INDUCTANCE AND ITS PROPOSED UNIT THE HENRY.*

BY A. E. KENNELLY.

Perhaps the greatest discovery of Faraday's long career of scientific research was that of electro-magnetic induction in the year 1831, when he first brought to light the influence exerted by a magnet or a current upon surrounding matter when subjected to a change of magnetic potential. Oersted had shown that a conductor carrying a current exercised electro-magnetic influence at a distance, and Ampère had enunciated those simple and beautiful laws this influence is admitted to obey, but Faraday's discovery was a great step; it revealed the action of magnetic force in apparently empty space; it inaugurated that deeper insight into the mechanism, still only dimly guessed, which connects matter with all other matter in space; and it invested the all-pervading ether with a dignity and power that, in the hands of many great men since his time, has probably paved the way for our future comprehension of magnetism, gravitation, and radiant energy, while making the hypothesis of action-at-a-distance a mere mathematical conception and process of thought.

The development of this discovery of electro-magnetic induction has practically created electrical engineering, for it is to machinery operating by electro-magnetic induction that we owe nearly every branch of electrical industry except, perhaps, telegraphy, the forerunner of all; and the condition of modern electrical engineering is such that the units and nomenclature relating to steady currents and permanent magnets is insufficient for practical requirements, and the conditions developed by variable currents and magnets demand the establishment of engineering practical units for the purposes of convenience in expression and computation.

Foremost among these required units is that of inductance, or, as it is commonly called, the coefficient of induction. This inductance is a property fully as essential to every electric conducting circuit as resistance and electrostatic capacity, and the inductance of a circuit when conveying variable currents is often a far more important factor in regulating the flow than the ohmic resistance. In fact, we know that Ohm's law does not apply to a circuit so long as the current is unsteady, unless the inductance of the circuit or the counter electromotive force it involves be introduced into the expression.

In conformity with the conventional and so-called absolute units of electro-magnetism, an inductance is a length, and theoretically can always be computed from the geometrical relations of a circuit; that is to say, if the distance of each point from all other points of a circuit be measured, or inferred, in inches or centimetres, the inductance of the circuit will be some definite number of inches or centimetres, capable of being determined by a possible if not a convenient process of summation. If the circuit, however, be associated with iron or other magnetisable matter, then magnetic permeability of the environment will enter the terms of summation as a multiplier. In the absolute centimetre-gramme-second system of units, inductance will be necessarily expressed in centimetres, and the centimetre is thus the natural scientific unit, although unsuited to the requirements of electrical engineering.

It may be well to notice that inductance is only conventionally and perhaps not essentially a length. Prof. Rücker has pointed out† that the multiplication of the permeability factor with the length factor is always tacitly, if not expressly involved, even when the circuit considered is far from magnetisable matter in the ordinary sense; that is to say, when residing in a medium of unit permeability, and therefore the nature of inductance is not merely length, but length multiplied by permeability, while physics has not yet decided whether permeability is the simple numerical factor at present assumed, or a function of length, mass, and time. Until this question is settled, the real nature of inductance must be considered as doubtful, and the fact that inductance will probably, in any event, be always measured by lengths is no more validly an argument as to its

* A Paper read at the fifty-second meeting of the American Institute of Electrical Engineers, New York, December 16, 1890.

† *Phil. Mag.*, February, 1889. Fifth series, Vol. XXVII., p. 104.

Digitized by Google

nature than the usual determination of a body's mass by the earth's gravitational force upon it is an argument that mass is a force. However, the question is one of theory only, and does not affect the consideration of the practical unit.

As has been pointed out by Dr. Sumpner,* there are no less than three ways of defining the inductance of a circuit, or a portion of a circuit, and the three definitions are equivalent when the permeability of the magnetic medium is unity, but are not generally equivalent in the opposite event, being then only related in a definite manner by the magnetic properties of the medium. In other words, the inductance of a hollow solenoid of copper wire, placed in a vacuum and far from all iron, has the same numerical value in each of the three definitions, but if an iron core be inserted in it, its inductance will depend upon the definition selected, and will only be capable of interpretation from its value in one to its values in the others, by taking into account the characteristic permeability curve of the iron, and the conditions of the measurement.

For convenience and general use, however, the secondary definition of Sumpner and Fleming† is probably the best to adopt, and valuations in the other two can be reduced if necessary to this when the data for so doing are available.

The inductance of a circuit or portion of a circuit is then the ratio between the total induction through it to the current producing it. Thus taking a simple helix of five turns carrying a current of two units, and assuming that 1,000 lines of force,‡ passed through the central turn, of which, owing to leakage, only 900 thread the next adjacent on each side, and again only 800 through the end turns, there would be 800+900+1,000+900+800, or 4,400 linkages of lines with the wire, and this being with 2 units of current there would be 2,200 linkages with unit current, and consequently the self-inductance of the helix would be 2,200 centimetres. (Fig. 1.)

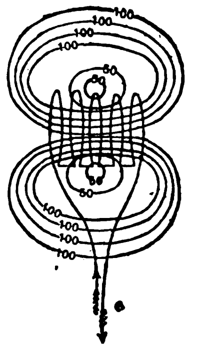


FIG. 1

The fact that such helices are used in galvanometers, and that the magnetic force at any point within them is admitted to be proportional to the strength of the traversing current, renders it evident that had the current in this case been one unit, 2,200 lines linked with the coil would actually have been produced. Supposing, however, that the helix had been wound upon an iron core, the total number of linkages with the same two units of current would have been greatly increased, perhaps twenty-fold, or to 88,000, and the inductance then by the same rule would be 44,000. In this case one unit of current would not in all probability reduce the number of linkages to 44,000, the exact number would depend upon the characteristic curve of the iron core, and the degree of saturation, so that it would now be necessary to state the conditions of the measurement along with result, in order to convey a clear and definite meaning.

It appears anomalous at first sight to state the above inductances in centimetres when they are derived from the number of lines of force, but it is to be remembered that the total number of linkages is divided in each case not by a mere numeric, but by a current, and this quotient can be proved to be a length in the existing system of dimensions.

In the same way the mutual inductance of two conductors is the ratio of the total induction through one of them to the strength of current in the other producing it. Suppose two coils of copper wire to be held in free space far from iron, and let one of them be traversed by a steady current of say four units. Of all the lines of force issuing from this coil, suppose 500 pass through the other coil. For simplicity, imagine the second or recipient coil to be composed of eight turns so disposed that the 500 lines pass through all in succession. There will then be 4,000 linkages of lines with that coil, and the mutual inductance of the two will be 4,000 ÷ 4 or 1000 centimetres. It is interesting to notice that the same result would be reached if the second coil had the current and the linkages were counted in the first, the pair being mutually conjugate in this respect provided they reside in a medium of constant permeability.

Thus far we have only considered the centimetre or absolute unit, whose unfitness for practical use is evident, since the smallest inductance that is at present known to engineering amounts to several thousand, while the average values met with are counted in millions of centimetres. It would, of course, be possible to name suitable units from the metrical system of lengths, but it is the proposal of this institute to adopt the word henry as a practical unit, in honour of the man who, beyond all doubt, was among the foremost to extend the knowledge thus far possessed of self and mutual inductance.

If the selection of the practical unit were entirely free and subservient only to practical requirements, so that its magnitude should express ordinary values in digits with fewest decimals on the one hand, or large numbers on the other, there seems most reason to believe that the thousandth of the earth-quadrant or myriametre would be the most eligible.

| Proposed Name. | Length. | No. of Centimetres. | Unit. |
|---|---|---|---|
| Henry. | Earth Quadrant. | 1,000,000,000 | Practical Unit. |
| | | 100,000,000 | |
| | | 10,000,000 | |
| Millihenry. | Myriametre. | 1,000,000 | |
| | Kilometre. | 100,000 | |
| | Hectometre. | 10,000 | |
| Microhenry. | Decametre. | 1,000 | |
| | Metre. | 100 | |
| | Decimetre. | 10 | |
| | Centimetre. | 1 | Absolute Unit. |

Of course large iron machines employing many turns of wire linked by dense magnetic fields would have inductances more appropriately expressed in earth quadrants, which might then be termed the kilohenry, just as we now have the watt and kilowatt, but there is one restriction which makes such a selection undesirable, and that is the hitherto unbroken system of practical units itself. This practical system is a sub-scheme of the great international C.-G.-S. system, and especially planned for adaptability to practical requirements. It is derived from that parent system by the substitution for the unit of length, one thousand million centimetres in place of one centimetre, and for the unit of mass an impalpable entity definite only in thought, the one-hundred millionth of a milligramme in place of the gramme. By this substitution in the C.-G.-S. electro-magnetic units, we obtain the hitherto unbroken system of the volt, ohm, ampere, coulomb, joule, watt, and farad. Even these units are not always the most convenient, witness, for example, the microfarad in common use, whose prefix is maintained simply in deference to the harmony of the system, for the farad is a capacity that exists only in imagination: the capacity of the earth itself being only about 700 microfarads, and of the sun, or rather a sphere having the apparent dimensions of the sun being only about 76,000 microfarads. On the other hand a proposition has lately been made to infringe the system by making the volt, the ampere, and the watt ten times their present values, on the ground of practical convenience.* However, at the present time, it would surely be unadvisable to attempt the precedent of infringing a system that has hitherto been supported by time, custom, and international Congress.

In this practical system the unit of inductance must be 1,000 million centimetres. That is an earth quadrant or the distance from the pole to the equator, measured on the meridian of Paris. Strictly speaking, it is only the quadrant of the French standard earth, which is about one-tenth of one per cent. shorter than the acknowledged actual earth quadrant, according to the best determinations, but the fact of the latter being 10,001 kilometres instead of 10,000 is a matter of precision in definition only and in no way affects the practical unit.

As regards the history of the subject, it would appear that prior to 1887 measurements and deductions were confined to scientific works, and were expressed in absolute units—centimetres. In that year, however, a Paper was read before the British Institution of Electrical Engineers by Messrs. Ayrton and Perry,† who invented and developed a practical measuring instrument for the measurement of inductance, who, aided by Dr. Sumpner, made important contributions to the literature of the subject, and who proposed a name provisionally for the practical unit. That name was the secohm, a contraction of second-ohm, implying the fact

* *Phil. Mag.*, June, 1888. Fifth series. Vol. XXV., p. 453.

† "The Alternate Current Transformer" by J. A. Fleming, Vol. 1, p. 55.

‡ The term line of force here is used in the sense of a line of induction; the distinction being necessary when the lines pass through iron.

* *The Electrician*, of London, Sept. 19, 1890, p. 558, Report of British Association Discussion.

† *Journal* of the Institute of Electrical Engineers, London, April, 1887, Vol. XVI., p. 291.

Digitized by Google

that the product of the two was the length equal to the practical unit. They drew attention to the fact that since the Paris Congress of 1884 had fixed the standard legal ohm as the resistance of a column of mercury at zero centigrade, 106 centimetres long and one square millimetre in cross section, whereas the true ohm was in all probability 106·3 centimetres, or one-quarter of one per cent. greater, the inductances measured in the manner they suggested from seconds and legal ohms, would be in terms not of the standard earth quadrant of 10,000 kilometres, but of legal earth quadrants 9,778 kilometres in length. The difference practically is not very great, but to avoid error or confusion in definition they advocated provisionally the term secohm in place of quadrant.

The Paris Congress of 1889 adopted the "quadrant" as the practical unit of inductance, defining it as 1,000 million centimetres.

The practical range of inductances is second only to that of resistances, and the latter we know from a few microhms up to thousands of megohms. The smallest inductances are those of Hertz resonators which descend to the order metres. Excluding these, however, the smallest are, perhaps, met with in measuring instruments intended to have negligibly small inductance, such as doubly-wound resistance coils, Cardew voltmeters, and the like. These descend to the order of decametres, and can generally be expressed as such without prefixing decimal points. It is evident that the term microhenry would suitably apply to their designation. At the other end of the scale we find large induction machines linking dense fields with many turns of wires, and reaching inductances of hundreds or even thousands of henrys. Intermediate between these limits, there exists a large class of circuits having many turns but little iron, or clad in iron with few turns of wire, and these seem to be best expressed by the term millihenry, equivalent to the myriametre.

With the object of setting forth the advantages to be derived from the use of this nomenclature, it may be permissible to adopt it provisionally in describing the measurements that follow. These measurements have been made on different types of apparatus at different times and by different methods, so that they represent mean values from several observations in many cases, but allowance must be made for the variations of standard and type.

In telegraphy, the inductance of an ordinary Western Union 140-ohm relay is about three henrys with the armature drawn well back, and nine henrys with the armature pressed against the poles, in the latter case, of course, the magnetic reluctance of the iron circuit is a minimum, and the same current in the coils causes three times as many lines to circulate through the iron. At the position of the armature in ordinary adjustment the inductance is about five henrys.

The inductance of an ordinary standard 10ω relay is from 200 to 500 millihenrys, according to the position of the armature relatively to the poles.

The inductance of an ordinary sounder is similarly from 25 to 50 millihenrys. These inductances are the values obtained with only a few milliamperes through the coils, and since the path of the induction is largely through iron, the inductance varies with the strength of the current used. Practically, however, the variation is small within the range of current at which instruments usually operate.

*(To be continued.)*

## ELECTRO-MAGNETIC MECHANISMS.

### PRESIDENTIAL ADDRESS TO THE JUNIOR ENGINEERING SOCIETY.

BY PROF. SILVANUS P. THOMPSON, D.SC., B.A.

*(Continued from page 241.)*

*Cycle of Operations in the Stroke of an Electro-Magnet.*

Passing from the properties of the material to those of a definite electro-magnetic apparatus, the cycle of relations between magnetising force and magnetism may be still traced out by means of diagrams. Fig. 4 relates to a certain horse-shoe electro-magnet. The curve O P represents the ascending curve of the electro-magnet, when its armature was about one-twenty-fifth of an inch away. Under these circumstances, owing to the reluctance to magnetisation of the air gaps, a given magnetising power (ampere-turns of circulation of current) will produce less magnetisation than if the magnetic circuit were closed. The second curve Q R is the descending curve of the same electro-magnet when the armature is close up to the core, closing the magnetic circuit. Now, suppose such an electro-magnet to be used to do the work of drawing up its armature. We may consider the successive operations of producing a complete stroke, exactly as the engineer discusses the cycle of operations in the stroke of the piston in the cylinder. Starting at O, with the armature away from the core, the magnetising current is turned on, and the magnetisation is carried to the point corresponding to P. Suppose, now, the armature is allowed to move up to the core. The magnetisation is increased because of the more perfect condition of the magnetic circuit. During the movement of the armature mechanical work is performed, and as the magnetising power is kept all the time at a constant value, the line P Q represent (magnetically) this operation. If, now, the magnetising current is cut off the magnetisation follows the right-hand descending curve to R. During this operation a certain amount of energy is restored magnetically. If, now, the armature is permitted to fly back to its initial position, thus opening the gaps in the magnetic circuit the residual magnetisation will disappear almost entirely (provided the iron is soft), and the energy it represents is wasted as heat. The area O P Q R O represents the whole quantity of energy magnetically applied to the system. Part of this O Q R O is wasted by hysteresis; the other part O P Q O is utilised in doing mechanical work. As a matter of fact, these four operations do not occur separately in a stroke; for the armature usually begins to move before the magnetism has grown up to the point P, and it begins to fly back before the residual magnetism has entirely disappeared. The actual cycle is not made up of two straight lines and two magnetic curves any more than the actual diagram on the indicator card of a steam engine consists of the two isothermals and two adiabatics of the ideal case.

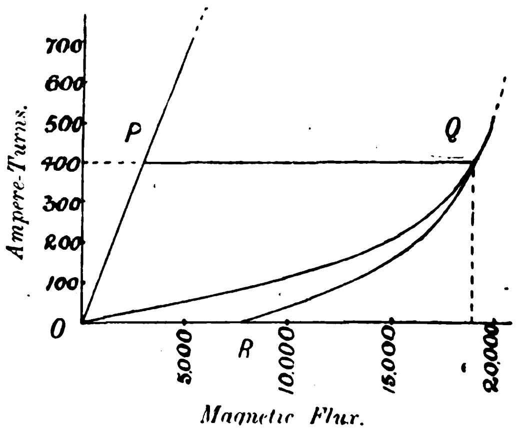



Fig. 4.

As a matter of fact the motion of the armature itself sets up in the copper wire an induced electromotive force which tends to diminish the magnetising current during the time that the motion lasts. The efficiency of the arrangement as an engine depends indeed upon the magnitude of such counter-electromotive forces, and upon the degree to which they cut down the working current. But this diagram does not represent the electrical losses; it exhibits solely the magnetic quantities concerned. Were a greater amount of time available, one might enlarge upon the mode in which the energy is transferred electrically to the magnetic system; how the approach of the armature, by increasing the magnetic induction as it completes the magnetic circuit sets up counter-electromotive forces, the electric energy utilised being proportional to the integral product of the current into the counter-electromotive force so generated. This is too wide a field for discussion at the present moment.

It might also be pointed out that this diagram does not exhibit the mechanical value of the force at any part of the stroke. During the part of the stroke corresponding to P Q, in which the armature is approaching the core there is an ever-increasing pull. On the other hand, during the return stroke the magnetism is undergoing the transition from R to O, and work is being done upon the armature instead of by it. There is an analogy, however, here also to Carnot's cycle diagram. That diagram does not exhibit the thermal quantities concerned in the different parts of the cycle. Heat is taken in along one of the isothermals and rejected along the other, but the length or position of those isothermals does not exhibit the quantities thus supplied to the engine or expelled from it. Heat values are not exhibited upon the Carnot diagram of mechanical work; neither are mechanical values exhibited upon my diagram of magnetic work.

*The Essentials of Electro-magnetic Engineering.*

It will be evident from what I have already said that amongst the most essential matters with which an electro-magnetic engineer must be conversant, are the properties of iron and the principle of the magnetic circuit. No inconsiderable part of the training of the mechanical engineer is devoted to acquiring a know-

Digitized by Google

ledge of the mechanical properties of materials; expensive and elaborate testing machines are devised for investigating those properties. The numerical values ascertained by such tests enter into every calculation of structures; affect every point in the design of machinery. For the electro-magnetic engineer there is, indeed, the double study not only of the magnetic properties of iron, but of the electric properties of the copper. He has to be thoroughly acquainted with the laws governing the generation and flow of electric currents; an acquaintance not to be made second-hand from books or lectures. Doubtless a complete experimental knowledge of these things may be facilitated by judicious teaching. Analogies are often helpful. No excuse is therefore needed for introducing the following table of analogies concerning the matters which are akin in several branches of engineering :—

| Mechanical. | Hydraulic. | Electrical. |
|---|---|---|
| Force | Pressure | Volts (pressure) |
| Rate of Displacement of mass (lbs. per min.) | Quantity of flow (Gals. per min.) | Amperes (current) (Coulombs per sec.) |
| Friction (coefficient of) | Fluid friction (coefficient of) | Ohms (resistance) |
| Inertia of mass | Inertia of mass | Quads(self-induction) |
| Elasticity | Compressibility | Farads (capacity) |

One of the most strange things about electricity, which until recent years can scarcely be said to have been comprehended, is this: that although electricity, when at rest, apparently possesses no weight, and occupies no space, yet, when it is moving along in a wire as a current, that current possesses a species of inertia. Still more strange is it that the inertia of the current apparently resides not in the copper wire within which the so-called current is flowing, but in the space outside the wire, and depends on the external medium. The inertia of an electric current flowing along in a copper wire is less if the surrounding medium is air than it is if the surrounding medium is iron. This inertia effect is, indeed, inextricably mixed up with the fact that the current sets up a magnetising action in the medium surrounding it. Our electromagnets are examples of spaces filled with iron, entirely exterior to the copper wire in which the electricity flows, nevertheless, being magnetised by that flow of electricity, and acting as an inertia-drag upon it.

Supposing these things, magnetic and electric, to be mastered, there remains yet one piece of practical education of the highest importance to the electro-magnetic engineer, namely, how to convey an electric current and to confine it to its proper channel. The proper jointing of electric conductors is relatively a much more important matter than the rivetting of girders, the splicing of belts, or the wiping of plumbers' joints. And the problem of properly insulating an electric conductor is much more difficult than that of preventing leakage of water, gas, or steam. To make things water-tight, or steam-tight, is a comparatively simple matter. To make things properly electric tight is by no means so easy, especially when high electric pressures are employed. To insulate an electric conductor is a fine art. The materials employed must be not only electrically non-conducting, but mechanically capable of resisting the (electric) stresses to which they are subjected. Moreover, these same stresses, acting as mechanical tensions at right angles to the surfaces of the copper conductors, combined with mechanical pressures in all directions parallel to those surfaces, are proportional, not to the electric pressure, but to the square of it. Thus, Mr. Ferranti, supplying certain districts of London by electric mains from Deptford at an electric pressure of 10,000 volts, has to provide adequate insulation capable of resisting being pierced by tensions which are 25 times as great as those that would arise if the conductors were worked at a pressure of 2,000 volts only. The insulator must mechanically resist being broken down by a spark piercing it. Adequate mechanical resistance is an absolute necessity, quite apart from any apparent value of its so-called electrical resistance. The electro-magnetic engineer must understand all about this.

But in addition to any mechanical knowledge he may possess, and beside all the practical experience he may acquire about the behaviour of electric currents and changes at various pressures, he must acquire, as my discourse to-night will have shown you, a thorough knowledge of the purely magnetic branch of the subject. You cannot ignore the fact that much of this knowledge is quite of recent date: is not yet possessed by any very large number of men. There are, as yet, very few shops or factories where a young engineer can pick up a knowledge of these things. They are not like the ordinary matters of mechanical engineering, things to be learned anywhere, and known to thousands of trained men. Indeed, I think I am putting forward no unfair claim when I say that it is to the technical colleges of one description or another that the majority of young engineers must, in the present state of the industry, betake themselves if they wish to make a full acquaintance with the principles, not to say the practice, of electro-magnetic engineering. Not that there do not exist factories and shops where this branch of the great engineering industry is carried on, and where an admirable practical training is to be had; but these are relatively few, and hence entrance to them is a matter of some difficulty.

*Experiments on Magnetic Circuits.*

Returning to the principle of the magnetic circuit, I will now illustrate by experiments the important principle which I have already enunciated that the circuit always tends so to alter its configuration as to better its form and close up all gaps. The cylindrical iron plunger which I showed you a few minutes ago is sucked into the tubular coil in virtue of this very principle. It tends to settle down with both ends equally protruding, for in this position it best affords a passage for the magnetic lines which leak back outside invisibly, through the air, from one end of the plunger to the other. Coned plungers act a little differently; their range of action is somewhat more extended. With them the maximum pull occurs not when the apex is just protruding through the coil, but after it has protruded some distance; and the final position in which they tend to settle is one in which the apex end protrudes much further out of the coil than the broad end protrudes.

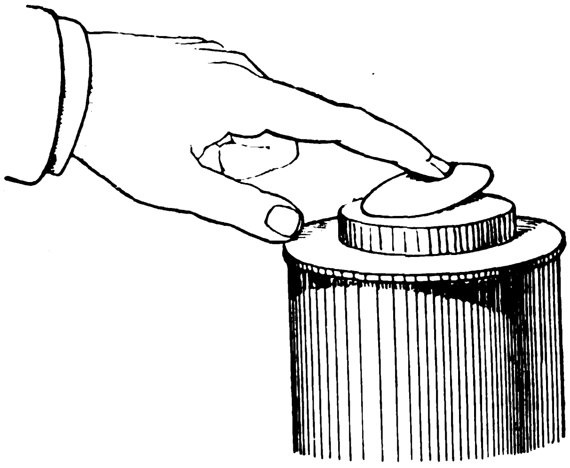


FIG 5.

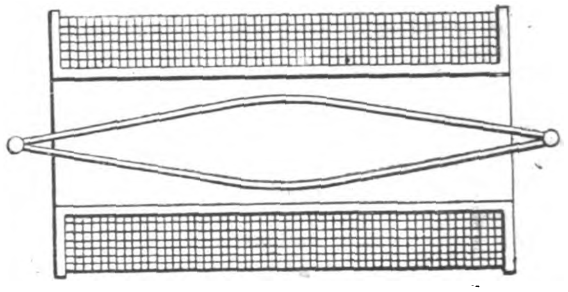


FIG. 6.

Here I have an electro-magnet consisting of a vertical cylindrical core about 12in. long and 3in. in diameter, surrounded by a coil of copper wire. When I turn on the current the magnetic circuit must complete itself in a very imperfect way by an invisible fountain of magnetic lines streaming up mostly through the top face and turning down on all sides in curved paths. Obviously these magnetic lines, where they emerge through the top surface, will crowd toward the periphery, rather than come up through the centre, so that they may traverse as short a route as possible. One would therefore expect to find, if one explored the top surface with an iron bullet, that the bullet is attracted more powerfully at the edges than at the middle part. It is a very easy thing to try this with a spring-balance to which the bullet is hung; but it is still more readily shown to an audience in another way. Here is an iron ball, about 1½in. in diameter. If I place it on the top of the electro-magnet it immediately rolls to the edge—taking that position where it helps most to complete the magnetic circuit. If I now transfer my iron ball to this large electro-magnet, which has two cylindrical cores, each about 2in. in diameter and 11in. high, connected at the bottom by an iron yoke, I find that the ball placed on the end of either core invariably rolls to the innermost point on the periphery nearest to the other core; for in this position it most nearly fills the gap between the poles.

Let me show you in this same connection a strange and paradoxical experiment with the same vertical cylindrical electro-

Digitized by Google

magnet that I used a moment ago. Its top surface is about 3in. in diameter. Here is a disc of tin-plate nearly 2½in. in diameter. Every engineer knows that tin-plate is made of iron, tinned upon its surface; and every engineer will therefore be quite ready to believe that if I lay this little disc of tin-plate down upon the middle of the circular surface of the electro-magnet, and then turn on the electric current, the little disc will be held tightly down. But will it? Not by any means. Instead of sticking itself down you will see it jump suddenly over and lie down, overhanging the edge. It tries to get into such a position that it improves the circuit. I replace the disc of tin-plate by a thinner disc of ferro-type iron (Fig. 5), and you notice how it actually bends up under my finger in its effort to turn over and get away from its central position.

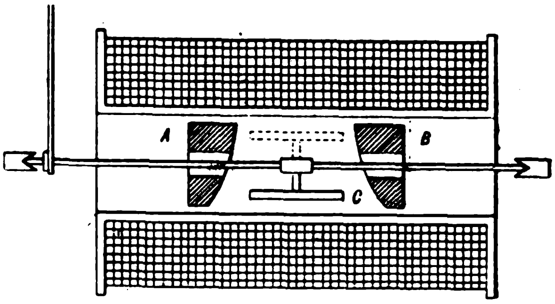



FIG. 7.

Not less strange is the action exhibited by the apparatus before you, consisting of an iron tube, surrounded by a coil of wire, and having two short iron cores inserted in the ends of the tube. You expect these cores to be drawn in when the electric current is made

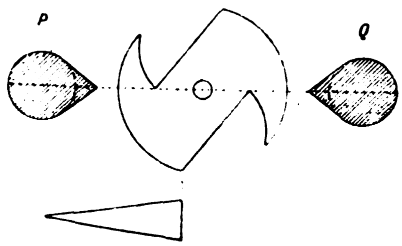



FIG. 8.

to circulate around the tube. Not a bit of it! There is iron already—the tube—through the coil, and the short cores will best complete the circuit not by being drawn in, but by being pushed out. I turn on the current, and they instantly protrude. Two light

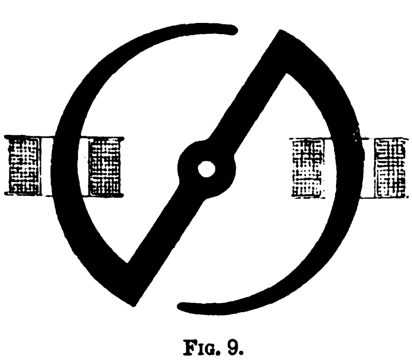


FIG. 9.

pendulums of wood are placed opposite to them, so that you may see at a distance how the cores are urged outwards. This apparatus was devised by Mr. Shelford Bidwell, who also has lent me another model, illustrating the same principle (Fig. 6). This consists of two strips of thin springy sheet iron joined at the ends, but bowed outwards. If this is placed inside a magnetising coil it elongates itself when the current is turned on. If, on the contrary, you place within the coil two separate flat strips tied together at their middle they tend to open out at their ends when the magnetising power is applied, for by opening out they can best help the magnetic lines to find return paths through the air. There is a whole class of small pieces of mechanism, used chiefly in the construction of ampere-meters and such-like instruments, depending on this same principle of an apparent magnetic repulsion. Several of the sheet diagrams on the wall relate to these devices.

In another instrument (an ampere-meter) devised by Mr. Evershed, a small piece of iron, C (Fig. 7), pivotted upon an axis, is attracted round, parallel to itself, into a position between the curved cheeks of two other pieces of iron; A and B, all being enclosed within a tubular coil of copper wire. Another way of carrying out the same idea is shown in Fig. 8, where a curiously wrought central piece of iron, R, having two wedge-shaped tongues—one of which is shown below in an edge-view—is placed between the poles, P and Q, of an electro-magnet. This central piece tends so to turn as to bring into the direct line between the poles the greatest possible thickness of iron.

One of the latest devices for procuring a rotatory movement electro-magnetically is depicted in Fig. 9. Here there are two magnetising coils, each with an aperture through its middle. The iron cores are both coned, and joined together so as to constitute portions of the rim of a wheel. They tend to plunge deeper and deeper into their respective coils.

[ERRATUM. In FIG. 3., p. 241, the letters B and H have been interchanged from their proper positions.]

*(To be continued.)*

## SUMMARY OF ELECTRICAL EVENTS FOR 1890.

JANUARY.

The St. Pancras Vestry resolve, by 38 votes to 16, to obtain plans, specifications, and tenders for the supply of electricity for 10,000 10 candle-power incandescents and 90 arcs (1st).

An 18,000-light Edison station in Pearl-street, New York, destroyed by fire (2nd).

Death of Mr. Charles Lever (5th).

Death of Father Perry, well known for his researches in terrestrial magnetism.

Presidential address on "Magnetism" by Dr. John Hopkinson, the newly-elected President of the Institution of Electrical Engineers (9th).

Cessation of the overhead wire cutting in New York.

Paper on "Galvanometers" read before the Physical Society by Prof. Ayrton (17th).

The Brighton Town Council decide, by 35 votes to 3, to establish electric lighting works at a cost of £30,000 (23rd).

Lecture by Prof. Dewar, at the Royal Institution, on "The Scientific Work of Joule" (24th).

Important experiments by MM. Sarasin and de la Rive on multiple resonance in connection with electric oscillations.

The contract for the electric lighting of the eastern division of the City awarded to the Laing, Wharton, and Down Construction Syndicate (28th).

Introduction of the electric light at the Public Record Office.

Inauguration of the new electric light installation at the British Museum—137 arcs, 827 incandescents (28th).

Cantor Lectures on "The Electro-magnet," by Prof. Silvanus Thompson.

Considerable agitation on the part of the American telephone companies against the single-trolley system of electric traction.

Dividends declared: Anglo-American Telegraph Company, 2¾ per cent.

FEBRUARY.

Meeting of the National Electric Light Association at Kansas City (11th to 14th).

Paper on "The Theory of Armature Reactions in Dynamos and Motors," by James Swinburne, read before the Institution of Electrical Engineers (13th).

Draft of a Bill establishing a system of Government telegraphs presented by Postmaster-General Wannamaker to a Committee of the United States House of Representatives.

Paper on "Some Points in Dynamo and Motor Design," by W. B. Esson, read before the Institution of Electrical Engineers (20th).

M. Auguste Frei, Director of Swiss Telegraphs, appointed Director of the International Telegraph Bureau at Berne.

An electrical engineering scholarship, within the gift of the Council of the Institution of Electrical Engineers, founded by Sir David Salomons.

Dividends declared: Direct Spanish Telegraph Company, 5½ per cent.; Taunton Electric Lighting Company, 5 per cent.; India-rubber Gutta-percha and Telegraph Works Company, 10 per cent.; Indo-European Telegraph Company, 10 per cent.

Digitized by Google

MARCH.

Action commenced by the Edison Electric Light Company against the United States Illuminating Company of New York for alleged infringement of Edison's "electromotor" meter patent of 1881; the infringing meter being the Schallenberger alternate current "induction" meter (4th).

Death of Mr. W. H. Snell, Editor of the *Electrician* (5th).

Public trial of the electric locomotives on the City and South London Railway (5th).

Deputation to the Board of Trade from the Association of Municipal Corporations. The Board of Trade agreed to the insertion of clauses in municipal Orders giving local authorities power to transfer their Orders, but declined to allow local authorities to divest themselves of all responsibility.

The question of the Government purchase of the telephones raised in the House of Lords by the Duke of Marlborough (15th).

Lecture on "Electro-Magnetic Radiation," delivered at the Royal Institution by Prof. G. F. Fitzgerald (21st).

Publication of the result of the Paris electric meter competition.

Important statements made by the chairman (Mr. J. S. Forbes) at a meeting of the shareholders of the London Electric Supply Corporation, with regard to the position of affairs at Deptford (31st).

Death of Herr Johann Georg Halske, one of the founders of the firm of Siemens and Halske, of Berlin.

Important decision rendered in the United States District Court, sustaining the broad claim of the Brush Company to a storage battery wherein the active material is applied to the plates by any mechanical means whatever.

Dividends declared: Eastern Extension Telegraph Company, 7 per cent.; Telegraph Construction and Maintenance Company, 20 per cent.

APRIL.

Large contract concluded for an electric railway on the Short System at Rochester, N.Y.—100 cars, dynamo capacity of station to be 1,100 horse-power.

Paper on "Signalling across Rivers in India," by Mr. W. F. Melhuish, read before the Institution of Electrical Engineers (10th).

The streets of Chelmsford lighted for the first time by electricity —18 2,000-candle-power arcs and 210 32-candle-power incandescents (14th).

Paper on "Electric Welding," read before the Institution of Civil Engineers by Sir Frederick Bramwell (15th).

Earl Compton moved in the House of Commons, "That, in the opinion of the House, the present position of telegraphists in London and elsewhere is unsatisfactory, and their just grievances require redress." Motion rejected by a majority of 39 in a House of 245 (15th).

The Paris municipality decree the expulsion of foreign steam and electrical plants from the Paris central lighting stations.

Annual general meeting of the Electrical Trades Section of the London Chamber of Commerce (21st).

The Central London Railway Bill came before a Select Committee of the House of Commons (21st).

Paper on "A Lightning Guard for Telegraph Purposes, and on the Protection of Cables from Lightning," read before the Institution of Electrical Engineers by Dr. Oliver Lodge (24th).

Bill to amend the Electric Lighting Acts introduced into the House of Commons (28th).

Local Government Inquiry into the proposed Brighton municipal electric lighting scheme (29th and 30th).

Paper on "Electric Traction Data," by Mr. Reckenzaun, read before the Old Students' Association (30th).

Dividends declared: Western and Brazilian Telegraph Company, 4 per cent.; Great Northern Telegraph Company, 5 per cent.

MAY.

Opening of the Edinburgh Exhibition (1st).

A deputation from electric light supply companies approached the President of the Board of Trade on the subject of the clauses which the Board proposed to insert in the Provisional Orders of local authorities (2nd).

The Select Committee of the House of Commons decide in favour of the Central London Railway Bill (6th).

Duplication of the cable communication between Australia and New Zealand.

Sir John Pender, in a letter to the Agents-General of the Australasian Colonies, offers to reduce the Australasian cable tariff to 5s. per word for one year by way of experiment, provided that the Colonies guarantee half of any loss that the cable companies suffer (13th).

Death of M. Jacques-Louis Soret, the eminent French physicist (13th).

Lecture by Dr. Fleming at the Society of Arts, on Prof. "Elihu Thomson's Electro-Magnetic Induction Experiments" (14th.)

Demonstration of the Worms-Balé process of tanning by electricity at the Works of the British Tanning Company (14th).

Royal Society Soirée (14th).

Opening of the International Telegraph Conference in Paris (16th).

The Intercolonial Conference on Postage and Cable Rates, sitting at Adelaide (South Australia), decide to accept the modified proposals of Sir John Pender for the reduction of the Australian cable rates to 4s. per word, on the condition that the Imperial Government consent to pay one-half of the subsidies and guarantees payable to the companies.

Meeting of the American Institute of Electrical Engineers at Boston (19th).

An important Paper on "Life and Efficiency of Arc Light Carbons," read before the American Institute of Electrical Engineers by Mr. Louis E. Marks (21st).

Death of M. Daniel Napoli, head of the laboratory of the Eastern Railway Company of France (29th).

Dividends declared: Consolidated Telephone Construction and Maintenance Company, 6 per cent.; Hastings and St. Leonards-on-Sea Electric Light Company, 3 per cent.

JUNE.

Announcement in the House of Commons by the Postmaster-General that the Government do not intend to purchase the telephones (20th).

Close of the International Telegraph Conference at Paris (21st).

Inauguration of the Public Lighting of the streets of Bath by electricity, 81 1,200 candle-power arcs being employed (24th).

Rejection by the House of Commons of the Overhead Wires Bill promoted by the London County Council (26th).

Death of M. Auguste Frei, Director of the International Telegraph Bureau at Berne.

Death of Mr. John Bordeaux, Chief Engineer to the Submarine Telegraph Company.

The Local Government Board sanction the borrowing of £32,500 by the Brighton Corporation for the purpose of carrying their electric lighting scheme into effect.

Notices of intention to apply for Provisional Orders to the number of 263 served upon Local Authorities.

JULY.

Royal Assent given the Electric Lighting Acts Amendment Bill (Scotland) (4th).

The tenders in connection with the proposed municipal central station accepted by the Brighton Town Council (10th).

The three Australian cables of the Eastern Extension Company interrupted by an earthquake (10th).

Publication of the revised regulations relating to the pay, leave, &c., of the Postal Telegraph clerks (14th).

Meeting of the Institution of Electrical Engineers at the Edinburgh Exhibition (15th, 16th, 17th). Papers read: "Working Efficiency of Secondary Cells." By Prof. Ayrton. "Observations on currents originating in Ordinary Aerial Telegraph Conductors." By A. R. Bennett. "Some of the Chief Features of the Edinburgh Exhibition, and mainly of the Electrical Section." By Dr. R. Mullineux Walmsley.

Judgment given in the First Division of the Court of Session in the action brought by Messrs. King, Brown and Co., to reduce the compound-winding patent, No. 2,003, of 1878, belonging to the Brush Electrical Engineering Company. The decision of Lord Trayner, invalidating the patent, was upheld (16th).

The House of Lords Committee decide that the preamble of the Central London Railway Bill is not proved (16th).

Explosion in the battery room of the New York offices of the Western Union Telegraph Company; a disastrous fire ensued, and damage to the amount of 250,000 dols. was done before it could be extinguished. The telegraphic service was greatly crippled (18th).

The appeal of Mr. John Dixon Gibbs and the National Company for the Distribution of Electricity by Secondary Generators against the decisions of Mr. Justice Kekewich (9th July, 1888) and of the Court of Appeal (4th March, 1889), invalidating the Gaulard-Gibbs transformer distribution patent, No. 4,362 of 1882, came before the House of Lords on the 25th inst., with the result that the judgments below were affirmed, and the appeal was dismissed.

Digitized by Google

Dividends declared: Crompton and Co., 5 per cent.; Direct United States Cable Company, 3½ per cent.; Eastern Telegraph Company, 6½ per cent.; Edison-Swan United Electric Light Company, 7 per cent. ("A" shares); National Telephone Company, 6 per cent.

AUGUST.

Completion of the Southend Pier electric tramway (2nd).

Execution of Kemmler by electricity, Auburn Prison, New York (6th).

The Grande Medaille d'Ampère awarded to M. Gramme by the Société d'Encouragement for his invention of the Gramme ring; the same Society also awarded the Giffard prize of 6,000 francs to M. Ferdinand Carré for his improvements in the manufacture of arc light carbons.

Meeting of the National Electric Light Association at Cape May (19th).

Publication of the Board of Trade Safety Regulations (21st).

Publication by the Board of Trade of a list of the electric lighting Provisional Orders granted by them and confirmed by Parliament during 1890. Total, 74: Local Authorities, 43; Companies, 31. The following are the Local Authorities who obtained electric lighting powers:—Aberdeen, Accrington, Ayr, Bacup, Barnsley, Bedford, Belfast, Birkenhead, Blackburn, Blackpool, Burnley, Burton-on-Trent, Bury, Cambridge, Cheltenham, Chester, Darlington, Derby, Dover, Dundee, Glasgow, Great Yarmouth, Hastings, Hove, Huddersfield, Kingston-on-Hull, Lancaster, Leicester, Malvern, Manchester, Nottingham, Oldham, Portsmouth, Salford, Stafford, Stockton-on-Tees, Tiverton, Walsall, Wigan, Wolverhampton, Worcester, York.

Dividends declared: General Electric Company, 7½ per cent.

The Local Authorities of the following towns resolve to obtain Provisional Orders: Canterbury, Kidderminster, Llanelly.

SEPTEMBER.

Meeting of the British Association at Leeds (3rd).

The streets of Fareham (Hants) lighted by electricity; 21 1,200-candle-power arcs and 85 20-candle-power incandescents (8th).

Publication of Prof. J. A. Ewing's molecular theory of induced magnetism.

Opening of the first Westinghouse electric railroad at Lansing (Mich.).

National Telephone Convention at Detroit (9th).

Meeting of the Association of Edison Illuminating Companies at Minneapolis (16th).

Accident to an electric tramcar running between Florence and Fiesole, by which five persons were killed and twenty injured (24th). Accident due to the driver omitting to switch off the current on going down hill.

At a meeting of the Emperors of Germany and Austria at the Castle of Rohnstock, in Silesia, selections from "Carmen" and other operas were transmitted by telephone from Berlin, a distance of 250 miles.

The Local Authorities of the following towns decide to apply for electric lighting Provisional Orders: Bromley, Edinburgh.

OCTOBER.

Death of Mr. C. H. Gimingham (2nd).

Approval by the Swiss and Bavarian Governments of the plans for applying two-thirds of the water of the Rhine, near Rheinfelden, to the generation of electricity for the purpose of the distribution of power.

Meeting of the National Street Railway Association at Buffalo. Electric traction much discussed.

The Local Authorities of the following towns resolve to obtain electric lighting Provisional Orders: Croydon, Dewsbury, Exeter, Gloucester, Gravesend, Hanley, Monmouth, Paisley, Sunderland, Weston-super-Mare, Whitby.

Dividends declared: Brazilian Submarine Telegraph Company, 7½ per cent.; Woodhouse and Rawson United, 15 per cent.

NOVEMBER.

Close of the Edinburgh Exhibition (1st).

Inauguration of the City and South London Railway by the Prince of Wales (4th).

Laying of the foundation-stone of the Brighton Municipal Central Station (4th).

Shutting-down of the Grosvenor Gallery Station and transference of the entire load to Deptford.

Laying of the foundation-stone of the St. Pancras Municipal Central Station (5th).

At a meeting of the Committee of the Electrical Trades Section of the London Chamber of Commerce it was unanimously resolved that the Chairman should be requested to bring the whole question of the Board of Trade regulations, issued in August, before the Council of the Chamber with a view of getting the Council to move in the matter (10th).

Paper on "The Chemistry of Secondary Cells," read by Prof. Ayrton before the Institution of Electrical Engineers (13th).

Destructive fire at the Grosvenor Gallery transformer sub-station, resulting in the cessation of the electric supply for over a fortnight. The fire was caused by the arcing of a plug switch, due to a nervous employé withdrawing the plug instead of pushing it home when engaged in switching in a bank of transformers (15th).

Permission given by the Leeds County Council to the Thomson-Houston agents to run some experimental electric cars on the Roundhay Park line.

The London, Manchester, Liverpool, and Birmingham telephone trunk wire opened to the public (19th).

Large reduction of telephone rentals announced by the National Telephone Company at Liverpool, Birkenhead, Newcastle, and other large towns in the North. These reductions to take place on and after January 1, 1891.

The series tramway line at Northfleet ceased running.

Conversazione of the Institute of Electrical Engineers (19th).

The Hammersmith Vestry agree to the working of the Uxbridge-road-Kew tramway by the Lineff closed-conduit system of electric traction (20th).

Second Annual Dinner of the Institution of Electrical Engineers (20th).

Presidential address to the Junior Engineering Society, by Prof. Silvanus Thompson, on "Electro-magnetic Mechanisms" (21st).

Dr. Rothen appointed Director of the International Telegraph Bureau at Berne.

The Governments of Victoria, New South Wales, South Australia, and Western Australia decide to propose to their respective legislatures the adoption of the cable guarantee required by the Eastern and Eastern Extension Companies to enable them to put in force the projected reduced tariff.

The new cable of the Great Northern Telegraph Company, between Newbiggin and Newcastle, opened to the public (22nd).

The Local Authorities of the following towns resolve to obtain electric lighting Provisional Orders: Harrogate, Kingston-on-Thames, Southend, Southport, Stockport, Tynemouth.

Dividends declared: Electric Construction Corporation, 6 per cent.; Swan United Electric Light Company, 10 per cent; Blackpool Electric Tramway Company, 7½ per cent.

DECEMBER.

Anniversary meeting of the Fellows of the Royal Society; Sir William Thomson elected President; presentation of the Rumford Medal to Professor Hertz for his researches in electro-magnetic radiation, and of a Royal Medal to Dr. John Hopkinson for his researches in magnetism and electricity (1st).

Formation of the American Tanning Company of New York for the purpose of introducing the Worms and Balé process of tanning by electricity into the United States.

The Barnsley Town Council enters into a contract with the Westinghouse Company.

Breakdown of the transformers at the Grosvenor Gallery sub-station and stoppage of the supply (3rd).

Death of Mr. H. G. Erichsen of the Great Northern Telegraph Company (6th).

Watt *v.* Maxim Electric Company and Maxim Electric Company *v.* Watt. Mr. Hugh Watt, M.P., to return £1,000 to the Company and pay costs (8th).

Expiry of the Bell Telephone patent (9th).

Paper on "The Electric Lighting Progress in London," read before the Society of Arts by Mr. Frank Bailey (10th).

Election of the President and Council of the Institution of Electrical Engineers for the year 1891. Award of premiums: Institution premium, W. B. Esson; Paris Exhibition premium, W. F. Melhuish; Fahie premium, K. L. Murray. President for 1891, W. Crookes, F.R.S (11th).

A Paper on "Some Experiments with Selenium Cells," read before the Physical Society by Mr. Shelford Bidwell, F.R.S.; a paper on "Alternate Current Condensers," read before the same Society by Mr. James Swinburne (12th).

Digitized by Google

The contract for the lighting of the western district of the City awarded to the Brush Electrical Engineering Company (17th).

Swansea Corporation accept the tender of Crompton and Co. for arc lighting (17th).

The City and South London Railway opened to the public (18th).

Seventy applications for Provisional Orders lodged with the Board of Trade (21st), 37 of which were lodged by Local Authorities.

Appointment by the Board of Trade of a Committee "To consider whether any, or if so, what, steps should be taken for the provision of Electrical Standards." The Committee comprised: Sir W. Thomson, Lord Rayleigh, Prof. Carey-Foster, Mr. R. T. Glazebrook, Dr. John Hopkinson, Prof. W. E. Ayrton, Mr. W. H. Preece, Mr. E. Graves, Major Cardew, R.E., and Mr. Courtenay Boyle; Sir Thomas Blomefield acting as Secretary (23rd).

Death of Mr. Wm. Lant Carpenter (23rd).

*From the forthcoming 1891 Edition of "The Electrician" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.*

# CENTRAL LIGHTING STATIONS OF THE UNITED KINGDOM.

## LONDON.

### IN OPERATION.

| Station. | Name of Company. | System. | Capacity in 8-C.P. Lamps: Actual. | Ultimate. |
|---|---|---|---|---|
| Cadogan (Manor-street, Chelsea)... | Cadogan Electric Light Co. | Secondary Batteries (E.P.S.) in consumers' houses | 10,000 | 80,000 |
| Chapel-place, Brompton-road............ | Kensington & Knightsbridge Elec. Light Co. | Secondary Battery Sub-stations (Crompton-Howell) | 7,000 | 60,000 |
| Chelsea ............... | Chelsea Electricity Supply Co. | Secondary Battery Sub-stations (E.P.S.) | 10,000 | 30,000 |
| Deptford ............ | London Elec. Supply Corporation | Alternate Cur. Trans. (Ferranti) | 90,000 | 290,000 |
| Davies-street, W. ... | Westminster Electric Supply Cor. | Low Tension with Secondary Batteries (Crompton-Howell) | 20,000 | 50,000 |
| Eccleston-place, W.. | Westminster Electric Supply Cor. | Low Tension, with Secondary Batteries (Crompton-Howell) | 20,000 | 80,000 |
| Kensington Court... | Kensington & Knightsbridge Elec. Light Co. | Secondary Battery Sub-stations (Crompton-Howell) | 22,500 | 84,000 |
| Lincoln's Inn-fields.. | Gwynne-Pilsen Co. | Low Tension Incandescent Lighting, Pilsen Arc Lighting | — | — |
| Manchester-square .. | Metropolitan Electric Supply Co. | Alternate Cur. Trans. (Lowrie-Parker) | 30,000 | 30,000 |
| Rathbone - place, Oxford-street ..... | Metropolitan Electric Supply Co. | Alternate Cur. Trans. (Lowrie-Parker) | 15,000 | 15,000 |
| Sardinia-street ...... | Metropolitan Electric Supply Co. | Alternate Cur. Trans. (Westinghouse) | 40,000 | 40,000 |
| Stanhope-street...... | Gwynne-Pilsen Co. | Pilsen Arcs and Low Tension Incandesent Lighting | — | — |
| St. John's Wharf, Westminster...... | Westminster Electric Supply Cor. | Low Tension, with Secondary Batteries (Crompton-Howell) | 15,000 | 30,000 |
| St. James's ........ | St. James's and Pall Mall Electric Light Co. | Three-wire system, with Secondary Batteries (E.P.S.) | 40,000 | 40,000 |
| Strand ............... | Messrs. Gatti | Low Tension | — | — |
| West Brompton...... | House-to-House Electric Light Supply Co. | Alternate Cur. Trans. (Lowrie-Hall) | 32,000 | 96,000 |
| Whitehall ............ | Metropolitan Electric Supply Co. | Low Tension, with Batteries (E.P.S.) | 10,000 | 10,000 |

### IN PROGRESS.

| Station. | Name of Company. | System. | Capacity. |
|---|---|---|---|
| Brixton .................. | Fyfe-Main Co. | Fyfe-Main | — |
| *City (West and Central...................... | Brush Electrical Engineering Co. | ... ... | — |
| *City (East) ............ | Laing, Wharton, and Down Construction Syndicate | Thomson-Houston Arcs (600) and Alt. Current Trans. | 100,000 |
| *Crystal Palace and District .............. | Electric Installation & Maintenance Co. | Secondary Batteries (E.P.S.) and continuous current transformers | 30,000 |
| Notting Hill (Victoria Gardens) ............ | Notting Hill Electric Light Co. | Secondary Batteries | — |
| *Southwark Bridge ... | Metropolitan Electric Supply Co. | (Not Selected) | — |
| Stanhope-street (No. 1 Station) ............... | St. Pancras Vestry | Three-wire system, with secondary batteries | 25,000 |
| *Paddington ............ | Metropolitan Electric Supply Co. | ... ... | — |
| *Waterloo ............... | Metropolitan Electric Supply Co. | Alternate Cur. Trans. (Kapp) | — |

* Those marked with an asterisk are only projected.

Digitized by Google

# CENTRAL LIGHTING STATIONS OF THE UNITED KINGDOM.

## PROVINCES.

### IN OPERATION.

| Station. | Name of Company. | System. | Capacity in 8-c.p. Lamps. Actual. | Capacity in 8-c.p. Lamps. Ultimate. |
|---|---|---|---|---|
| Barnet | H. F. Joel and Co. | Low Tension | — | — |
| Bath | H. G. Massingham | Alternate Current Transformers (Mordey) Thomson-Houston Arcs (200, 1,200 c.-p.) | 12,000 | 30,000 |
| Blackpool | Corporation | Siemens Arcs | — | — |
| Bournemouth | Brush Electrical Engineering Co. | Alternate Current Transformers (Mordey) | — | — |
| Bradford | Corporation | Low Tension with Secondary Batteries | — | — |
| Brighton | Brighton & Hove Electric Light Co. | Alternate Current Transformers (Lowrie-Hall) | — | — |
| Chatham | Chatham, Rochester and District Electric Light Co. | Alternate Current Transformers (Ferranti) | — | — |
| Chelmsford | Crompton and Co. | ... ... | — | — |
| Cowpen | Nicholson & Jennings | Arcs and Incandescents | — | — |
| Derby | J. Davis and Son | Low Tension with Secondary Batteries | — | — |
| Eastbourne | Eastbourne Electric Light Co. | Alternate Current Transformers (Lowrie-Hall) | — | — |
| Exeter | Exeter Electric Light Co. | Alternate Current Transformers (Mordey), Thomson-Houston Arcs (60, 1,200 c.-p.) | 6,000 | 19,000 |
| Fareham | Fareham Electric Light Company | Thomson-Houston Arcs (60) & Alt. Cur. Trans. | 1,000 | — |
| Galway | Galway Electric Light Co. | Low Tension | 600 | 8,000 |
| Glasgow (2) | Muir, Mavor and Coulson | Alternate Current Transformers (Ferranti) | — | — |
| | do. do. | Low Tension | — | — |
| Hastings | Hastings & St. Leonards Electric Light Co. | High Tension Direct Current; Arc and Incandescent (Brush) | — | — |
| Ipswich | Laurence, Scott and Co., Ltd. | Low Tension | — | — |
| Keswick | Keswick Electric Light Co. | Alternate Current Transformers (Kapp) | — | — |
| Leamington | Midland Elec. Light & Power Co. | Low Tension | — | — |
| Liverpool (3) | Liverpool Electric Supply Co. | Low Tension | — | — |
| Lynmouth & Lynton | C. Geen | Alternate Current Transformers (Mordey) | 4,000 | — |
| Manchester | Brush Electrical Engineering Co. | Low Tension | — | — |
| Newcastle | Newcastle and District Electric Lighting Company | Alternate Current Transformers (Parsons) | 9,000 | 50,000 |
| Newcastle | Newcastle - on - Tyne Electric Supply Company | Alternate Current Transformers (Mordey) | — | — |
| Norwich | Laurence, Scott and Co., Ltd. | Low Tension | — | — |
| Okehampton | H. Geen | Low Tension | 220 | — |
| Reading | Laing, Wharton, and Down | Thomson-Houston (90 Arcs) | 1,000 | — |
| Sheffield | Sheffield Telephone Ex. & Electric Light Co. | Thomson-Houston (50 Arcs) and Alternate Current Transformers (Mordey) | 6,000 | — |
| St. Austell | St. Austell Electric Light Co. (J. E. Veale) | Low Tension | — | — |
| Taunton | Taunton Electric Light Company | Thomson Houston (90, 1,200 c.-p. Arcs) | 6,000 | 12,000 |
| Thetford | Thetford Electric Light Company | Low Tension with Accumulators | 1,000 | 2,500 |
| Waterford | Laing, Wharton, and Down Con. Synd. | Thomson-Houston (70 Arcs) | 1,000 | — |
| Weybridge | Laing, Wharton, and Down Con. Synd. | Thomson-Houston | 2,000 | — |
| Woking | Woking Electric Light Co. | ... ... | — | — |

### IN PROGRESS.

| Station. | Name of Company. | System. | Capacity. |
|---|---|---|---|
| Brighton | The Corporation | Low Tension with Secondary Battery | — |
| *Dublin | The Corporation | Private Lighting; Alt. Cur. Trans. Public Lighting Continuous Current Arcs | — |
| *Glasgow | The Corporation | ... ... | — |
| *Leeds | Electric Installation & Maintenance Co. | Secondary Batteries (E.P.S.) & Con. Cur. Trans. | 50,000 |
| Northampton | Northampton Elec. Light & Power Co. | Secondary Batteries (Crompton-Howell) | — |
| *Oxford | Electric Installation & Maintenance Co. | Secondary Batteries (E.P.S) & Con. Cur. Trans. | 30,000 |
| Southampton | Southampton Electric Light & Power Co. | Secondary Batteries (Crompton-Howell) | — |
| *Swansea | (Municipal) | (Not Selected) | — |

* Those marked with an asterisk are only projected.

Digitized by Google

## ELECTRIC RAILWAYS AND TRAMWAYS IN THE UNITED KINGDOM.

| Place. | Length. | System. | Worked by. |
|---|---|---|---|
| IN OPERATION :— | Miles. | | |
| Alexandra Park | ½ | Telpherage | Electrical Engineering Corporation. |
| Barking | 1¼ | Accumulator Cars | General Electric Power & Traction Co. |
| Bessbrook—Newry | 3¼ | Third Rail (Dr. E. Hopkinson) | Bessbrook and Newry Tramway Company. |
| Blackpool | 2 | Holroyd-Smith's Conduit | Blackpool Electric Tramway Company, |
| Carstairs | 1¼ | Anderson-Munro | Anderson and Munro. |
| Glynde (minerals) | 1½ | Telpherage | Electrical Engineering Corporation. |
| Birmingham | 3 | Julien Accumulator Cars | Birmingham Central Tramway Company. |
| City and South London Railway (King William - street—Stockwell) | 3¼ | Third Rail (Dr. E. Hopkinson) | City and South London Railway Co. |
| East Pool (minerals) | 1½ | Telpherage | Electrical Engineering Corporation. |
| Southend Pier | ¼ | Third Rail (Crompton) | Local Board. |
| Portrush — Giant's Causeway | 8 | Third Rail (Siemens) | Giant's Causeway Electric Tramway Company |
| Ryde | ¾ | Third Rail (Siemens) | Ryde Pier Company |
| IN PROGRESS :— | | | |
| Liverpool Overhead Railway | ... | ... | ... |
| Stockwell and Clapham | 1 | ... | City & South London Railway Company |
| Wellingborough and District Tramroads | 2½ | ... | Wellingborough and Dis. Tramways Co. |
| Uxbridge-road, Kew | 3 | Lineff Closed Conduit | West Metropolitan Tramways Co. |
| PROJECTED :— | | | |
| Central London Railway (City and Bayswater) | 6 | ... | Central London Railway Company. |
| City and South London Railway (King William street—Islington) | 2 | ... | City & South London Railway Company |
| North Metropolitan Tramways | ... | ... | North Metropolitan Tramways Co. |
| Leeds (Roundhay Park Line) | ... | Thomson - Houston Overhead | ... |

## ELECTRIC LIGHTING NOTICES FOR 1891.

The following is a corrected list of the applications for Provisional Orders deposited with the Board of Trade on or before 21st December, 1890. An asterisk (*) indicates that the gas supply is in the hands of the applicants :—

### THE METROPOLIS.

ACTON LOCAL BOARD apply for an Order for Acton.

BRUSH ELECTRICAL ENGINEERING COMPANY make application for three Orders—(1) St. Leonard, Shoreditch ; St. James and St. John, Clerkenwell ; and St. Luke, Old Street ; (2) St. Saviour, Southwark ; (3) A portion of the City of London.

CAMBERWELL AND ISLINGTON ELECTRIC LIGHT AND POWER SUPPLY, apply for two Orders—(1) A portion of the parish of St. Giles Camberwell ; (2) St. Mary, Islington.

CHISWICK LOCAL BOARD—Chiswick.

EALING LOCAL BOARD apply for an Order for Ealing.

NEW CADOGAN AND BELGRAVE ELECTRIC SUPPLY COMPANY apply for one Order to supply electricity in portions of the parishes of St. Luke, Chelsea, and St. George, Hanover Square.

LAING, WHARTON, AND DOWN.—Whitechapel, Shoreditch, Hackney.

PADDINGTON AND BAYSWATER ELECTRIC LIGHT AND POWER SUPPLY—Paddington.

STAMFORD-HILL, TOTTENHAM, AND EDMONTON ELECTRIC LIGHT AND POWER SUPPLY—(1) St. John, Hampstead ; (2) Wandsworth.

WESTMINSTER ELECTRIC SUPPLY CORPORATION, apply for powers to extend the area of supply so as to include the portion of the united parishes of St. Margaret and St. John, Westminster, not already included in their area of supply.

WOOLWICH DISTRICT ELECTRIC LIGHT COMPANY—Woolwich.

### PROVINCES.

| Town, &c. | Name of Applicants. |
|---|---|
| Aberystwyth | Provincial Electric Light and Power Supply. |
| Birmingham | Birmingham Electric Supply Company. |
| Bishop Stortford | Bishop Stortford Electric Light and Steam Laundry Co. |
| *Bolton | The Corporation. |
| Brighton | Brighton and Hove Electric Light Company. |
| Bromley (Kent) | Urban Sanitary Authority. |
| Canterbury | The Corporation. |
| Cardiff | The Corporation. |
| *Coventry | The Corporation. |
| Croydon | The Corporation. |
| *Dewsbury | The Corporation. |
| *Edinburgh | The Corporation. |
| Exeter | The Corporation.<br>Exeter Electric Light Company. |
| Harrogate | The Corporation. |
| Hanley | The Corporation. |
| *Heckmondwike | The Local Board. |
| Hertford | The Corporation. |
| Ipswich | Ipswich Electricity Supply Company.<br>Laurence, Scott and Co. |
| Kidderminster | The Corporation. |
| Killarney | The Town Commissioners.<br>C. E. Leahy, Esq. |
| Kingston-on-Thames | The Corporation. |
| *Leamington | The Corporation. |
| Leamington Royal Spa | Midland Electric Light and Power Company. |
| Leeds | National Electric Supply Company.<br>Electric Installation and Maintenance Company.<br>Yorkshire House-to-House Electricity Company. |
| Liverpool (†) | Liverpool Electric Supply Company. |
| Llanelly | The Local Board. |
| Londonderry | The Corporation. |
| Newcastle-on Tyne | Newcastle and District Electric Lighting Company. |
| Newport (Mon.) | The Corporation. |
| Norwich | Norwich Electricity Company. |
| *Paisley | The Corporation. |
| Poole | Brush Electrical Engineering Company. |
| Preston | National Electric Supply Company. |
| Scarborough (‡) | The Corporation. |
| Southend | The Local Board. |
| *Southport | The Corporation. |
| South Shields | The Corporation. |
| *Stockport | The Corporation. |
| *Sunderland | The Corporation. |
| Surbiton | The Improvement Commissioners. |
| Torquay | The Local Board. |
| Toxteth Park | Liverpool Electric Supply Company. |
| Tunbridge Wells | The Corporation. |
| Tynemouth | The Corporation. |
| Weston-super-Mare | The Improvement Commissioners. |
| Weybridge | Laing, Wharton, and Down Construction Syndicate. |
| Weymouth | Weymouth Electricity Supply Company. |
| Whitby | The Local Board. |
| Whitehaven | The Town and Harbour Trustees. |
| Withington | Manchester House-to-House Electricity Company. |

**The following list shows the number of applications which have been served by each of the several Companies and by the Local Authorities :—**

| Name of Applicant. | No. of Applications. |
|---|---|
| Birmingham Electric Supply Company | 1 |
| Bishop Stortford Electric Light and Steam Laundry Company | 1 |
| Brighton and Hove Electric Light Company | 1 |
| Brush Electrical Engineering Company | 4 |
| Camberwell and Islington Electric Light and Power Supply | 2 |
| Electric Installation and Maintenance Company | 1 |
| Exeter Electric Light Company | 1 |
| Ipswich Electricity Supply Company | 1 |
| Laing, Wharton and Down | 2 |
| Laurence, Scott and Co. | 1 |
| Leahy, Mr. C. E. | 1 |
| Liverpool Electric Supply Company | 2 |
| Manchester House-to-House Electricity Company | 1 |
| Midland Electric Light and Power Company | 1 |
| National Electric Supply Company | 2 |
| New Cadogan and Belgrave Electric Supply Company | 1 |
| Newcastle and District Electric Lighting Company | 1 |
| Norwich Electricity Company | 1 |
| Paddington and Bayswater Electric Light and Power Supply | 1 |
| Provincial Electric Light and Power Supply | 1 |
| Stamford Hill, Tottenham, and Edmonton Electric Light and Power Supply | 2 |
| Westminster Electric Supply Corporation | 1 |
| Weymouth Electricity Supply Company | 1 |
| Woolwich District Electric Light Company | 1 |
| Yorkshire House-to-House Electricity Company | 1 |
| | 33 |
| Local Authorities | 37 |
| Total | 70 |

† The Liverpool Electric Lighting Order, 1889, to be amended or revoked.
‡ The Scarborough Electric Lighting Order, 1883, to be amended or repealed.

Digitized by Google

## ELECTRIC TRACTION NOTICES FOR 1891.

In the following notices of proposed applications to Parliament or the Board of Trade powers to use Electric Traction are expressly sought :—

THE METROPOLIS.

| Applicant. | Powers sought. |
|---|---|
| Central London Railway (Company to be formed). | To construct an underground railway from Shepherd's Bush to the City, and to use electricity as the motive power. |
| City and South London Railway Company. | To extend the existing underground line from King William-street, City, to the northern end of the City-road, Islington. Also to construct a subway for foot-passengers along the proposed route. To use electricity or any other mechanical power (except steam locomotives). |
| South Kensington and Paddington Subway (Company to be formed). | To construct subways from South Kensington to Paddington, to make use of electricity or cable power. |

PROVINCES.

| Applicant. | Powers sought. |
|---|---|
| Birmingham Central Tramways Company. | To make use of electrical, steam, cable, mechanical, or other power. |
| Bolton Corporation. | To make use of animal, steam, electrical or other power. |
| Bristol Tramways and Carriage Company. | To use electrical, cable, or any other power except steam. |
| Burton-on-Trent Tramways (Company to be formed). | To work the tramways for the purposes of traffic of every description or for the purposes of such traffic as may be limited by the Provisional Order by means of locomotive, steam, electric or other engines, or other mechanical, electrical, or other motive power, in addition to or in substitution for animal power, and to hold and acquire patent and other rights or licences to use patent rights in relation to any such locomotive power as aforesaid. |
| Dover and Calais Tubular Railway (Company to be formed). | To construct a tubular railway under the Straits of Dover, to employ as motive power steam, electricity, or other mechanical power. |
| Liverpool Corporation. | To let same on lease or otherwise ; to use steam, electrical, or other mechanical power. |

## NEW COMPANIES OF 1890.

The following are the more important of the new Companies dealing with electricity and engineering which have been registered during the past year :—

| Name of Company. | Capital. |
|---|---|
| Archer Pipe Company | £10,000 |
| Andrews and Preece | 25,000 |
| Amalgamated Electricity Supply Company | 100 |
| Atlas Engine Company | 12,000 |
| Avon Indiarubber Company | 50,000 |
| British Insulated Wire Company | 60,000 |
| Buller's (Limited) | 200,000 |
| British Gas Lighting Improvement Company | 160,000 |
| British Guiana Electric Lighting and Power Company | 10,000 |
| Bishop Stortford Electric Light and Steam Laundry Company | 10,000 |
| Baxter's (Limited) | 20,000 |
| Barry and Cardiff Electric Light and Power Supply Company | 1,000 |
| Bristol Electricity Supply Company | 100 |
| Chagford and Devon Electric Light Company | 2,000 |
| Camberwell and Islington Electric Light and Power Supply Company | 1,000 |
| Canterbury Electricity Supply Company | 100 |
| Cardiff Electricity Supply Company | 100 |
| Column Printing Telegraph Company | 100,000 |
| Combination Telephone and Electrical Engineering Company | 20,000 |
| Commercial Contract Corporation | 3,000 |
| Durand Electric, Petroleum and Gas Engine, and Manufacturing Company | 100,000 |
| Dick, Kerr and Co. | 160,000 |
| District Messenger Service and News Company | 200,000 |
| Devonshire Electric Light and Power Supply Company | 1,000 |
| Donald (John) | 20,000 |
| Electricity Supply Companies' Union | 100 |
| Earthy Metals Company | 2,000 |
| Elmore's French Patent Copper Depositing Company | 200,000 |
| Electrical Inventions Company | 35,000 |
| Elmore's Austro-Hungarian Patent Copper Depositing Company | 200,000 |
| Electro-Metallurgical Company | 2,500 |
| Electro-Chemical Syndicate | 5,000 |
| Electrical Supplies and Fittings Company | £20,000 |
| "Electricity and Electrical Engineering" Newspaper Company | 500 |
| Electrolytic Syndicate | 100,000 |
| Electric Stores | 15,000 |
| East Coast Electric Light and Power Supply Company | 1,000 |
| Electrical Engineering Corporation | 150,000 |
| Electrical Engineering Company of Ireland | 50,000 |
| Electric Meter Company | 50,000 |
| Elmore's Wire Manufacturing Company | 300,020 |
| Egestorff (J. A.) and Co. | 10,000 |
| Electric Welding Company | 460,000 |
| Electric and General Investment Company | 200,000 |
| Edinburgh Electric Supply Corporation | 100,000 |
| Fowler, Lancaster and Co. | 22,000 |
| Fareham Electric Light Company | 5,000 |
| Foreign and Colonial Electrical Power Storage Company | 100,500 |
| Ferranti, S. Z. de | 100,000 |
| Franco-African Lighting Syndicate | 25,000 |
| Freedman Battery Company | 2,000 |
| Foreign Electric Date and Time Stamp Company | 100,000 |
| Friedenthal and Co. | 20,000 |
| General Electric Power and Traction Company | 350,000 |
| Grangemouth Gas Company | 10,000 |
| Grange Syndicate | 2,000 |
| Gordon Electric Traction Syndicate | 2,400 |
| Gordon (J. E. H.) and Co. | 50,000 |
| Glass and Metal Engineering Company | 5,000 |
| Hanley Electricity Supply Company | 100 |
| Heyford Iron Company | 20,000 |
| Holmes and Sons | 14,000 |
| International Okonite Company | 340,000 |
| Indiarubber Estates Company | 235,000 |
| Ipswich Electricity Supply Company | 100 |
| Keys's Electric Company | 15,600 |
| Kent Patent Arc Lamp Company | 100,000 |
| Kaye (Joseph) and Sons | 30,000 |
| Kidderminster Electric Light and Power Supply Company | 1,000 |
| Kidd (James) and Co. | 3,000 |
| Lane-Fox Electrical Company | 100 |
| Loughboro' Electricity Supply Company | 100 |
| Leeds and London Electrical Engineering Company | 100,000 |
| London Metallurgical Company | 15,000 |
| Lactite | 30,000 |
| Mills's Patent Sectional Boiler Company | 100,000 |
| Mulholland, Maugham and Co. | 5,000 |
| Morgan's Automatic Electric Signal System Syndicate | 5,000 |
| Mutual Telephone Company | 100,000 |
| Maclellan, P. and W. | 300,000 |
| Macmahon's Patent Electric Check Company | 50,000 |
| Muntz's Metal Company | 300,000 |
| Manchester Electricity Supply Company | 100 |
| Norwich Electricity Supply Company | 50,000 |
| New Zealand Electrical Syndicate | 30,000 |
| New Cadogan and Belgrave Electric Supply Company | 1,000 |
| Northern Counties Electric Light and Power Supply Company | 1,000 |
| Nonpareil Electric Lighting Syndicate | 6,000 |
| North British Boiler and Machinery Insurance Company | 75,000 |
| Purnell High-Speed Gas Engine and Manufacturing Company | 50,000 |
| Purdon-Walters' Motor Syndicate | 10,000 |
| Poole and White | 20,000 |
| Paddington and Bayswater Electric Light and Power Supply Company | 1,000 |
| Pascoe, Grenfell and Sons | 200,000 |
| Penzance Electricity Supply Company | 100 |
| Provincial Electric Light and Power Supply Company | 1,000 |
| Plenty and Son | 25,000 |
| Practical Electro-Plating and Enamelling Company | 2,000 |
| Ratcliff and Horner | 20,000 |
| Railway Construction and Maintenance Company of Mexico | 100,000 |
| Steam Loop Company | 70,720 |
| Sleeman Controlled Torpedo Syndicate | 12,000 |
| Scott (Ernest) and Mountain | 70,000 |
| Sheffield Telephone Exchange and Electric Light Company | 100,000 |
| Stamford-hill, Tottenham, and Edmonton Electric Light and Power Supply Company | 1,000 |
| Sherrin Electric Power Generator Company | 100,000 |
| Store's Patent Submarine Engineering Company | 6,100 |
| Trent Gas Engine Company | 15,000 |
| Thorneburry Miners' Safety Lamp Company | 50,000 |
| Tubular Frame Waggon Company | 200,000 |
| Thetford Electric Light and Power Company | 5,000 |
| Tylor (J.) and Sons | 100,000 |
| Thomas and Green | 39,000 |
| United Alkali Company | 6,000,000 |
| Universal Electric Light and Power Trust Corporation | 5,000 |
| United Electricity Supply Company | 100 |
| Vaughan-Sherrin Electrical Engineering Company | 25,000 |
| Venezuela Telephone and Electrical Appliances Company | 70,000 |
| Victoria Torpedo Company | 16,000 |
| Weston-super-Mare Electricity Supply Company | 100 |
| Weymouth Electricity Supply Company | 100 |
| Woolwich District Electric Light Company | 10,000 |
| Weymersch Electric Battery Syndicate | 20,000 |
| TOTAL | £13,121,740 |

Digitized by Google

## PUBLIC COMPANIES WOUND UP IN 1890.

Amongst the companies wound up during the past year are the following (those with an asterisk being voluntary windings-up ordered to be continued under the supervision of the Court):—

Australasian Electric Light Power and Storage Company (amalgamated with the Brush Electrical Engineering Company, Limited).
*Automatic Electric Railway Signal Company, Limited.
Blackman Air Propeller Ventilating Company, Limited (re-constructed as the Blackman Ventilating Company, Limited).
*Buckingham Electric Light and Power Supply Company, Limited.
Buller, Jobson and Co., Limited (re-constructed as Bullers, Limited).
Byng Telephone Company, Limited.
Chemical Carbon Company, Limited.
Edmundson (J.) and Co., Limited.
Electric Traction Company, Limited (amalgamated with the General Electric Power and Traction Company, Limited).
Farmer, Robey, Clarke and Co., Limited.
*International Cable Company, Limited.
Kent Patent Arc Lamp Company, Limited.
Lundy Cable Company, Limited.
MacMahon's Electric Automatic Registering Company, Limited.
Manchester Electric Supply Company, Limited.
Maxim-Weston Electric Company, Limited.
Midland Engineering Company, Limited.
Montevidean and Brazilian Telegraph Company, Limited (amalgamated with the Western and Brazilian Telegraph Company, Limited).
Muntz's Metal Company, Limited (re-constructed).
*Mudge Marchant Engine Company, Limited.
Parker's Electric Wire Corporation, Limited.
Patent Electric Fire Lighter Company, Limited.
Railway and Domestic Electric Lighting Company, Limited.
Railway and Electric Appliances Company, Limited (amalgamated with the Electric Construction Corporation).
Schanschieff Electric Light and Power Company, Limited.
Schanschieff Electric Battery Syndicate, Limited.
Sheffield Telephone Exchange and Electric Light Company, Limited (re-constructed).
*Southwark Foundry Company, Limited.
Statter (J. G.) and Co. (amalgamated with the United Electrical Engineering Company as the Electrical Engineering Corporation, Limited).
Submarine Telegraphs Company, Limited (taken over by the Postal Telegraph Department).
Taunton, Delmard, Lane and Co., Limited.
Telpherage Company, Limited (amalgamated with the Electrical Engineering Corporation, Limited).
United Electrical Engineering Company, Limited (amalgamated with J. G. Statter and Co. as the Electrical Engineering Corporation, Limited).
Volta Electrical Company, Limited.
Whitehall Electric Supply Company, Limited (amalgamated with the Metropolitan Electric Supply Company, Limited).
Woodhouse and Rawson Electric Contract and Maintenance Company, Limited.
Woodhouse and Rawson, Limited.

## AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *December* 19, 1890.

**"The Henry."**—The regular monthly meeting of the Institute of Electrical Engineers, December 16th, brought out two very interesting Papers. One of them was on inductance and its proposed unit, the henry, by Mr. A. E. Kennelly, and dealt with both the relations of the henry to other units and to the values met in practice among familiar instruments. The Paper contained a large amount of new and important experimental work, and dealt directly with the question of the proper magnitude for this practical unit. A committee that had previously been appointed by the Institute to determine the most practical value for the henry reported in favour of making this unit equal to one earth quadrant, on the ground that although the small numerical values met with in ordinary practice make so large a unit inconvenient, as it involves many small fractions, nevertheless it would not be advisable to break in on the symmetry of the system of practical units that we already have by adopting a sub-multiple of the earth quadrant for the henry. The new name shows signs of rapidly making its way into general use in this country.

**The Gramophone.**—The other Paper of the evening was by Mr. Emile Berliner on the gramophone. Mr. Berliner gave a full account of the principles and general operation of the gramophone, and illustrated it both by etching the records and reproducing a large variety of musical selections through the instrument. The process of making the records, which is a very interesting one, consists of allowing the tracing point of the diaphragm to form a spiral on a rotating zinc covered with an almost infinitesimally thin layer of wax. The vibrations of the voice are impressed on the wax cutting it through to the zinc in sinusoidal curves. The plate is then etched with chromic acid, so that the record is a permanent one. The reproductions of music as given by the instrument were remarkably diversified and distinct; those heard at the meeting did not, however, compare favourable with the best performances of the phonograph or the micrographophone, although the instrument, it should be said, is a much simpler one, and was turned by hand instead of being driven by a motor.

**The Edison Company.**—The Edison Company has been cutting prices left and right recently, presumably with the intention of starving out small competitors. The drop in prices has been so great as to cause very general comment, and it must result in making the Edison Company very formidable as a competitor, although it will presumably cut down profits. A 2 per cent. quarterly dividend was declared the other day, but the new schedule has not been long enough in operation to show marked effect upon the dividends, either in one direction or the other. It is not improbable that the Company may increase its capital stock ere long.

**The Thomson-Houston Company.**—The Thomson-Houston Company is bestirring itself. Its railway department has been recently put in charge of Mr. O. T. Crosby, well-known as one of the leading authorities on electric traction, and intimately identified with the development of the art when in the hands of the old Sprague Company. As the West End Railway Company of Boston is about to erect an electric elevated road in which the Thomson-Houston system is to be used, the acquisition of Mr. Crosby is a specially valuable one.

## SCANDINAVIAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

COPENHAGEN, *December* 26, 1890.

The Christiania Telephone Company's new central exchange is now completed. The company has now about 2,500 subscribers. In the year 1884, when the Company was formed by the amalgamation of two older companies, the subscribers numbered 1,400. The present station is able to accommodate twice the present number of subscribers, viz., 5,000. The present traffic amounts to about 13,000 conversations per day. There are thirteen tables, each with 200 numbers, and each attended by two female clerks, and the new station is very well appointed in every respect.

The Stockholm General Telephone Company continues to do all it can for the purpose of accommodating its subscribers. The recent severe white frost has proved very troublesome for the Company, and has interfered materially with their business. The constantly increasing weight of the hoar frost has broken a number of wires, which has, of course, led to further complications. Great efforts have been made to counteract the frost, and the Company has tried to melt it by sending currents through the wires from the electric light installation. The remedy, however, proved worse than the disease.

The new Swedish ironclad "Göta" has had electric light installed on rather an extensive scale. The installation comprises 159 incandescent lamps of 16 candle-power, and four reflectors of about 50,000 candle-power each. The dynamos are coupled direct to the engines, the speed being about 400 revolutions. The engines are supplied from the Government workshops, the electric installation by the firm of Luth and Rosen. The central electric station at Halmstad, Sweden, has been recently completed, the installation having been carried out by the L. M. Ericsson's Engineering Company, Stockholm. It comprises both street and house lighting, the former taking 50 1,200-candle-power arcs and 25 25-candle-power incandescents. The house lighting amounts to some 700 16-candle-power incandescents. The street lighting is divided into two sections which can be handled independently of each other. One section is turned out at 11 p.m., and the other does the lighting till daybreak.

The Danish State Telegraphs show, as usual, a loss on last year's working; this has been the case since 1876, and the loss on the

Digitized by Google

working amounts in the aggregate to 1,239,867kr. (£62,000). The number of telegrams amounted to 1,494,622, which is about 30,000 messages less than the previous year. During the year the length of line was increased by 13, and the length of wire by 52 geographical miles, the total length of wire now being 1,629 geographical miles. There are 162 State telegraph stations, and 202 railway telegraph stations; 57 telephone stations have direct connection with the State Telegraphs. The Danish State Telegraphs have a total of 496 instruments, of which 7 are Wheatstones, 384 ordinary Morse instruments, and 105 telephone instruments. The revenue for telegrams amounted to 720,076kr. (£36,000), as far as the State was concerned. The number of telegrams sent averages 36 per 100 inhabitants per annum.

The new cable between Newcastle and Gothenburg further enhances the importance of this latter town as a cable station. The new cable is the fourth which connects Sweden with the East of Europe, there being now three between Sweden and England, and one between Sweden and Denmark, for France, Spain, Portugal, &c.

## CORRESPONDENCE.

### THE DETERMINATION OF INDUCTANCE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of November 21, 1890, you reproduced an abstract of my article on the determination of inductive resistances and coefficients of self-induction of measuring instruments, which appeared a short time ago in the *Electrical Engineer* of New York, and accompanied it with a few editorial remarks. In regard to these I would like to give some explanations, which I hope will make the matter clear.

I have found this method especially satisfactory for determining the coefficient of self-induction of measuring instruments, and cannot consider those five observed quantities in equation (13) as a drawback, because, as you will see from the fundamental equations (10) and (11), in reality only two alternate-current readings are needed, and the other terms are resistances, which even in a factory generally can be determined with a very high degree of exactness. That, nevertheless, I prefer a specialised form of equation (13) for practical use in determining the self-induction of *ammeters* is justified by the fact that such low resistances as occur in ammeters are generally more exactly measured by current-strength and potential than by Wheatstone's bridge.

The great number of decimals given in the application of the method ought not to astonish you either. I gave these figures as it is usual in exact sciences, for instance, in astronomy, that is, "the result of calculation is given with one decimal more as can be relied upon." Those figures are not at all single readings, as it may seem at first, but are the average values each of a set of about 10 readings. Therefore a greater exactness than is usual with a single instrument-reading is not at all surprising.

As you will see, nowhere the current, but everywhere the ratio of two currents enters the equations, and these, therefore, hold good even for a proportional and simultaneous increase or decrease of one pair of current-readings. Therefore different values: $c_1', c_1'', c_1''' \ldots c_1^x$ were observed, and also the corresponding values: $c_2', c_2'', c_2''' \ldots c_2^x$, and then all these values were reduced to the average value: $c_1 = \text{av.}\ \{c_1', c_1'' \ldots c_1^x\}$

$$c_2 = \text{av.} \left\{ c_2' \frac{c_1}{c_1'},\ c_2'' \frac{c_1}{c_1''} \ldots c_2^x \frac{c_1}{c_1^x} \right\}.$$

It is obvious that in this way a rather high accuracy can be reached even with ordinary instruments, if it is necessary, as it was in my case.

The instrument which I used for measuring inductive resistances was not a Cardew voltmeter, but an electro-dynamometer-voltmeter, with a shifting of phase of 5deg. for 100 complete periods per second. If a Cardew voltmeter is used for the determination of inductance, the ammeter will more conveniently be arranged in series with inductive resistance and voltmeter, these being connected in parallel. Then the ammeter measures the resulting current of voltmeter and inductance current, that is, the third side in a triangle, the one side of which is the voltmeter current, and the other side the current in the inductance, and the angle between both latter sides the shifting of phase by the inductance, and therefore the coefficient of self-induction of the ammeter does not enter the equations, which assume a little different form: always the coefficient of self-induction of either the ammeter—when the voltmeter is "in long shunt" or of voltmeter when being "in short shunt"—enters the result, and, if the self-induction of the voltmeter = 0, we, therefore, will prefer the latter arrangement.—Yours, &c., CHAS STEINMETZ.

Yonkers, New York, December 12, 1890.

[When mean readings are given, it is desirable to state the average divergence of the single observations from the mean, as a comparison of the two always forms an excellent test of the practical value of the method.—ED. *E.*]

### PERMANENT MAGNET VOLTMETERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In an editorial paragraph which appeared in the issue of *The Electrician* of the 5th inst., you make a statement concerning the temperature error of the Weston voltmeter, of the permanent magnet type, that requires correction. The temperature compensating device, attributed to Mr. Weston, and described in your notes, is not used in connection with the permanent magnet type of voltmeter. While applicable to many instruments, it was especially designed for use in connection with a portable electro dynamometer for measuring alternating current potentials. In order to keep the current in this instrument low, and to obtain the necessary couple for a full scale (6in.) deflection of the index, with a given potential difference, it was deemed expedient to wind the coils with copper wire. This, of course, necessitates a correction of the instrument readings amounting to 1 per cent. for each five degrees of temperature (Fahrenheit) variation from the normal. While the compensating device may be neither novel or positively accurate, it is in this particular instrument more feasible and far less costly than the differential winding of the coils with conductors having different temperature coefficients mentioned by you.

The Weston permanent magnet voltmeter is wound with German silver wire, having a temperature coefficient of ·02 per cent. per degree Fahrenheit. As the average resistance of these instruments exceeds 100 ohms per volt, it is evident that the temperature error cannot be large, as you state, but instead it is so small as to require no correction, except in very accurate test work. The actual error for a variation of external temperature of 35 degrees above or 35 degrees below 70 degrees Fahrenheit is a small fraction of 1 per cent. The instrument may, therefore, be left continuously in circuit, and to this end, when contact keys are provided, they are made with a locking attachment, so arranged that the circuit may be maintained intact by a quarter turn of the key.

In view of the general distrust of permanent magnet instruments, it may not be amiss to add that the writer has used one of these instruments daily in calibration work for nearly two years, and that, although checked at frequent intervals with a series of Clark cells (zero method), no change has yet been observed amounting to one-tenth of 1 per cent. It is a fact also that of the very large number of these instruments used in commercial work, when they are exposed to the action of powerful magnetic fields, but a very few have changed, and of these few the majority have shown an increase in the strength of the magnets instead of the expected decrease, the maximum change, however, seldom exceeding two per cent.

Results like the above are substantial evidence of a reformation of the past character of instruments of the permanent magnet type, and certainly warrant their re-adoption and continued use for all direct-current measurements.—Yours, &c.,

The Electric Club, New York, EDWARD F. COLBY.
Dec. 19, 1890.

[It would not appear that for ordinary work a thermometer need be used, when the temperature coefficient is ·02 per cent. per degree Fah. But for accurate testing, of course, thermometers are always used, and have been used for years; such thermometers may be easily read to ·025°C. We understand

that the compensation winding to which we alluded, and which we much prefer to the device referred to by our correspondent, costs about 10s. extra.—Ed. *E.*]

## "SHAKING THE FOUNDATION OF SCIENCE."

TO THE EDITOR OF THE ELECTRICIAN.

Sir: My attention has been drawn to the article in *Nature* under the above title, and, as it presents to your readers the proposed South Kensington and Paddington Subway, in an aspect which the writer erroneously describes as "the hosts of Mammon threatening the domains of science," I feel sanguine that a scientific journal such as yours will be even more than ordinarily desirous to have the correct view set before them.

The writer appears to ignore the fact that the rectangular area bounded by Kensington, Cromwell, Exhibition, and Prince Albert (now Queen's-gate) roads forms part of the estate purchased out of the surplus funds of the Great Exhibition of 1851, and vested in a body of Commissioners by Royal Charter; and that this land was originally destined, to use the words of the late Prince Consort, "at no distant day to form the inner court of a vast quadrangle of public buildings rendered easily accessible by the broad roads which surround them, buildings where Science and Art may find space for development, with the air and light which are elsewhere well nigh banished from this overgrown Metropolis." The site of the Exhibition of 1862, and of the buildings of the South Kensington and Science and Art Departments, originally formed part of that estate. When the Royal Albert Hall was first projected, a pneumatic railway from it to the South Kensington Station, *viâ* Exhibition road, formed part of the original scheme, which was promoted by the Commissioners who own the estate, and the paramount necessity of such a means of communication has never been lost sight of. When the existing subway was constructed in 1885 its continuance as far as the Albert Hall was a recognised part of the project, and the route alongside of the Eastern Arcades was then decided upon by the Commissioners. When the District Railway Company obtained their Act of Parliament for the subway its use with traction was sanctioned.

The proposal now before Parliament is for absolutely no more and no less, so far as the estate of the Commissioners of 1851 is concerned, than the completion of that subway, with nearly its present form and dimensions, and with almost the same powers to use it in the same way. All attempts hitherto made to complete the work as far as the Albert Hall have failed, and the existing incomplete portion of the subway is practically closed, and is a dead loss financially.

At last a practical solution of the difficulty has been found, with the additional advantage that, besides the means of covered access being afforded from South Kensington Station through the length of the estate, easy and rapid communication will also be afforded to hundreds of thousands of persons living to the north of Hyde Park to visit and use all the great institutions collected at South Kensington, to which covered access will thus further be secured from all parts of the Metropolis.

In his eagerness to prove that the present means of access are all that can be desired, your contributor refers to the congregations of visitors attracted by former Exhibitions. The steady annual decline in the records of the numbers of visitors to the permanent institutions is not the only evidence which utterly refutes such a misleading line of argument.

I do not dispute for one moment that Urania must have her quiet retreats, secluded from the movements and throng of men and vehicles, and it is hardly surprising that, as your contributor states, the repose she loves cannot even now be found at South Kensington. But it is pure affectation to contend that the interests of the highest scientific education for the many will suffer because laboratories and observatories for original research used for the instruction of a very few experts may have to find a home elsewhere. If the vibration caused by omnibuses by day and market carts by night, passing at each end of Exhibition-road in the Kensington and Cromwell-roads (to say nothing of "small and earlies") are found already to affect the ultra-sensitive nerves of Urania, the question may be asked why the Professors continue to countenance the expenditure of the "vast sums" mentioned by your contributor, and also if it is right that any more public money should be allowed to be spent in a way which experience has already shown to be injudicious.

It appears, therefore, evident that the degree to which the traffic in the proposed subway might augment this inconvenience does not affect the true merits of the case as set up by your contributor.—Yours, &c.,

C. E. Webber, Major-General.

## ELECTRICAL TREATMENT OF SEWAGE.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I have read with interest the criticisms on Webster's System of Sewage Treatment; *first*, because I am intimately connected with the Electrical Company formed for the purpose of verifying and demonstrating the practical application of the process, and, *secondly*, it was I who, owing to Mr. Webster's ill-health, was asked at the eleventh hour, and who consented, to read Mr. Webster's paper, which has given rise to the present discussion.

As stated by Mr. Webster in his paper, a searching investigation has been made this year by the Corporation of Salford, on a working scale, as to the merits of various processes of sewage treatment, including the Electrical. I personally followed the electrical trials throughout, which, as well as the other processes, were independently controlled by several engineers and chemists representing the Salford authorities. Until the joint report of these gentlemen is issued it is, in my opinion, premature to reply to the various points raised, as such report, being from independent sources, will necessarily carry more weight than anything I can say.

I may, however, state it is the intention of myself, and of all those directly interested in the electrical process, that there should be no concealment of any fact in connection with it. The original reports of chemists and others who have examined the process from the date of practical working on London sewage and up to the present time will be open to inspection by all scientific men, so that those capable of reading between the lines may see that everything is fair and above board. I personally undertake that the fullest details in possession of the company, both as to chemical results, cost, and practical every-day working, shall at the earliest possible moment be put at the disposal of the scientific public: the fullest criticism will be welcome.

I think there will be no difficulty in satisfying your correspondent, Mr. Ed. C. de Segundo, on any of the questions raised by him, even that of simplicity. He will, I hope, pardon me for saying that he has gone outside the heading of his letter, "*Electrical* Treatment of Sewage," to give the palm to the "International" Company. Doubtless the "International" and other companies will, as well as the Electrical, eagerly seize the opportunity of submitting with the Salford report the fullest details of practical working wherever the respective systems may have been tested.—I am, &c., F. G. Worth.

Whitehall Club, Parliament-street, S.W.,
December 23, 1890.

## COMPOUND DYNAMOS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In your issue of this week, under the head of Notes, you remark with regard to the City and South London Railway that owing to the dynamos being used as simple shunt machines, variations in the main current produce an awkward variation in the light in the carriages. May I be allowed to draw attention to a point which I have sometimes found occasion considerable annoyance to users of large compound machines; it is the excessive sluggishness of the compounding which one gets when large masses of iron are employed in the magnets, due to Foucault currents and self-induction. In machines with magnets of about three square feet in section the series turns sometimes require as much as half a minute to complete their work after a considerable variation in the main current. It remains to be seen whether this effect will cause trouble in the case of

Digitized by Google

the City and South London Railway, when the series turns on the magnets of the dynamos are used. I enclose a few curves which may be of interest as helping to illustrate the lag of induction through the armature of a dynamo behind the exciting current in the field circuit. The experiments refer to a compound dynamo with magnets 20in. by 8in. in section (unfortunately somewhat small). Figs. 1 and 2 illustrate

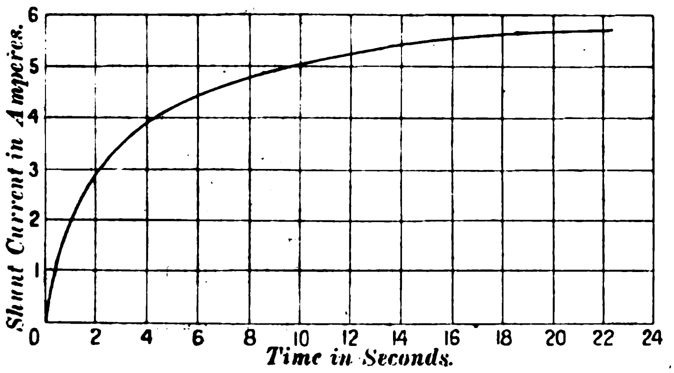



Fig. 1.

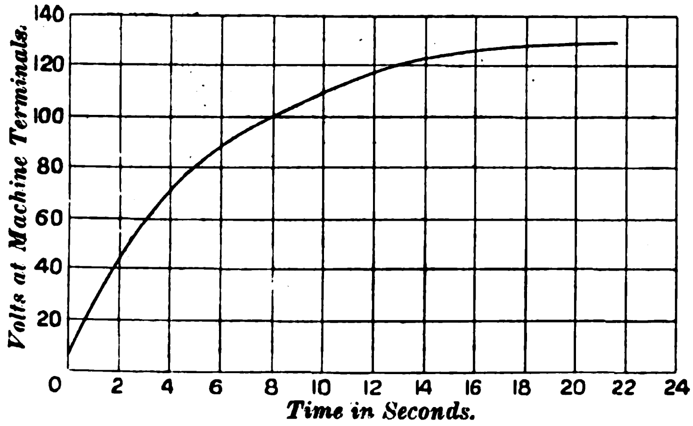



Fig. 2.

the rise of current in the exciting circuit, and the rise of potential difference at the terminals of the machine respectively, when running on open circuit at constant speed, the shunt circuit then being suddenly switched on to mains at a potential difference of 130 volts. A comparison of the ordinates of these two curves at the same instant gives us a third curve which will

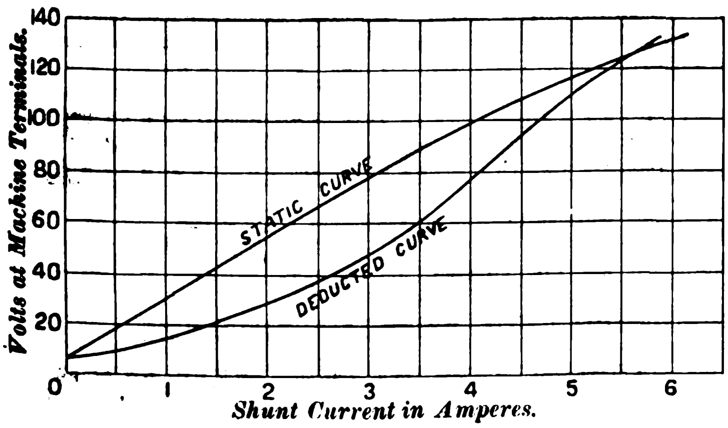



Fig. 3.

represent to a certain scale the variation of the induction through the armature, with the exciting current producing it.

In Fig. 3 this curve, with varying current, is compared with a similar one taken with a steady magnetising current, a considerable interval being given between each reading to allow the magnetism to settle.

The voltmeter used was one made by Messrs. Siemens, known as Type No. 3, having a resistance of 1878·12ω at 18° C., and an ordinary electro-dynamometer was used in the shunt circuit to measure the current, both instruments being zero instruments. Curves like those given may readily be obtained by means of a good stop-watch and zero instruments by noting the time that elapses between the closing of the switch and the crossing of the zero by the index, a certain torque having been previously placed upon the torsion head, after which the circuit is broken, the torsion on the heads of the instruments varied, and the operation repeated. In the case of large magnets a short-circuiting switch should be provided to avoid the stress which would otherwise be placed upon the insulation of the shunt coils at the moment of breaking the circuit between each reading. The value of L for the voltmeter was measured with various currents by my alt-current method, published in *The Electrician*, No. 632, Vol. XXV., and checked by Lord Rayleigh's bridge test. The average value was found to be 1·05 henrys, corresponding to a time constant of ·00053 secs., the correction for which, upon the potential difference curve it was thought might be neglected.—Yours truly, William Brew.

British Museum, Electric Light Department,
December 20, 1890.

## DRUM WINDING.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I notice in your issue of December 19, in the article by Mr. F. M. Weymouth on armature windings, that the spiral end winding is attributed to a person in the employ of Messrs. Latimer, Clark, Muirhead and Co.

This system of end winding was claimed and described in my patent, A.D. 1884, November 7th, No. 14,723. It has been almost exclusively used for my Turbo-electric generators, of which some 5,000 horse-power are now in use; and, so far as I know, has not been described or used elsewhere.

I have no doubt that you will be pleased to have this small correction made. Thanking you in anticipation.—Yours, &c.,

Charles A. Parsons.

Heaton Works, Newcastle-on-Tyne, December 26, 1890.

[We may mention that a Mr. A. J. White, of Newcastle, wrote us a few days ago stating that he was the young *employé* alluded to by Mr. Weymouth. We should be glad to hear from him as to the date of his invention.—Ed. *E.*]

## TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

Plant for Sale.—We call our readers' attention to the particulars of several lots of first-class electrical plant, &c., for sale by Messrs. Wheatley Kirk, Price and Goulty, and others.

Great Fire in the City.—Amongst the firms whose premises have been seriously injured by the great fire which occurred on Tuesday last in Queen Victoria-street, E.C., were Messrs. Davey, Paxman, and Co., and the Rossendale Belting Company, but we understand that in neither case will business be interfered with.

Church Lighting. — Emmanuel Church, Maida-hill, is being wired for the electric light by Messrs. Laing, Wharton, and Down, under the direction of Mr. A. E. Gosset-Tanner.

Messrs. Arthur B. Gill and Co.—We are in receipt of this firm's price list of shades, globes, and reflectors for incandescence lamps.

Paterson and Cooper.—During the whole of the year, Messrs. Paterson and Cooper have been busy, and have carried out a large number of ship lighting installations. A larger number of dynamos has been turned out than in any previous year, and the sizes have all round averaged larger. In the instrument and fittings department trade has also been good, a new alternating current arc lamp has been designed. The prospects for the new year are very encouraging.

Messrs. J. H. Holmes and Company.—This firm state that they have been kept extremely busy throughout the year, their output

in dynamos being about double that of any previous year. The demand for their machines has increased so rapidly that, although the works have been doubled in size during the year, the firm have been obliged to decline some urgent orders. Messrs. Holmes have also completed 66 installations of electric light in mills, factories, residences, steamships, &c.

Messrs. Drake and Gorham.—The increase of business during the past year has been so marked that Messrs. Drake and Gorham state they have been compelled to make constant additions to their staff, and to extend their offices and stores. The number of installations carried out has exceeded the record of any previous year. Amongst the more important installations are the new police buildings and the exhibition at Madame Tussauds. During the year the Cardew Earthing Device has been adapted by the London Electric Supply Company, the Newcastle Company, and Metropolitan Electric Supply Company. Messrs Drake and Gorham have made arrangements for driving the printing machinery at New Scotland-yard by means of electricity.

The Electrical Accessories Company.—This Company has been during the past year engaged in completing its standard patterns of switches, &c., in which departments they record a busy trade. We understand that further capital will shortly be raised, and that it is contemplated taking larger manufacturing premises.

Poole and White's Logarithm Table.—It is an indication of the scientific character of the electrical trade, that one of the leading firms for electrical supplies should consider that a neatly-bound table of logarithms is a suitable article for issue at Christmas. The table is mounted on strong linen, and is about 12in. by 8in. Above it is a good list of constants and coefficients, and in a lower corner a sheet of celluloid, on which pencil calculations may be made and effaced. The logarithms are four figure, with differences, arranged in accordance with Mr. Bottomley's well-known plan. The table, which is excellently printed and got up and folds in a leather binding, will be appreciated by all engineers, whether electrical or using slide rules or otherwise.

Postal Reductions and Extensions.—The postage to be prepaid on letters to India and the British Colonies in Asia, Australasia, South and West Africa, and the West Indies is now at the rate of 2½d. per ½oz., instead of 5d. as formerly. The reduced postage is applicable to all routes, except in the case of the Cape and Natal. The rate for postcards to Australasia, New Zealand, Fiji, and British New Guinea is 2d. British North Borneo has now entered the Postal Union. The letter rate will be 2½d. per ½oz. ; postcards, *viâ* Brindisi, 2d., and by French packet, 1½d. ; newspapers, 1½d. per 4oz. Postcards may now be sent to Natal either by the sea route or *viâ* Lisbon, the postage being 1½d. per card by the sea route and 2d. *viâ* Lisbon.

## BOOKS, &c., RECEIVED.

"The School of Mines Quarterly." No. 1, Vol. XII. (Columbia College, New York.)

"Fortschritte der Elektrotecknik." By Dr. Karl Strecker. (Berlin : Julius Springer.)

## PATENT RECORD.

### APPLICATIONS FOR PATENTS.

December 12, 1890.

20,289. T. D. Bottome, Hoosick, New York. Improvements in and relating to the manufacture of insulating compositions for electrical uses.

20,294. M. Sutherland and A. J. McGeoch. London. Improvements in junctions for electric conductors.

20,307. C. G. Dahlgren and J. H. Svensson. London. Improvements in electrical switches.

20,321. O. H. Stovell. London. Improvements in the lighting of tables and the like by electricity.

20,329. A. B. Woakes. London. Improvements in and relating to transformers for electric currents.

20,332. S. Hargreaves and R. J. Bott. London. A combined arrangement of switches and gearing for controlling any number of dynamos and engines from one or more fixed positions.

### SPECIFICATIONS PUBLISHED.

1889.

13,389. Harper. Electro-magnets for arc lamps. (Price 8d.)

19,450. Leblanc. Electro motor, (Price 8d.)

20,022. Wilson. Electric switch. (Price 8d.)

1890.

1,026. Boult. Automatic accumulator switches. (Price 8d.)

1,302. Trotter. Facilitating calculations relating to supply of electrical energy. (Price 8d.)

1,629. Boult (Wm. Giovanni). Electric accumulators.

7,094. Upward. Applying electrical energy for advertisements. (Price 4d.)

9,956. Kennedy. Heating by electricity. (Price 8d.)

11,480. Thomson. Dynamo electric machines and electro motors. (Price 8d.)

12,221. Lake, (Weston). Measuring electrical energy. (Price 6d.)

14,548. Wiegand. Telegraphing and telephoning. (Price 8d.)

15,741. Douse. Electric fire indicator. (Price 8d.)

17,327. Miller. Electric meter. (Price 6d.)

## COMPANIES' MEETINGS.

### Elmore's Foreign and Colonial Patent Copper Depositing Company (Limited).

The first annual general meeting of this Company was held on Monday, at the offices, 64, Cannon-street, under the presidency of Sir John Morris, K.C.S.I.

The SECRETARY (Mr. J. Shurmer) having read the notice convening the meeting,

The CHAIRMAN said that they were met to transact the ordinary business of the Company, which, on this occasion, was merely to approve and pass the accounts and to re-elect the retiring directors and auditors.

PATENT
SILICIUM BRONZE AND SILICIUM COPPER WIRE.
The best for overhead Telephone and Telegraph Lines,
AND ALL ELECTRICAL PURPOSES.
Hard Drawn High Conductivity Copper Wire.
ROLLED AND DRAWN PHOSPHOR BRONZE.
PHOSPHOR BRONZE — VULCAN — PHOSPHOR — DURO METAL
PHOSPHOR BRONZE BEARINGS, BUSHES, AND OTHER PARTS OF ELECTRICAL MACHINERY
SOLE PROPRIETORS of the British, Indian and Colonial Patents,
THE PHOSPHOR BRONZE COMPANY (Limited),
87, Sumner Street, Southwark, London, S.E.
WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

Digitized by Google

They had not issued any report; because, in the period embraced in the accounts, there had been little or no business done. The purpose for which this Company was formed was to dispose of their foreign patents. They had nothing to do with the working of the process. They had only to sell their patents to foreign countries. Therefore, in the period covered by the accounts, namely, from June 6, 1889, to March 31, 1890, nothing of importance had been done. He did not mean to say that they had been idle. Negotiations were carried on with several parties for the sale of the patents, but in consequence of the undeveloped state of the process, they could get no specific offers. They would recollect that he told them at the statutory meeting that they were prepared to enter into negotiations, but that they wanted specific offers which, when they came to negotiate, they found they could not get on account of their process not being sufficiently proved, and also because they were not ready to let people go over the English Company's works—which the Directors did not think were then sufficiently advanced to warrant their doing so. Such negotiations as were carried on up to March 31st accordingly fell through. There were, therefore, no sales made, a circumstance which would explain why there was little or nothing on the credit side of the accounts. They had simply an amount of interest, and a small amount of transfer fees. On the expenditure side there were the ordinary items of office expenses, salaries, wages, and Directors' fees. The only two large sums which he need notice were those of salaries and Directors, fees, which were strictly in accordance with the Articles of Association. As for the patent charges, they were fixed, and could not be modified. He might mention that the accounts, if passed now, would be again brought up before them in January, and would be embodied with those which they proposed to submit, taking them up to the end of the year. He concluded by moving a resolution approving of the accounts as submitted.

Mr. JOHN MACFARLAN seconded the motion, which was passed unanimously.

The retiring Directors, Messrs. E. J. Carson, J. J. Atkinson, and John T. Cooper were afterwards re-elected, as were also the auditors, Messrs. Pixley and Co.

The CHAIRMAN then proposed a resolution altering the date to which the statement of accounts should be made up, namely, to December 31. He explained that the reason for this was that they had carried through some important sales of the patents of the Company, and as they all knew they had paid an interim dividend of £4 per share on the priorities, they were, therefore, naturally anxious to lay before the shareholders a full account of what they had been doing during the nine months which had relapsed since March 31st.

Mr. EWEN seconded the resolution, which was agreed to *nem. con.*, and the proceedings terminated with a vote of thanks to the Chairman and Directors and Staff.

## NEW COMPANIES REGISTERED.

**JOHN DONALD (LIMITED).**—Registered in Scotland by Paul and Macfarlan, writers, Glasgow. This Company has a capital of £20,000 in £10 shares. Object: to carry on in the United Kingdom and elsewhere the business of iron merchants, engineers, boiler-makers, shipbuilders, ironfounders, and general contractors, and any other trade and business arising out of or incidental thereto.

**THE SAMPAN PATENT RAILWAY SLEEPER AND STEEL PLANT SYNDICATE (LIMITED).**—Registered by R. Jordan, 120, Chancery-lane, with a capital of £10,000 in £50 shares. Object: to carry on the business of mechanical engineers, manufacturing machine and engine tool makers, iron, brass, and metal founders, &c., &c.

**NEW ZEALAND ELECTRICAL SYNDICATE (LIMITED).**—Registered by Reyroux, Phillips and Golding, 99, Cannon-street, E.C., with a capital of £30,000 in £10 shares. Object: to acquire charters, concessions, privileges and other grants for the manufacture and employment of electric lighting, &c., in New Zealand, Victoria, New South Wales, North, South, or Western Australia, Tasmania, New Guinea, and the Fiji Islands, and particularly to acquire the central stations for the supply of electricity erected by the Gulcher (New) Electric Light and Power Company (Limited), in the city of Wellington, New Zealand. The first subscribers are:—

| | Shares. |
|---|---|
| D. de Castro, 6, New-square, Lincoln's-inn | 1 |
| W. Turnbull, Mount Hanley, Sydenham | 1 |
| R. Pryor, 79, Gracechurch-street, E.C. | 1 |
| M. S. Vanderbyl, 187, Queen's-gate, S.W. | 1 |
| H. Grëwing, 14, Austinfriars | 1 |
| J. Alexander, 3, Great Winchester-street | 1 |
| W. Farmer, 48, Aldermanbury | 1 |

There shall not be less than three nor more than seven Directors. The first are D. de Castro, H. Grëwing, M. S. Vanderbyl, and J. E. Williams. Qualification and remuneration not specified.

## CITY NOTES, &c.

**BRAZILIAN SUBMARINE TELEGRAPH COMPANY.**—The receipts of this Company for the week ending December 26th amounted to £4,441.

**W. T. HENLEY'S TELEGRAPH WORKS COMPANY (LIMITED).**—At the meeting of this Company, which was held on the 19th ult., the Chairman, in the course of his remarks, stated that the business for the year 1889 had been far more successful than any previous year in the history of the Company, and that the present year (1890) showed a very considerable improvement upon 1889. The business carried out successfully included the manufacture and laying of the Halifax and Bermudas cables, 850 nautical miles, by the ss. "Westmeath," and the construction of over 1,000 miles of submarine telegraph cable to be laid in the West Indies, and on the coast of South America, news having been just received of the successful completion of the laying of these cables by the ss. "Westmeath." The machinery for the manufacture of the miscellaneous products of the Company, which included all descriptions of wires and cables for electric lighting, telephony, &c., had been fully employed.

**SPIEL'S PETROLEUM ENGINE COMPANY (LIMITED).**—At the annual meeting held on Wednesday, the Chairman, Mr. D. W. Forbes, said that the Directors were in negotiation with a firm of very high standing for the manufacture of their engines in the place of the late Mr. Clarke, and if they were successful in treating with them, there was no doubt of the Company becoming very prosperous. The Directors' report and accounts were adopted.

**STOCK EXCHANGE.**—Applications have been made to the committee to appoint a special settling day in the shares and debentures of the Venezuela Telephone and Electrical Appliances Company (Limited), and to allow the shares of Elmore's French Patent Copper-Depositing Company (Limited) to be quoted in the Official List.

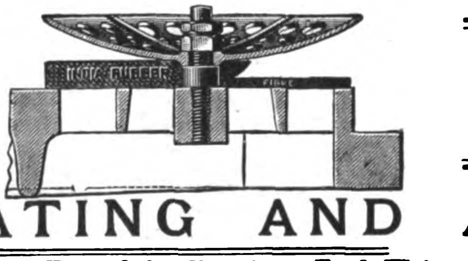
**WESTERN AND BRAZILIAN TELEGRAPH COMPANY.**—The traffic receipts of this Company for the week ending December 26, 1890, after deducting the "fifth" of the gross receipts payable to the London Platino-Brasilian Telegraph Company (Limited), were £3,453.

**THE WESTINGHOUSE ELECTRIC COMPANY.**—A special despatch from Pittsburg of December 10th says:—"The committee of local bankers recently appointed to investigate the financial standing of the Westinghouse Electric Company finished its labours to-day. Its report is understood to be favourable. The committee determined that the electric company stocks are worth over $25 per share, and decided to advance the $500,000 recently requested by Mr. Westinghouse, on condition that the parties making the loan have the privilege of naming the general manager for the company.

**WHITE'S ASBESTOS (LIMITED).**—A meeting of this Company was held on Tuesday at Winchester House, Mr. J. H. Hamilton presiding. After a long discussion upon the unsatisfactory condition of the Company, a committee of shareholders was appointed to confer with the Directors, and investigate the affairs of the Company.


NEW VALVE

No Rubber, Percha, or Leather.



One-half the price of Rubber or Metal.

FOR CIRCULATING AND AIR PUMPS.

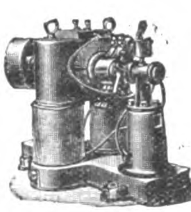
Unaffected by any Lubricating Oils. Does not Expand in diameter. Feed Water may be worked at any temperature Suitable for any shaped guards. Only one quality manufactured.

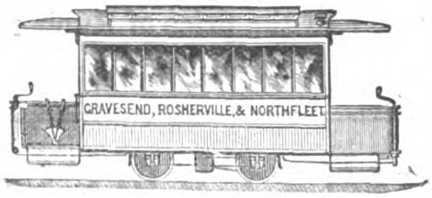
"12, John-street, Sunderland, 26th Sept. 1885.
"DEAR SIRS,—In reply to your letter of the 25th inst., the Valves I got from you have done their work well, and ARE AN UNQUALIFIED SUCCESS. I will continue to get them from you as required.—Yours faithfully, JAMES WESTOLL."

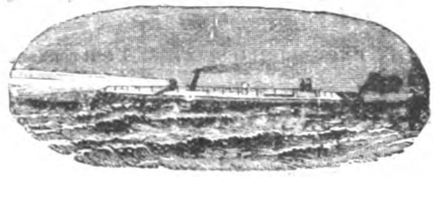
For further Testimony and Prices, apply to MOSSES & MITCHELL, 68-71, Chiswell Street, London.

# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name. | Previous Week's Price, Dec. 22. | | Price Wednesday, Dec. 31. | | Rate per Cent. Yielded. | Dividend Due. | Business Done During Week Ending Dec. 31. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | £ s. d. | | Highest. | Lowest. |
| | | | **TELEGRAPHS.** | | | | | | | | |
| £1,381,380 | Stock | 15/0 | Anglo-American | 48½ | 49½ | 48½ | 49½ | 5 16 2 | Jan., Apr., July, Oct | .. | .. |
| £ ,809,310 | Stock | 30/0 | Do. Preferred | 84½ | 85½ | 84½ | 85½ | 6 11 6 | ,, ,, | 85¼ | .. |
| £ ,809,310 | Stock | .. | Do. Deferred | 13¼ | 13¾ | 13¼ | 13¾ | .. | .. | 13¾ | .. |
| £25 ,000 | £100 | 4% | African Direct, 4 per Cent. Debentures | 98 | 101 | 98 | 101 | 3 19 3 | January and July .. | .. | .. |
| £ 30, 00 | 10 | 6/0 | Brazilian Submarine xd | 11¼ | 11¾ | 11 | 11½ | 6 10 5 | Mar., June, Oct., Dec. | 11⅛ | .. |
| £84, 00 | 100 | 5% | Do. 5 per Cent. Bonds | 101 | 103 | 101 | 103 | 4 17 1 | January and July .. | .. | .. |
| £ , 0 | 100 | 5% | Do. 5 per Cent. Bonds (2nd Series, 100 ) xd | 104 | 108 | 102 | 106 | 4 14 4 | June and December | .. | .. |
| $7,216,0 0 | $100 | $1½ | Commercial Cables xd | 104 | 106 | 102 | 104 | 5 15 5 | April and October .. | .. | .. |
| £16,000 | £10 | 8/0 | Cuba Submarine | 11½ | 12 | 11½ | 12 | 7 1 8 | February and August | .. | .. |
| £3,000 | 10 | 10% | Do. Preference 10% | 17 | 18 | 17 | 18 | 5 11 1 | ,, ,, | 17¼ | 17⅛ |
| £ 2,931 | 5 | 2/4¾ | Direct Spanish (£4 paid) | 3¾ | 4¼ | 3¾ | 4¼ | 5 12 11 | April and October .. | .. | .. |
| £3,000 | 5 | 10% | Do. Preference 10% | 9 | 10 | 9 | 10 | 5 0 0 | ,, ,, | .. | .. |
| £30,710 | 20 | 3/6 | Direct United States | 10¼ | 10⅝ | 10¼ | 10⅝ | 6 15 0 | Jan., Apr., July, Oct. | 10⅝ | 10 1/16 |
| £100,000 | 10 | 2/6 | Eastern | 13⅜ | 14⅛ | 13¾ | 14½ | 4 12 0 | ,, ,, | 14⅛ | 13⅜ |
| £70,000 | 10 | 6% | Do. 6 per Cent. Preference | 14¼ | 15¼ | 14¾ | 15¼ | 3 18 8 | ,, ,, | .. | .. |
| £ ,200,000 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock | 104 | 107 | 104 | 107 | 3 14 9 | May and November | .. | .. |
| £200,000 | £100 | 5% | Do. 5 per Cent Debentures, 1899 | 106 | 109 | 106 | 109 | 4 11 9 | February & August | .. | .. |
| £250,000 | 10 | 2/6 | Eastern Extension | 14 | 14¼ | 14 | 14¼ | 4 18 3 | Jan., Apr., July, Oct. | 14¼ | 14 1/16 |
| £320,000 | 100 | 6% | Do. 6 per Cent. Debentures, 1891 | 101 | 103 | 101 | 103 | 5 16 6 | February & August | .. | .. |
| £91,800 | 100 | 5% | Do. 5 p. c. (Aust'n. Gov. Sub.) Debs. 1900 | 103 | 106 | 104 | 107 | 4 13 6 | January and July .. | 106 | .. |
| £145,300 | 100 | 5% | Eastern & S. African 5 per Cent. Mor Deb., 1900 | 102 | 105 | 103 | 106 | 4 14 4 | ,, ,, | .. | .. |
| £180,227 | 10 | 1/9 | Globe Telegraph and Trust | 8¾ | 9 | 8¾ | 9 | 5 8 4 | Jan., Apr., July, Oct. | 8 13/16 | 8⅝ |
| £180,042 | 10 | 6% | Do. 6 per Cent. Preference | 14½ | 14¾ | 14½ | 14¾ | 4 1 4 | ,, ,, | 14⅝ | .. |
| £150,000 | 10 | 5/0 | Great Northern | 16 | 16½ | 16 | 16½ | 4 10 11 | Jan., April, and July | 16⅛ | .. |
| £15,000 | 100 | 5% | Do. 5 per Cent Debentures, 1881 | 101 | 104 | 101 | 104 | 4 16 2 | January and July .. | .. | .. |
| £ 30,000 | 100 | 5% | Do. 5 per Cent. Debentures, 1883 | 104 | 107 | 104 | 107 | 4 13 6 | March & September | .. | .. |
| £17,000 | 25 | 12/6 | Indo-European | 35 | 37 | 35 | 37 | 6 15 2 | May and November | .. | .. |
| £38,248 | 10 | 4/0 | London Platino-Brazilian | 6 | 7 | 6 | 7 | 5 14 4 | ,, ,, | .. | .. |
| £100,000 | 100 | 6% | Do. 6 per Cent. Debentures | 106 | 109 | 107 | 110 | 5 9 1 | March & September | .. | .. |
| £ ,000 | 8 | 4/0 | Reuter's | 8½ | 9 | 8½ | 9 | 5 11 1 | April and October .. | .. | .. |
| £3,381 | £100 Cert | 6% | Submarine Cables Trust | 108 | 112 | 110 | 114 | 5 5 3 | ,, ,, | .. | .. |
| £15,609 | £10 | 6/6 | West African xd | 8½ | 9½ | 8 | 9 | 5 11 1 | January and July .. | .. | .. |
| £290,000 | 100 | 5% | Do. 5 per Cent. Debentures | 98 | 101 | 98 | 101 | 4 19 0 | March & September | .. | .. |
| £30,000 | 10 | 3/0 | West Coast of America | 2 | 4 | 2 | 4 | .. | January and July .. | .. | .. |
| £150,000 | 100 | 8% | Do. Debentures 8% xd | 100 | 105 | 97 | 102 | .. | June and December | .. | .. |
| £38,321 | 10 | Nil. | West India and Panama | 2⅞ | 3⅜ | 2¾ | 3 | .. | .. | 2⅞ | .. |
| £34,563 | 10 | 6/0 | Do. 1st Preference 6% | 11¼ | 11¾ | 11¼ | 11¾ | 5 2 2 | May and November | 11 11/16 | 11⅝ |
| £4,669 | 10 | £1 | Do. 6 p. c. 2nd Pref. | 10½ | 11½ | 11 | 12 | 5 0 0 | ,, ,, | .. | .. |
| £34,174 | 15 | 6/0 | Western and Brazilian | 10¾ | 11¼ | 10¾ | 11¼ | 5 6 8 | ,, ,, | 11 | 10⅞ |
| £27,873 | 7½ | 6/0 | Do. 5 per Cent. Cumulative Preferred | 6¼ | 6¾ | 6¼ | 6¾ | .. | — | .. | .. |
| £27,873 | 7½ | 4/6 | Do. 5 per Cent. Deferred | 4½ | 5 | 4½ | 5 | .. | .. | .. | .. |
| £200,000 | 100 | 6% | Do. 6 per Cent. Debs., Series "A" | 103 | 106 | 103 | 106 | 5 13 2 | February & August | .. | .. |
| £250,000 | 100 | 6% | Do. 6 per Cent. Mort. Debs., Series "B" | 103 | 106 | 103 | 106 | 5 13 2 | ,, ,, | .. | .. |
| $1,336,000 | $1,000 | 7% | Western Union 7 per Cent. 1st Mortgage | 120 | 125 | 120 | 125 | 5 12 0 | May and November | .. | .. |
| £175,100 | £100 | 6% | Do. 6 per Cent. Sterling Bonds | 99 | 103 | 99 | 103 | 5 16 0 | March & September | .. | .. |
| | | | **TELEPHONES.** | | | | | | | | |
| £224,850 | 14/0 | 0/1½ | Consolidated Telephone Const. & Maintenance. .. | ½ | ⅝ | 7/16 | 9/16 | .. | May and November | .. | .. |
| £220,000 | £1 | 3% | Oriental (11s. paid) | ¼ | ⅜ | ¼ | ⅜ | 4 8 3 | Yearly .......... | .. | .. |
| £138,984 | 5 | 3/0 | National | 4⅜ | 4⅝ | 4⅜ | 4⅝ | 5 18 11 | June and December | 4⅝ | .. |
| £15,000 | 10 | 6/0 | Do. 6 per Cent. Cumulative 1st Pref. | 12 | 12½ | 12 | 12½ | 4 16 0 | ,, ,, | .. | .. |
| £15,000 | 10 | 4/9⅗ | Do. 6 per Cent. Cumulative 2nd Pref (£8 pd) .. | 9¾ | 10¼ | 9¾ | 10¼ | 5 17 1 | ,, ,, | .. | .. |
| £209,750 | 1 | ½% | South of England, Ordinary | ⅛ | ⅜ | ⅛ | ⅜ | .. | .. | .. | .. |
| £20,000 | 5 | 2/1 | Do. 6 per Cent. Cumulative Pf. (£3 10s. pd) .. | 2½ | 3 | 2½ | 3 | .. | .. | .. | .. |
| £58,000 | 5 | 1/0 | United River Plate | 3 | 4 | 3 | 4 | .. | January and July .. | .. | .. |
| £146,128 | Stock | 5% | Do. 5 per Cent. Debenture Stock xd | 90 | 95 | 90 | 95 | 5 5 3 | .. | .. | .. |
| £3,200 | 100 | 7% | Do. 7 per Cent. Debentures | .. | | .. | | .. | .. | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | | | |
| £200,000 | £5 | .. | London Electric Supply | 1¾ | 2 | 1¾ | 2 | .. | .. | .. | .. |
| £43,900 | 10 | .. | Metropolitan Electric Supply (£8 paid) | 7½ | 8 | 7½ | 8 | .. | .. | 7 11/16 | 7½ |
| £12,853 | 5 | .. | Westminster Electric Supply (£3 paid) | 2½ | 3 | 2½ | 3 | .. | .. | 2¾ | 2½ |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | | | |
| £63,416 | 3 | .. | Brush Electrical Engineering | 1¼ | 1¾ | 1¼ | 1¾ | .. | .. | .. | .. |
| £63,416 | 2 | 0/10 | Do. 6 per Cent. Preference | 1½ | 2 | 1½ | 2 | 6 0 0 | June and December | .. | .. |
| £20,000 | 5 | 7% | Crompton and Co, 7 per Cent. Pref. Shares | 5½ | 5¾ | 5 | 5½ | 6 7 3 | January and July .. | .. | .. |
| £17,139 | 5 | .. | Edison and Swan United | .. | | .. | | .. | .. | .. | .. |
| £45,000 | 10 | 6% | Electric Construction | 7 | 7½ | 7 | 7½ | 8 0 0 | .. | 7½ | 7⅜ |
| £70,000 | 2 | 10/0 | Elmore's Patent Copper Depositing | 4¼ | 4¾ | 3¾ | 4¼ | .. | .. | 4¼ | 4 |
| £20,000 | 5 | .. | Fowler-Waring Cables (£4 paid) | 2½ | 3½ | 2½ | 3½ | .. | .. | .. | .. |
| £41,600 | 10 | 10/0 | India Rubber, Gutta Percha & Telegraph Works | 18½ | 19½ | 18½ | 19½ | 5 2 7 | February & August | .. | .. |
| £200,000 | 100 | 4½% | Do. 4½ per Cent. Debentures, 1896 | 100 | 102 | 100 | 102 | 4 8 3 | March & September | .. | .. |
| £11,331 | £10 | .. | International Okonite, Ordinary | .. | | 9½ | 10 | .. | .. | .. | .. |
| £11,334 | £10 | .. | Do. Preference | .. | | 9½ | 10 | .. | .. | .. | .. |
| £78,949 | 5 | 10% | Swan United (£3. 10s. paid) ..10% for year | 4½ | 5 | 4½ | 5 | 6 19 10 | May and November | 4⅞ | .. |
| £37,350 | 12 | 12/0 | Telegraph Construction and Maintenance | 43 | 45 | 43 | 45 | 5 6 8 | March and July..... | .. | .. |
| £150,000 | 100 | 5% | Do. 5 per Cent. Bonds, red. 1894 | 100 | 102 | 100 | 102 | 4 18 0 | January and July .. | .. | .. |



# BEFORE ORDERING!

## ELECTRICAL PLANT & ACCESSORIES

(Statter's) WRITE FOR THE FOLLOWING PAMPHLETS TO THE (United)

## ELECTRICAL ENGINEERING CORPORATION, Ld.

PLANT WORKS: WEST DRAYTON, near LONDON.
FITTINGS WORKS: ALBERT WORKS, 36, ALBERT EMBANKMENT, S.E.
LONDON OFFICES: 3, PRINCES MANSIONS, VICTORIA STREET, WESTMINSTER.

"ELECTRICAL DISTRIBUTION."—Commercially considered, with Estimates.
"MACHINE DRIVING BY ELECTRICITY."—The Uses of Electro-Motors for Traction and Stationary Purposes.
"THE TELPHER SYSTEM OF CHEAP TRANSPORT," for Minerals, Goods and Passengers.
"ELECTRICAL SUPPLIES."—Prices and Particulars of the most approved Electrical Appliances

ELECTRICAL PLANT ON VIEW.


Digitized by Google

# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 660.—Vol. XXVI. FRIDAY, JANUARY 9, 1891. Price Fourpence.

## NOTES.

Under the Public Health Acts (Amendment) Act of 1890 an Urban Authority may from time to time make bye-laws for the prevention of danger or obstruction to the public by overhead wires. By such bye-laws provisions may be made for the inspection and examination of posts, wires, &c., by the Urban Authority, who may prohibit any work that is dangerous or causes obstruction to the public. Such bye-laws have to be submitted to and confirmed by the Board of Trade, who may modify or disallow them. So far as we are aware no such bye-laws have yet been made since those of Bradford, and the proposed Liverpool rules are of a far more comprehensive nature. The overhead wire rules issued by the Board of Trade two years ago professed to be "for the protection of the public safety and of the electric lines and works of the Postmaster-General." These were subsequently incorporated in the second set of rules (*Electrician*, Vol. XXV., p. 466), which were issued in August last, "for securing the safety of the public, and for ensuring a proper and sufficient supply of electrical energy." The bye-laws which the Urban Authorities are invited to make are not intended to deal with the efficiency of supply, with the maintenance of standard volts, the detection and removal of leaks, or indeed with anything but overhead conductors. The need of a double set of regulations is not, therefore, very apparent. The Board of Trade rules are excellently drawn up, save in one or two points, to which we have on former occasions alluded, and it would seem that it is only under peculiar conditions arising out of local circumstances that there can be any occasion for the Urban Authorities to trouble themselves about the matter. The paternal work which the Board of Trade has executed should generally be sufficient, and unless good cause is shown, any additional rules are likely to produce more harm than good.

It is probable that the proposed bye-laws, if ever they are made, will affect telephone and telegraph wires much more than conductors for electric light. The conditions under which the latter may be erected are already so onerous that a very slight addition would prohibit them. The Board of Trade rules, however, being under the Electric Lighting Acts, could not deal in any way with telephone wires, and it is possible that this may be a device for controlling them. That they need some control is obvious, and now that a large number of private wires may be expected, especially in the Provinces, it is surprising that the Board of Trade have not themselves the power to issue a set of regulations.

We have received from Messrs. Knight and Co, a set of model bye-laws, which are evidently based upon the Board of Trade rules. There is not much to be said about them except that they suggest that each wire must be "shackled off and securely attached to the insulators at the supports," and that every support, if metal, must be efficiently connected with the earth, and if of wood, or other non-conducting material, to be protected from lightning by a proper and efficient lightning conductor.

We had hoped that the experience gained by the first few days' working would have resulted in the disappearance of the many small, but irritating, defects which were noticeable at the opening of the City and South London Railway. If we may judge, however, by a lengthy letter in an evening contemporary, there is still much room for complaint. The trains, it seems, are terribly overcrowded during the busy hours, the ventilation of the cars is indifferent, the lighting is "practically a nuisance," the lifts work slowly and irregularly, and the staff at the turnstiles is inadequate. It seems to us that in spite of encouraging traffic returns, the Directors would do well to have these defects remedied without further delay. The City and South London Railway must not only do as well as other suburban lines, it must do a great deal better. It is, moreover, to be borne in mind that novelty is only a temporary attraction, and that comfort and regularity will alone secure permanent patronage.

The shareholders of the Company are certainly to be congratulated on the traffic returns published yesterday. During the first fourteen days ending on Saturday last the receipts amounted to £1,947, showing that 233,640 passengers had been carried during that period, or on an average 16,688 per day; that is to say, nearly 40 per cent. more than was estimated by the pessimistic Mr. A. Willbond.

A note recently presented by Mr. Lucas to the *Comptes Rendus* on the Electro-magnetic Solution of Equations, raises a question of some interest. The applications of Mathematics to Physics have been both numerous and important, but few cases exist in which the process has been reversed; for, although experience of physical phenomena is sometimes useful in interpreting a solution, it has rarely served as a guide in

Digitized by Google

obtaining it. Mr. LUCAS has shown how the roots of an equation may be obtained by examining the magnetic field caused by passing currents of electricity through a number of parallel wires. The relative strength of the currents, and the position of the wires, is determined in a fairly simple manner from the numerical coefficients of the terms in the equation, and the points at which the magnetic force is zero indicate the solution of the problem. Although no one would attempt to solve an equation in this manner, the method is remarkable for its originality, and it is of interest to inquire whether mathematical processes would gain in usefulness by further attempts to solve problems in a similar manner. In applying analysis to explain a new physical phenomenon, it generally happens that the solution first obtained is unncessarily complex. This is often the case with alternate current problems, and the solution is usually simplified by merely ignoring some of the conditions of the problem, the consideration of which does not appear to have affected the answer practically, although it may have introduced complicated functions. Where the practical solution is known, it might, in some cases, be possible, by comparison with the complex theoretical solution, to arrive at rules of approximation which would be valuable both for practical applications and for mathematical theory.

THE dynamical experiments described in the paper on the measurement of electro-magnetic radiation are not only of great theoretical importance, but present a number of novel details in the apparatus employed. A brief abstract of the paper appeared in *The Electrician* (Vol. XXV., p. 210); but the text contains so much matter of interest that we reproduce it in full. While Mr. BOYS has enabled a new order of measurements to be made, dealing with thousand-millionth parts of a gramme, a suitable field is opened for such work in the dynamical treatment of those radiations which HERTZ has investigated statically. The practical application of Prof. J. J. THOMSON'S method of determining the conductivity of liquids by the opacity of thin sheets to oscillatory radiations, by the use of a duster soaked in water or dilute acid, is particularly novel, though such a homely screen seems to contrast in a singular manner with the minute delicacy of the fragile resonators and invisible quartz threads which were used. That the main results were negative does not detract from their interest; but it is obvious that such a research as this could not be carried on if the South Kensington and Paddington Underground Railway, which is threatened, should some day run almost beneath the laboratory.

As will be seen by the short article which is published in another column, the forthcoming Electrical Exhibition at Frankfort-on-Main is to be carried out with a characteristic thoroughness which deserves and probably will attain every success. "Object lessons" in electric traction, and the electric transmission of power from long distances will be provided on an extensive scale, and the electric motor is to be largely employed. We are also promised a series of tests of the various apparatus exhibited, with publication of the results obtained.

ON making inquiry from the London Electric Supply Corporation as to the progress which they are making with the repairs and reconstruction of their distribution plant, we learn that they have put down a set of transformers capable of supplying the whole of the demand which would be made, but they prefer to wait until the beginning of next month in order that they may provide a complete duplicate set. They have laid four mains of an aggregate length of about 40 miles. Two of these will easily carry the present load. The generating plant will also be in duplicate, the dynamos and engines from the Grosvenor Gallery having been arranged at Deptford for this purpose. There are four engines, two of 600 horse-power and two of 1,200 horse-power.

THE serious fire which recently destroyed an entire block of buildings in New York was attributed, by rumour, to some accident connected with the electric light. So many accidents have been put down to such a cause without any foundation whatever, that the statement did not appear to be worthy of attention. An evening paper, however, has stated that "it has now been definitely discovered" that the fire was "caused by two crossing electric wires." We have cabled to our New York correspondent to inquire as to the actual cause of the fire; and he replies, "Fire not electric, probably matches."

**Durham.**—A scheme is on foot to light Durham Cathedral by electricity, the motive power to be derived from the river Wear.

**Dusseldorf.**—The central station at this town is to be opened on August 1st. The price to be charged is equivalent to 11d. per Board of Trade unit.

**Institution of Electrical Engineers.—Change of Address.**—On and after the 25th inst. the address of the Institution will be as follows:—Victoria Mansions, 28, Victoria-street, Westminster.

**"Anales de la Electricidad."**—In consequence of the appointment of Señor D. Antonino Suarez Saavedra, the editor, as chief of the telegraph service of the Canary Islands, this periodical has ceased to appear.

**Electric Traction in Naples.**—The Naples Council of Public Works has approved of a project for the construction and working by electricity of the tramway from Naples (Musco) to Capodimonte and Miano.

**Birmingham.**—The Birmingham Electric Light and Power Company is rapidly progressing with the work of main-laying, and fair progress is being made at the generating station in Albert-street. Orders for over two thousand lights have already been received.

**Storage Battery Cars.**—The total mileage run during 1890 by the accumulator cars on the Barking-road line was approximately 80,000 car miles. According to schedule time the possible mileage was approximately 1 per cent. more than that actually run.

**The Telephone in Berlin.**—On December 17, 1890, the 15,000th telephonic apparatus was connected to the Berlin Exchange. The 10,000th telephone was installed April 18, 1889. The number of subscribers has, therefore, increased 50 per cent. in under two years.

**Electric Welding.**—M. Paul Hoho and a M. Lagrange, an officer in the Engineers, have devised a system of electric welding which is essentially different, so we are informed, to that of Elihu Thomson. The Hoho-Lagrange process will be worked in Belgium by the Julien Company.

Digitized by Google

**Telephonic Communication with Ships.**—The authorities of the Port of Bordeaux have decided to lay down a telephone cable to enable vessels in the roadstead at Pavillac, 26 miles distant, to communicate with the port.

**Cambridge.**—At a recent special meeting of the Town Council the Electric Lighting Committee recommended that application should be made to the Local Government Board to borrow the sum of £35,000 for the purposes of the Cambridge Electric Order, 1890. The report was carried with two dissentients.

**Personal.**—Mr. W. H. Stanger and Mr. Bertram Blount, of the Broadway Loboratory and Testing Works, Westminster, desire to correct a rumour which has become prevalent by stating that the Mr. William Fox who is at present associated with them at the above address is a member of the Institution of Civil Engineers, and not a practising analyst.

**Chelmsford.**—At the last meeting of the Town Council the Lighting Committee reported that they had appointed a small sub-committee to interview Messrs. Crompton and Co. as to the irregular working of the lamps, and they asked, if the interview was not satisfactory, for power to engage an expert to test the light. The recommendation was adopted.

**Electrical Transmission of Water-Power.**—The Gray Current Motor Company, of Elgin, Ills., has secured the large water-power at Oregon, Ills., and proposes to install a large electric water-power plant there. Large electric generators will distribute the power to manufacturing establishments in the town. A plant of a capacity to deliver some three thousand horse-power of electrical energy will be installed.

**Central Institution.**—A course of lectures will be given by Prof. Ayrton on accumulators, their manufacture, testing and practical applications; arc and glow lamps, construction, regulation, life, methods, and cost of electric lighting, electric traction; and the distribution of energy electrically, on Mondays and Wednesdays, from 3 till 4 o'clock, commencing Wednesday, January 14, 1891. Further particulars will be found in our advertisement columns.

**Institution of Civil Engineers.**—With a view to increase personal intercourse between the members of all classes, the Council have arranged for a series of receptions to be held after the ordinary meetings on Tuesdays, January 13th, February 3rd, March 3rd, April 7th, and May 5th. As it is believed that it will be convenient for the ordinary meetings to be closed at a somewhat earlier hour than usual, it has been decided to adjourn on these occasions at 9 p.m.

**Electric Traction Notices for 1891.**—In addition to Companies given in our list last week, the following have sent in notice of their intention to apply for powers to construct tramways and to make use of electrical or other motive power:—Southwark and Deptford Tramways Company in the Metropolis, and the Blackburn Corporation, the Bradford and Wyke Tramways Company, and a company to be formed to construct and work tramways at Matlock, apply for similar powers in the Provinces.

**Miniature Central Station Lighting.**—The little town of Vaison, in the Department of Vaucluse, which has only some 3,000 inhabitants, is now lighted by electricity on the Ganz system, the generating plant being over a mile and a-half from the town. The pressure employed is 1,800 volts. In a few weeks' time the little town of Monteux, in the same Department, will also be supplied with current on the alternate-current transformer system. In each case a single alternator of about 30 horse-power is used.

**Storage Battery Litigation in France.** — The Société Française d'Accumulateurs have just made some seizures of Tudor and of Bett accumulators. With regard to the Gadot accumulators which were impounded some time ago, the experts' report is expected to be published immediately. As to M. Julien, having recognised the Faure-Sellon-Volckmar patents and agreed to pay an indemnity to the Société Française, he has acquired the right to manufacture lead and lead peroxide accumulator plates on payment of a royalty of 20 centimes per kilogramme.

**Telegraph Statistics.**—With reference to our note under this heading, on p. 226 of our issue of December 26th, we are informed that the number of inland telegrams despatched in the United Kingdom during the year ending March 31, 1890, was 50,800,000, and including press, railway, Government, and foreign telegrams, 62,400,000. The figures in question related, however, in most cases, to the year 1888, and included only ordinary private messages, so that a comparison might be made of the degree to which the *bona fide* public utilised the telegraphic systems of their respective countries.

**Exeter.**—A meeting of the ratepayers was held on Tuesday evening to protest against the proposal recently made in the city Council to expend £30,000 on works for the supply of electricity. There was a large attendance. Captain Halford-Thompson stated that Exeter was deeply in debt. Their debt at the present time, including loans that have not yet been sanctioned, amounted to £400,000. In the face of this fact, and considering that sooner or later a vast sum would be required to improve their drainage, it would be very unwise to incur further expenditure. A resolution condemning the action of the Council was carried.

**Copper Statistics.**—The copper statistics do not show any special change during the month. The stock is a little less, but that is all, the visible supply in England and France and afloat thereto being 65,366 tons at the end of December, against 65,440 tons at the end of November. The present stock is about 33,500 tons less than what it was a year ago. The deliveries in England and France during December were 11,881 tons, or about 650 tons more than in the preceding month. For the year they aggregated 145,641 tons against 118,652 tons in the previous twelve months, and 63,906 tons in 1888.

**Vienna.**—A committee, consisting of Herren Bergk, Peters, and Klien, and Dr. Ulbricht, have been sent on behalf of the State Railways of Saxony to examine the Zipernowsky system of electrical distribution as laid down by the Internationale Elektricitäts Gesellschaft of Vienna.—On December 22nd a trial was made of the electric light installation at the Hofburg to the perfect satisfaction of the committee who have had the arrangements in hand. The work has been done by Messrs. Egger and Co., and the current is supplied by the Internationale Elektricitäts Gesellschaft. The Albrecht Palace, adjoining the Hofburg, is also shortly to be lighted throughout by electricity.

**The Telephone in France.**—According to the *Bulletin des Teléphones*, the number of subscribers to the nine chief telephone exchanges in France was at the end of November as follows:—

| | | | |
|---|---|---|---|
| Paris | 9,200 | Reims | 400 |
| Lyons | 800 | Roubaix | 350 |
| Marseilles | 600 | Tourcoing | 500 |
| Bordeaux | 500 | Nancy | 176 |
| Lille | 450 | | |

Cannes, Saint Étienne, Nantes, Troyes, Saint-Quentin, have about 150, and then come some thirty towns with from 50 to 100 subscribers each.

**Western Counties and South Wales Telephone Company.**—The following figures illustrate the remarkable appreciation by the public of the system of inter-urban telephone trunk wires which has been built up by the above Company in the West of England and the southern portion of Wales:—

| Period. | Miles of wire. | No. of communications. |
|---|---|---|
| 1888 | 1,387 | 284,886 |
| 1889 | 1,804 | 369,508 |
| 1890 | 2,215 | 496,520 |

**City and South London Railway.**—A correspondent points out in a financial contemporary that it is strange both the Board of Trade and the British public have overlooked the fact that the City and South London line is a railway, and that it was classed as such by the Board of Trade nearly a year ago. Yet the Company, whose railway is only 3¼ miles long, with stations about every half-mile, charges a uniform fare of twopence for any distance. It would be interesting to know, he remarks, whether the fact of charging twopence for any dis-

Digitized by Google

tance is not a violation of the Act stipulating that all railways shall run passenger trains at the parliamentary fare of one penny per mile.

**The Prague Exhibition.**—We are informed that January 31st is the last day on which applications for space can be entertained. The second section of the 27th group will consist of inventions, patents, &c., enjoying the protection of the Bohemian law. Foreigners may exhibit in this group. The charge for space is as follows: 1 square metre in the unroofed space, 2fl.; in a covered space, in the middle, 10fl. Half of the rent for space must be paid on presenting the demand for admission, and the second half on receiving certificate of admission. Awards will be granted by a special committee. English firms proposing to participate in this exhibition should apply to Arthur Gobiet, Karolinenthal, Prague.

**Hove.**—The Electric Lighting Committee of the Hove Commissioners have had under consideration the best means for carrying out their Provisional Order. Three modes were discussed:—(1) That the Commissioners themselves should carry out the Orders; (2) That the Commissioners should erect the buildings and provide the plant and mains, and then arrange with a Company to work the station; (3) That the Commissioners should transfer the undertaking to a responsible company. After full discussion the Committee have decided to recommend the adoption of the last of these modes. In order to obtain information for the Board, the Committee have selected Mr. R. E. Crompton as their consulting electrical engineer.

**Popp.**—The Compagnie d'Electricité Popp is determined to demonstrate the correctness of its title. A few weeks back the Conseil Municipal (see *The Electrician*, December 19, 1890, p. 195) spent several hours in discussing the fire at this Company's battery sub-station in the basement of the Grand Café, and a day or two ago a violent explosion occurred in another battery sub-station belonging to the same Company, at 20, Rue de la Verreris. According to *La Lumière Electrique* the batteries are installed in a dark, badly-ventilated cellar, and to prevent evaporation of the liquid it is covered with a thick layer of heavy petroleum oil, which itself gives off fumes. The result of these arrangements was an explosion when the cellar was opened one morning to permit of some workmen going into it to examine the cells.

**Colliery Lighting.**—The Golborne Colliery in Lancashire has recently been fitted with an interesting alternate-current transformer plant, designed to light the colliery both underground and on the surface, also to supply current for 150 16 candle-power lamps at the residence of the colliery owner at Golborne Park, about 1½ miles away. The dynamo is a 25-kilowatt 2,000-volt Mordey alternator. At the colliery itself there is a 300-light "Hedgehog" transformer. For the private house there is one 150-light "Hedgehog" transformer, and a 50-light transformer for the lamps lighting the drive, which is about a quarter of a mile long. The long-distance circuit is of 7/19 insulated cable, and is mostly run overhead upon poles and suspension wires. In order to comply with the requests of local authorities, wherever the cable crosses a road, which it does in three places, it is laid underground in suitably protected iron pipes.

**Snowstorms and Overhead Wires.**—Pittsburgh was visited about the middle of December by a terrific snowstorm, which rendered the streets almost impassable. According to the latest estimates the Western Union Telegraph Company and the District Telephone Company alone had their systems damaged to the extent of £10,000. Some 26in. of snow fell in 24 hours. The telegraph, telephone, electric light and electric street railway wires were covered with snow until the load often became too heavy and they snapped. In many instances where the wires did not break, the poles gave way under the heavy weight of snow and wires. The result throughout the city presented a complete scene of demoralisation as far as wires were concerned. Owing to the snow and sluish, as well as the condition of the wires, the electric roads had to suspend business altogther for a time. Out of 3,500 telephone wires 1,000 were broken down.

**Magnetic Observatories.**—At the present moment France leads the way as regards magnetic observatories where recording apparatus is in regular operation. These observatories are five in number, and are situated at Lyons, Perpignan, Nantes, Toulouse, and Clermont-Ferrand. At the observatory in the Parc St. Maur, Paris, magnetic observations are rendered impossible owing to the proximity and consequent perturbing effects of suburban railway lines. (See *Electrician*, Vol. XXIV., p. 566.) A sixth recording magnetic station is in course of completion at Besançon. Marseilles and Bordeaux also have obervatories, but there are no registering instruments at these places. M. Mascart's apparatus is used at all the six recording stations. After France comes England, with three magnetic observatories, and then Germany, Austria, and Portugal with two each. Russia, Spain, Belgium, and Holland have each one station, while Italy, but for the liberality of the Vatican. would be without any.

**Fire at West Drayton.**—We regret to have to record that a serious fire took place on Tuesday morning in the works of the Electrical Engineering Corporation. When the first workmen arrived, shortly before 5 a.m., the fire was not at first apparent, but on opening a door, a room in which it had been smouldering burst into flames. Hydrants had been provided, but before enough men had arrived the fire had got a good hold on the fitting and erecting shops, and the valuable tools and stock in them were destroyed. Although the damage, which amounts to about £15,000, is largely covered by insurance, the loss of a number of new tools, among them a large planing machine which had not yet been used, is very unfortunate. We learn that the smaller dynamos and other light work can be carried on in the buildings which were saved by the use of the hydrants, when it was too late to stop the conflagration. The Electrical Engineering Corporation were among those firms who assisted Messrs. Willans and Robinson after the fire at Thames Ditton, and we hope that they will, if need be, receive similar help.

**Arc Lights and Insects.**—Chicagoans who spent the summers of 1889 and 1890 in the city might, says the *Western Electrician*, with reason feel that there was a time when the electric arc lamp could be called a nuisance. Night after night the brilliant white light from the lamps on the streets of Chicago was the means of attracting vast swarms of bugs which filled the lamp globes and covered the pavements. Where these little insects came from it was difficult to say, but one thing was certain, they were a nuisance, and the electric light brought them together in great numbers. With this in mind, Chicagoans will be interested to read of the novel manner in which the electric arc lamp is employed in Bavaria to attract forest bugs to destruction. A beautiful park near Munich, Bavaria, had suffered from their depredations. At last a large arc lamp and reflector were set up in the forest. The lamp was located at or near the mouth of an opening leading from a powerful exhaust fan. This fan discharged into a grinding mill. This tells the story. The Bavarian bugs proved as partial to the arc light—and the grinding mill—as the Chicago sand flies.

**New Aluminium Alloys.**—Quite recently experiments, says the *Engineer*, have been made at the department of aërial navigation for military purposes at Chalais, with light aluminium alloys, and have been attended with an encouraging measure of success. The aluminium used was obtained from the Société de l'Aluminium, and was very nearly pure. Copper in the form of ordinary conducting wire was used to alloy with it, the whole being rolled into sheets 1mm. in thickness. Strips having a width of 5mm. were cut from these and tested, with the following results:—

| Composition. | Specific gravity. Calculated. | Specific gravity. Determined. | Tensile strength. kilos. per sq. mm. | Tons per square inch. |
|---|---|---|---|---|
| Aluminium | — | 2·67 | 18·7 | 12·0 |
| " 98 p. c., Copper 2 p. c. | 2·78 | 2·71 | 30·7 | 19·65 |
| " 96 p. c., " 4 p. c. | 2·90 | 2·77 | 31·1 | 19·9 |
| " 94 p. c., " 6 p. c. | 3·02 | 2·82 | 38·6 | 24·7 |
| " 92 p. c., " 8 p. c. | 3·14 | 2·86 | 35·5 | 22·7 |

These figures are sufficiently remarkable; the addition of only 2 per cent. of copper is seen to increase the tensile strength from 18·7 to 30·7 kilos. per square mm., while 6 per cent. more than doubles it.

**National Telephone Company.**—Special call-boxes have been opened at Oxford-court, Cannon-street, for telephonic con-

Digitized by Google

versation with Manchester, Liverpool, and Birmingham, and arrangements will shortly be made to give similar communication with Leeds, Bradford, and other centres of business. The charge for three minutes' conversation is as follows:—To Manchester, 3s.; Liverpool, 3s.; Birmingham, 1s. 6d. Subscribers wishing to talk direct from their own offices will be supplied with a separate exchange line, and suitable apparatus, at an extra cost of £15 per annum. They will be required to make a deposit with the Company of £5, and will receive a monthly statement of accounts for calls made during the month. In the metropolitan exchange system, second and additional exchange connections for business addresses will be reduced to £15 per annum for each connection after the first when within a radius of two miles of the Company's nearest exchange. The Company is now engaged in remodelling its system, and in the course of doing so the new wires, whilst being run, are sometimes unavoidably thrown into contact with those in use, and so cause disturbance in the service. Under these circumstances, the directors ask for friendly consideration, and a report to the secretary of any fault that may arise.

**Destruction of a Melbourne Electric Light Station by Fire.**—A disastrous fire occurred on the premises of the New Australasian Electric Lighting Company on November 16th. The building had been in the occupation of the Company for some nine years, and was partly two-storied. The upper story was utilised as officers' quarters and store room. All the machinery was on the ground floor. The steam plant comprised four large engines and boilers, two of the engines being by Ganz and Co., and the others by Marshall. The electrical plant comprised two 1,200-light Ganz alternators, and several Brush machines. The flames quickly obtained such a firm hold that the building was almost completely gutted before they could be subdued. Apart from the serious destruction of property, the fire caused considerable public inconvenience, as from these works the electric light was supplied to the Grand Hotel, Victoria Coffee Palace, Theatre Royal, and a number of smaller establishments. According to an engine-driver employed by the Company, he noticed, at 11:10, a flame on the switch-board, near the Theatre Royal switch. The flame ran along the board, and he and other *employés* tried to extinguish it with a bucket of water, but could not do so. The hose on the premises was then put on, but it burst. In a very little time the flames had possession of the building.

**The Photographic Action of Electro-magnetic Waves.**—In the *Wiener Berichte* of October 9, 1890, Franz von Dobrzynski says: I have for several months been engaged in investigating the photographic action of electro-magnetic waves. The electro-magnetic waves were obtained by the method of Hertz. They acted on dry bromide of silver and gelatine "Nys" plates procured from Geissler in Bonn. The plane of the plates either included the axis of the vibrator, or was at right angles to it. The exposure was three hours. No sensitisation of the plates was made. The development and fixation took place in the ordinary manner by ferric oxalate and hyposulphite. The action was visible after development and fixation by the appearance of alternating bright and dark bands across the direction of vibration of the waves, or by the appearance of dark bands in the direction of the vibration. Both kinds of bands could occasionally be observed together. In many experiments the plates were covered with tinfoil. Portions of the coating of the tinfoil were cut away. The tinfoil did not prevent the formation of bands. This points to the fact that the chemical action which here comes into play is not a primary one. The cross bands suggested stationary vibrations. They might be due to reflexion from the sides of the wooden box, by which the plates were protected from the influence of extraneous rays; but they might also owe their origin to reflexion from the side of the room. The only experiment which could be made with a reflecting metal ball was not in disagreement with this view; the cross bands were now more distinct and regular. If this view is correct, it may be concluded that waves of from 0·6 to 20 centim. are effective.

**The Magneto-Optical Generation of Electricity.** — Prof. Brackett and Mr. S. T. Dodd, of Princeton College, N.J., write to the *Electrical Engineer* of New York as follows:—"We have endeavoured to produce an electric current in the manner described by Prof. Sheldon in the *American Journal of Science*, September, 1890 (*Electrician*, Vol. XXV., p. 559), and we have also endeavoured to produce it by other similar means which his experiment suggested, but with entirely negative results. We first followed as nearly as possible the arrangement of Prof. Sheldon; the only essential change which we made was in the substitution of a glass tube for the brass one on which the coil was wound. The experiment was carried out with the result that faint musical sounds were heard in the telephone, which could be referred either to the action of the arc lamp or to the moving machinery. On interrupting the ray of light no change whatever was produced. We next discarded the oscillating apparatus, and substituted one by means of which we could rotate the Nicol prism about 200 times per second. . . . We failed, however, to obtain any indication of a direct current by the use of a delicate galvanometer, or of an interrupted current by means of a telephone, when the ray of light was rapidly and periodically interrupted. In the third place, if an electro-motive force can be induced by mechanically superimposing a third rotation upon the two existing rotations which are regarded as the equivalent of a plane polarised ray, then a still greater electro-motive force should be induced by suppressing one of the original rotations —that is to say, by using circularly polarised light. Accordingly this plan was employed, and with negative results."

**Lightning on a Lighting Circuit.**—The following account of some lightning strokes on electric lighting apparatus in a Michigan town during storms on August 8th and September 6th, 1890, may prove of interest to central station men. It is an extract from a lengthy report to the *Western Electrician.* At the station, on August 8th, the lightning arresters were marked by discharges, the discharge combs being burned considerably, one tooth being fused enough to make contact with the plate opposite itself, causing ground connection. The main switch was open, so that nothing was in circuit at the station except the lightning arresters. The primary fuses of five out of six converters were blown on both sides. The secondary of the sixth converter was open, so its impedance was at its maximum. One of the others had its secondary open also. All the other secondaries were closed. One converter was tested after the storm and found to be all right, and the others appeared none the worse for their experience. On the secondary circuits a 10-ampere branch fuse was knocked out, and 52 16-candle-power lamps had filaments broken. All the lamps that were up seemed to have been strained, and are breaking rapidly. A peculiar thing about the 10-ampere fuse being blown is that there was no circuit through it, the lights which it protected having been all turned off the night before, and at least three-fourths of the number of lamps which were damaged were turned off by key or switch; indeed, some of them were absolutely disconnected from the converters. The filaments in some lamps were blown to pieces; in others they had broken away from both platinums and were sticking to the inside of the glass. The insulation of the circuit is very good, unusual pains having been taken with it, both on primaries and secondaries, and there is no sign of a break to earth from the circuit anywhere. Whatever effects followed the lightning are not due to the circuits acting as a lightning rod. On Saturday, September 6th, during a violent storm, the saw teeth plates on the switch-board were melted at the edges and fused together so that the current generated by the dynamos ran straight to the ground, and the engineer was compelled to shut down. That was the only damage done on the second occasion.

**Magnetism and Recalescence.**—In a Paper on this subject recently read before the Royal Society, Dr. John Hopkinson describes some experiments carried out by him to obtain absolute proof that change of magnetic property occurs exactly when heat is liberated and absorbed. A copper wire for measuring temperature was well insulated with asbestos and laid in a deep narrow groove running round the iron ring. The secondary exploring coil was then wound on, next a serving of asbestos paper and mica, and then the primary coil, and, lastly, a good serving of asbestos paper was laid over all. The whole was placed in an iron pot, and this

Digitized by Google

again in a Fletcher gas furnace. By this arrangement it was possible to compare directly at the same instant the magnetic and thermal condition of the ring. In a sample of iron containing about ·3 per cent. carbon only a cooling curve was taken. In iron of this composition Osmond has noticed that there are two successive temperatures of recalescence. It was observed that there was considerable liberation of heat at 715° C., continuing for ten minutes to 660° C. At 660° C. the rate of liberation became so rapid that the fall of temperature was for several minutes almost arrested. Liberation of heat then ceased and normal cooling continued. Comparing the kicks of the galvanometer, it was observed that the ring began to be magnetisable at 715° C., and its magnetic property increased till the temperature of 660° C. was reached; after this point the magnetisability increased much more rapidly, and was practically fully developed immediately after the normal rate of cooling was recommenced. In this case the development of magnetic property followed precisely the whole of the liberation of heat, observed both at the temperature of about 700° C. and at 660° C. A magnetising force of 6·56 was employed. With a ring containing 0·9 per cent. of carbon the heating curve showed that there was a slight absorption of heat at 710° C. with doubtful effect on the magnetism. At 770° C. powerful absorption of heat began and continued to 808° C; it was between these times that the magnetisability was decreasing, and at the latter temperature it finally disappeared. The heating was continued to about 840° C. In cooling, heat was liberated at one point only, with a distinct rise of temperature. Recalescence began at 750° C., and it was precisely at this temperature that the ring began to be magnetisable. Recalescence continued for 21 minutes, and at the end of this time, and not before, the magnetisability attained a maximum. The ring was then heated to 966° C., and the curve showed plainly the effect of higher heating in *lowering* the temperature of recalescence, which had fallen from 750° C. to about 680° C. These experiments show that the liberation and absorption of heat known as recalescence, and the change in magnetic condition, occur simultaneously. Also that in the case of steel with 0·3 per cent. of carbon both temperatures of liberation of heat are associated with change of magnetic condition.

**A Windmill-Dynamo Plant.**—The huge windmill-dynamo plant erected by Mr. Brush in his back garden at Cleveland has attracted considerable attention in America, and as plants of this description are sufficiently rare, the following particulars may be of interest:—The windmill-tower, says the *Scientific American*, is rectangular in form and about 60ft. high. It is mounted on a wrought-iron gudgeon 14in. in diameter, and extending 8ft. into the solid masonry below the ground level. The gudgeon projects 12ft. above the ground, the weight of the tower, which is nearly thirty-six tons, being borne by a step resting on the top of the gudgeon. In the upper part of the tower is the main windmill shaft. This shaft is 20ft. long and 6½in. in diameter, and carries the main pulley, which has a diameter of 8ft. and a face of 32in. The windmill wheel is 56ft. in diameter, the sail surface being about 1,800 square feet. The length of the tail which turns the wheel toward the wind is 60ft., and its width is 20ft. The mill is made automatic by an auxiliary vane extending from one side, and serving to turn the wheel edgewise to the wind during a heavy gale. The countershafting arranged below the main shafting is 3½in. in diameter, and carries a pulley 16in. in diameter, with a face of 32in., which receives the main belt from the 8ft. pulley on the main shaft. The countershafting is provided with two driving pulleys, each 6ft. in diameter, with a face of 6½in., and the dynamo is furnished on opposite ends of the armature shaft with pulleys which receive belts from the drive wheels on the countershaft. The dynamo is mounted on a vertically sliding support, and is partially counterbalanced by a weighted lever. The countershafting is suspended from the main shaft by the main belt, and the dynamo is partly suspended from the countershafting by the driving belts. In this way the proper tension of the belts is secured. The ends of the countershafting are journaled in sliding boxes connected by equalising levers, which cause both ends of the shaft to move alike. The dynamo makes fifty revolutions to one of the wheel. The maximum speed of the dynamo is 500 revolutions per minute, the peripheral velocity of the windmill being therefore then 1,800ft. per minute. The automatic switching devices are arranged so that the dynamo goes into action at 330 revolutions, and an automatic regulator is provided which does not permit the electromotive force to run above 90 volts at any speed. The working circuit is arranged to automatically close at 75 volts and open at 70 volts. The brushes on the dynamo are rocked automatically as the load changes. In the basement of Mr. Brush's house there are 408 secondary cells arranged in twelve batteries of 34 cells each, which are charged and discharged in parallel. Each cell has a capacity of 100 ampere hours. The house is fitted with 350 incandescent lights, varying from 10 to 50 candle-power each, about 100 incandescent lights being in every day use. In addition to these lights there are two arc lights and three electric motors. This plant has been in constant operation more than two years, and has proved in every respect a complete success.

**The Inductance in Henrys of Common Instruments, &c.**—The following figures are taken from Mr. Kennelly's Paper. which is concluded in this issue, and are here placed in order of magnitude to convey a clear idea of the practical meaning of a henry. The last items in the list appear to be very high, no such inductance is to be found in armatures of ordinary dynamos. Very large arc light machines are probably referred to:—

| | | |
|---|---|---|
| Hertz resonators about | $\frac{1}{10}$ | microhenry. |
| Cardew voltmeter | 1 | ,, |
| Doubly-wound resistance coil | 1 | ,, |
| One section of a dynamo armature | 1 | millihenry. |
| Secondary of transformer (ratio 20) | 1 | ,, |
| No. 11 copper wire, per mile, 13ft. high | 2·84 | ,, |
| ,, ,, ,, 23ft. ,, | 3·02 | ,, |
| No. 19 ,, ,, 13ft. ,, | 3·2 | ,, |
| ,, ,, ,, 23ft. ,, | 3·4 | ,, |
| Telephone induction coil primary ·28 ohm | 3·5 | ,, |
| Medical induction coil, small, primary | 5· | ,, |
| Ordinary electric bell | 12 | ,, |
| Dynamo armature, from | 20 | ,, |
| Mutual inductance, transformer, from | 20 | ,, |
| ,, ,, small medical coil | 20 | ,, |
| Ordinary telegraph sounder | 25 to 50 | ,, |
| Telephone induction coil, mutual | 60 | ,, |
| Telephone Bell receiver, diaphragm removed | 65 | ,, |
| ,, ,, diaphragm on | 100 | ,, |
| Telephone induction coil, secondary | 100 | ,, |
| 10 ohm relay armature set back | 200 | ,, |
| ,, ,, ,, against poles | 500 | ,, |
| Transformer, primary, from | 400 | ,, |
| Telephone induction coil, secondary, 164 ohms | 734 | ,, |
| Field magnets of small dynamo, from | 1 | henry. |
| Telephone call bell (80 ohms) | 1·4 | ,, |
| Astatic mirror galvanometer (500 ohms) | 2 | ,, |
| Telephone magneto, core opposite to poles | 2·7 | ,, |
| ,, ,, ,, ,, right angles to poles | 7·3 | ,, |
| Mirror speaking galvanometer (cable), 2,250 ohms | 3·6 | ,, |
| Western Union, 140 ohm relay, armature back | 3 | ,, |
| ,, ,, ,, ,, ,, adjusted | 5 | ,, |
| Western Union, 140 ohm relay, armature against poles | 9 | ,, |
| Dynamo armature, up to | 50 | ,, |
| ,, field magnets, up to | 900 | ,, |

To these we add some of the values given in the Papers by Profs. Ayrton and Perry, read in March, 1889, before the Institution of Electrical Engineers:—

| | | |
|---|---|---|
| Single coils of Morse receiver, 32 ohms | 93 | millihenrys. |
| ,, ,, ,, 50 ohms | 444 | ,, |
| Two coils, with armature | 265 | ,, |
| Voltmeter coil, no iron, 333·5 ohms | 1·46 | henry. |
| Single coil of reflecting galvanometer, 2,700 ohms | 2·56 | ,, |
| Single coil of reflecting galvanometer, 100,000 ohms | 70 | ,, |
| Induction coil, 2in. spark, secondary | 51·2 | ,, |
| ,, ,, ,, mutual inductance | 460 | millihenrys. |
| Ferranti dynamo, 200 volts. 40 amps. armature. | 1·3 | ,, |
| ,, ,, magnets | 610 | ,, |
| Shunt dynamo, 100 volts 35 amps. armature. | 5 | ,, |
| ,, ,, magnets in series | 13·6 | henrys. |

Digitized by Google

## MAGNETISM IN IRON AND OTHER METALS.*—XXXIX.

BY PROF. J. A. EWING, F.R.S.

(*Continued from page 229.*)

§ 140. **Transient Currents produced by Magnetising Twisted Rods, or by Twisting Magnetised Rods.**—The sudden development of circular magnetism when a longitudinal magnetised rod is suddenly twisted, or when a longitudinal magnetising force is suddenly applied to a rod that is held in a state of torsion, is well shown by connecting the ends of the rods to a galvanometer, when it will be found that a transient current is induced along the rod. A still more effective experiment may be arranged by substituting a tube for the solid rod, and by placing within it an insulated wire in circuit with the galvanometer.† In experiments of this class the existence of hysteresis is shown in an interesting way by making back and forth twisting take place in a series of steps, when, by summing the transient currents, it is at once seen that the circular magnetisation exhibits hysteresis with respect to the angle of twist—a result which is of course to be anticipated from the known effects of pull and push. Thus in Fig. 117 an iron wire rather strongly magnetised in the direction of its length was twisted alternately to opposite sides, but the twisting was done in a series of steps, and the transient current for each step was noted.

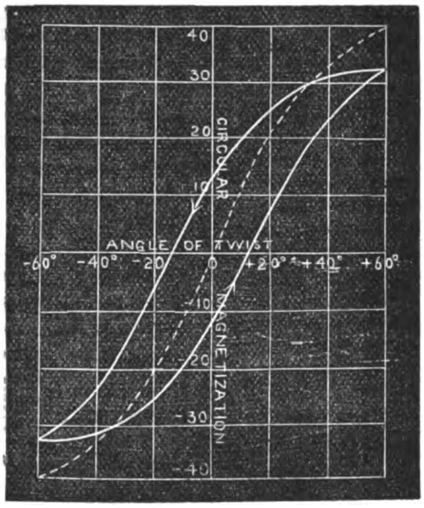



FIG. 117.—Circular Magnetisation produced by Twisting Magnetised Iron.

Summing up the transient currents we obtain the circular magnetisation in arbitrary units. The full lines of the figure show how the circular magnetisation was cyclically reversed by reversing the twist, but the change of circular magnetism lagged behind the change of twist.‡ The dotted line in the same figure exhibits the amount of circular magnetism found by first applying a given torsion and then reversing the longitudinal magnetising force. This procedure, of course, eliminates the hysteresis which appears in the other.

Fig. 118 gives the results of a similar experiment made with a piece of pianoforte steel wire in its usual condition of temper. The dotted line has the same meaning as in Fig. 117.

In these cases the process of back and forth twisting had been repeated often enough to bring about a cyclic *régime* before the observations were taken. It is interesting to notice the manner in which the cyclic state is reached. This is shown in Fig. 119, which relates to the same wire as Fig. 118. Starting from the condition that had been reached by reversing the longitudinal magnetisation, when the angle of twist was +90deg., the changes shown in the diagram were brought about by twisting back to −90deg., again to +90deg., back to −90deg., and again to +90deg.

In all these cases the direction of the circular magnetisation was such as would correspond to *increase* of magnetism by pull. And a careful inquiry has shown that the effect of torsion is not reversed, though the longitudinal magnetising force be made very great. What happens in that event is that the tansient currents due to torsion become much weakened; but their sign does not change. Here, again, the explanation is that the intensity of magnetism on which the pull and push of

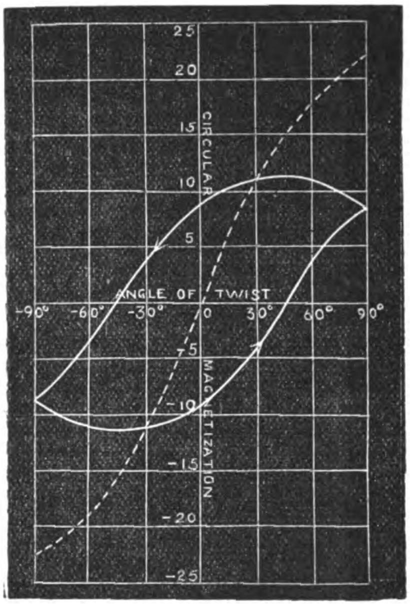



FIG. 118.—Circular Magnetisation produced by Twisting Magnetised Steel

the torsion act, is the component at 45deg. to the axis, and this remains below the Villari critical value, even when the whole magnetism approaches saturation* (*see* § 138, above).

When this longitudinal magnetism is residual instead of in duced, torsion still produces transient currents of the same general character, but the effects are complicated by a progressive shaking out of the magnetism.†

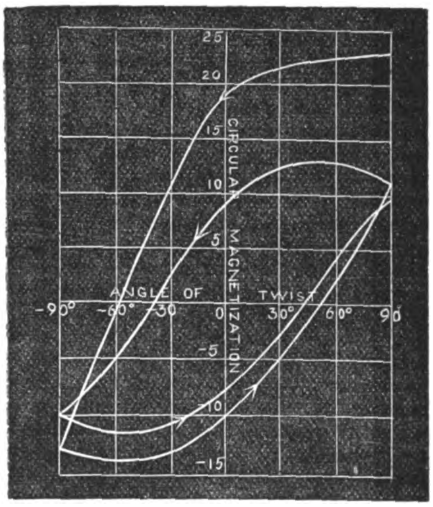



FIG. 119.—Effects of Twist.

Using a telephone in place of a ballistic galvanometer, Hughes has observed the production of transient currents in a twisted wire, when the current in a surrounding solenoid is rapidly interrupted or reversed. He has also illustrated the production of longitudinal out of circular magnetism in a twisted

* All rights are reserved.
† *Proc.* Roy. Soc. 1883, p. 117; 1881, p. 21.
‡ It was in connection with this instance of lagging, one of the first which the author met with in his experiments, that the word "hysteresis" was originally introduced. (*Proc.*, Roy. Soc., 1881, p. 22.)

* *Proc.* Roy. Soc., 1883, p. 129.
† *Loc. cit.*, p. 126.

Digitized by Google

wire, by passing an interrupted current through the wire, and putting a telephone in circuit with a coil wound round the wire.*

In nickel, the effects of simple pull and push are, as we have seen, opposite in sign to the effects in iron, provided the magnetisation of the iron is not so great as to cause the Villari reversal. Hence we may expect the transient currents produced by twisting a longitudinally magnetised nickel rod or tube to take the opposite direction to that which they take in iron. This fact has been verified by the independent experiments of Zehnder † and Nagaoka‡, who found that when a nickel wire is twisted as a right-handed screw the transient current flows from the south to the north pole.

(*To be continued.*)

* *Proc.* Roy. Soc., Vol. XXXI.
† Wied. *Ann.*, 1889. Vol. XXXVIII., p. 68.
‡ *Jour.* Coll. of Science, Imperial Univ. of Japan. Vol. III., 1890, page 335.

## THE INTERNATIONAL TELEGRAPH BUREAU AT BERNE.

The Bureau International des Administrations Télégraphiques, to give it its official title, was created by the Vienna Conference of 1867, and its objects are defined in the St. Petersburg revision of the International Telegraph Convention under the following heads:—(1.) To collect, arrange, and publish all kinds of information relating to International Telegraphy. (2.) To circulate requests for the modification of tariffs or for the alteration of the service regulation. (3.) To notify all changes of tariffs and rules to every administration.

The first object is partly attained by the publication of an official journal, the *Journal Télégraphique*, issued every month, the editor of which is the Director of the International Bureau for the time being. The present Director, Dr. Rothen, has for years past contributed scientific articles to this journal.

Once every year the Bureau issues a form to every Administration to be filled up, giving the length of line, number of stations, instruments, staff, and forwarded, received, and transmitted telegrams. The receipts from telegraphic work, and the expenses in connection therewith, are also asked for, but a large number of the States fail to give this information in consequence of their postal and telegraph accounts not being separately kept. When this information is received at Berne, it is published in a tabulated form, generally 18 months to two years after date. These statistics are not quite so serviceable as they might be, since some States do not regularly supply the information asked for. One of the Administrations has not supplied anything since 1870.

Another most important work of the Bureau is the preparation of official telegraph maps of three different kinds:—(1) A small map of the world; (2) A large map of the world on Mercator's projection; (3) A large map of Europe and the countries adjacent to the Mediterranean. These maps are executed with great care and accuracy, and form an invaluable adjunct to a telegraph office.

A list or "nomenclature," containing the name of every telegraph station in the world, and the country in which it is situated, is also published and kept revised by bi-monthly circulars. This list is an absolute necessity to a telegraph station. Another publication is a list of all the submarine cables of the world, giving their length, date of immersion, and ownership. Fresh editions of the maps, nomenclature, and list of submarine cables are published every two or three years.

The second part of the duties of the International Office is performed chiefly by means of ordinary correspondence, and also by the issue of circulars to all administrations. It very seldom happens however that any of the regulations are altered between the Conferences.

The third part of the duties of the International Office is performed by means of notifications, telegraphic and postal. The telegraphic notifications relate principally to the interruption or restoration of submarine cables and main line routes, also to sudden changes of tariff by non-adhering administrations. The ordinary notification is issued on the first of each month, and contains notices of alteration of tariff, confirmation of previous telegraph rates, opening of new routes, and a host of information which is of great service to all administrations. Occasionally the Berne Office has to publish one or more supplementary notifications in the course of the month, owing to the large amount of information coming to hand.

One of the most important duties of the International Bureau is the preparation for the quinquennial Conferences. It has to prepare and publish all propositions for the alteration or regulation of tariff. The Director and Secretary attend the Conferences, take the minutes of all the various sittings, and after the Conferences are over publish all the acts of the Conferences, together with the tariff lists, and a mass of information relating to various subjects. It may be safely said that during the sitting of the Conference the hardest worked men are the Director and Secretary of the International Bureau.

One other duty has been placed upon the Bureau by the last Conference at Paris—viz., the compilation and publication of an authorised vocabulary, the use of which will be compulsory in the European *régime* for code telegrams, a work that will occupy the office for at least two or three years, and, when finished and in operation, will be of immense use, both to the telegraph service and to the public.

The International Bureau is placed under the control of the Swiss Government, and consists of a director, secretary, and three or four clerks. The Director has always previously occupied the post of Director-General of Swiss Telegraphs. M. Curchod was the first Director, and he was succeeded by M. Lendi, and on this gentleman's decease M. Curchod again took up the duties. M. Curchod died in October, 1889, and was succeeded by M. Frey, who died in June, 1890. Dr. Rothen has recently been appointed Director. M. St. Martial, the first Secretary, died in May, 1885, and was succeeded by M. Eschbaecher, who has made himself universally popular with all who have been brought in contact with him. At the London Conference a pension scheme was authorised for the officials of the International Bureau. The expenses of the International Office are paid by all the administrations adhering to the Convention, in certain proportions agreed upon at each Conference, and its accounts are published, duly audited by the Swiss Government every year.

The International Telegraph Bureau at Berne, it will thus be seen, is an institution which performs many most useful functions, and as time goes on its utility is in no way likely to be diminished.

## AN IMPROVED PROCESS FOR THE PRODUCTION OF COPPER.

Copper is a material of such supreme importance to the electrician that any advance in its method of manufacture must be of direct interest to him. Mr. Percy C. Gilchrist has recently communicated to the London section of the Society of Chemical Industry the results he has obtained by applying what is known as the "basic process" to copper refining.

In the production of steel by the original Bessemer process, only pig iron free from all but a very small amount of phosphorus could be used, owing to the facts that phosphorus has a most deleterious influence on the finished metal, and that it was not eliminated in the natural course of events. By the substitution of a "basic lining" (*i.e.*, one composed of material such as magnesia) for the "acid lining," composed of siliceous matter, such as sand or ganister, it was found possible to remove the phosphorus owing to its tendency to become oxidised to phosphoric acid and combine with the basic material. It therefore seemed probable that the same device would be applicable in the case of copper for the removal of

Digitized by Google

arsenic — the electrician's *bête noir*. The high price of copper of good conductivity mainly depends on the cost of the elimination of those impurities which are, perhaps, more objectionable for electrical purposes than for any others.

Mr. Gilchrist's experiments have taken practical shape, and at least one big copper company is using furnaces with basic linings. Speaking generally, the value of the process lies rather in the elimination of arsenic more readily and at a cheaper rate (less copper passing into the slag and having to be reworked) than in any extraordinary perfection in the refined product. Its adoption should, therefore, lead to a reduction in the price of copper of good, but not abnormally good, conductivity, rather than to the attainment of any remarkably low resistance. Since it has become common practice to specify 98 per cent. conductivity, and such a conductivity being easily attained, manufacturers would do well to try and reduce the cost rather than to attempt to produce an article of greater purity but at a higher price.

## ELECTRO-MAGNETIC MECHANISMS.

### PRESIDENTIAL ADDRESS TO THE JUNIOR ENGINEERING SOCIETY.

BY PROF. SILVANUS P. THOMPSON, D.SC., B.A.

*(Continued from page 271.)*

*Some Paradoxical Cases.*

Passing on from these devices, I now invite your attention to another rather curious experimental result.

One consequence of the rule that the magnetic stress across a gap in the circuit is proportional to the square of the intensity of the magnetic flux, is the paradox that the pull exerted on an armature by an electro-magnet having a straight cylindrical core, is diminished by enlarging the surface of contact, and increased by somewhat diminishing that surface. This seems to be in direct opposition to all ordinary notions of mechanical structures; but it is, nevertheless, quite rational. If we diminish the end surface of the core, say 10 per cent., we shall produce thereby really very little difference in the total flux of magnetic lines, since the main reluctance to magnetisation lies in the long return path through the air. But if the flux of magnetic lines is now crowded into a lesser area, the intensity of the flux—that is to say, the number of magnetic lines per square inch—will be greater, and the square of this quantity will be, *à fortiori*, greater still. Now the pull exerted at the surface is equal to the product of this greater square number into the diminished area of surface; and as the increase in the square of the induction is greater than the decrease in surface, the nett result is that the pull is increased. Conversely, enlarging the contact surface diminishes the pull. This goes entirely against all preconceived notions of mechanical engineering; for the first instinctive impulse of an engineer, when he wants to strengthen the joint between two things, is to enlarge the surface of contact at the joint. Some diagrams that hang upon the wall (reproduced in my recent "Cantor Lectures") exhibit the results of a series of experiments by Dr. Julius Dub upon the deleterious effect of adding polar expansions to the end of an electro-magnet.

Another strange and interesting fact is that the pull exerted upon a piece of iron by a straight electro-magnet can be considerably increased by attaching a large mass of iron to the other end of the core of the electro-magnet. This is at once explained by reference to the principle of the magnetic circuit; for the mass of iron at the idle end of the core aids in the return of the magnetic lines through the air.

*Equalisers.*

I may now proceed to the consideration of sundry pieces of mechanism, in which an electro-magnet in one or other of its varied forms is combined with some other contrivance of a mechanical nature. In the first place I will deal with the subject of *equalisers*, or devices for equalising the otherwise unequal forces exerted by an electro-magnet on its armature when the latter is at different distances. You will have realised how, for example, with the ordinary two-pole or horse-shoe form of electro-magnet, the pull will become greater as the armature approaches, because as the gaps between it and the iron core are diminished, the resulting betterment of the magnetic circuit both increases the actual flux of magnetic lines and diminishes the amount of magnetic leakage. The variations of this force cannot be accurately expressed by a law of inverse distances or of inverse squares or cubes, and I shall not attempt the hopeless task of trying to fit a law to them. If an armature placed below the poles of such an electro-magnet at a little distance away is not constrained by any other opposing forces than that of its own weight, it is evident that there must be one particular strength of electric current which will just suffice to magnetise the electro-magnet sufficiently to overcome the downward pull of gravity, and raise the armature; but when once the armature has begun to rise, its mere approach betters the magnetic circuit and increases the upward attraction, so that it will be pulled right up to the pole. A strong current will perform no more in this case than one that is just strong enough to start the action. If, however, such an armature be controlled, not by the mere force of gravity, but by a spring so designed that, as the armature moves nearer to the poles, the opposing force of the spring shall be greatly increased, then a weak current will only produce a small motion, and a stronger current a larger motion, and there will be a determinate position of the armature corresponding to all different strengths of currents within the working limits of the apparatus. It is clear, then, that a properly designed spring, or combination of springs, may be used to equalise the movements of the armature in more or less strict proportion to the electric current. A device of this kind, with a series of set-screws behind a spring at different distances to stiffen it as it was moved, was indeed invented by Callaud, a French engineer. Another mode of equalising is by a

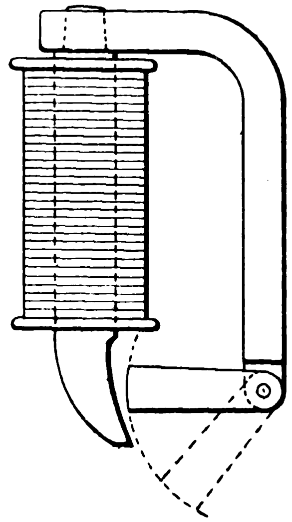


FIG. 10.

pair of rocking-levers which cause the armature as it approaches the poles to work with a lessened mechanical advantage. Equalisers on this plan were first suggested by the conjuror, Robert Houdin, and one used in the mechanism of several arc lamps. Another inventor, Burnett, has proposed to act on one armature by means of several electro-magnets which should successively be brought into play. A purely electrical method of equalising consists in arranging a series of contacts in the path of the armature, so that as it approaches the poles it should successively shunt out of action portions of the exciting current. Another device due to Froment consisted in applying a reversed Stanhope lever to the armature. Other varieties of linkage might doubtless be arranged to attain the same end. But the most interesting kinds of equalisers are those which depend on magnetic principles. It is possible, for example, by the device of shaping away the polar surfaces or by adding pole-pieces of appropriate shape to cause the approach of the armature to exert a very slight betterment of the magnetic circuit. One of such devices is depicted in Fig. 10, and consists in pivoting the armature to one pole of an electro-magnet, the other pole of which is provided with a curved pole-piece. By varying the contour of the latter any desired change may be made in the distribution of the pull at various points of the travel. In this particular instance, as the armature moves nearer, as a whole, it increases its distance from the curved pole-piece. An electro-magnet resembling this is used in Messrs. Paterson and Cooper's Phœnix arc lamp.

*Devices Based on Oblique Approach.*

It is not very easy to draw a hard-defining line between this device and another, due to Froment, who pivoted his armature upon two parallel levers, like the connecting bars of a parallel ruler,

Digitized by Google

and thus constrains the armature to move (parallel to itself) along a curve, which, though it approaches very near to the poles, falls short of actual contact. Devices with oblique approach have often been used in small electro-magnetic motors. One of these, due to Wheatstone, is depicted in Fig. 11, in which it will be seen that an electro-magnet, pivoted so as to revolve on its own middle, is surrounded by an iron ring through which the magnetic lines can stream back from the north to the south pole. The inner face of this ring is cut away in an oblique manner. Applying our principle that there is a tendency of the configuration so to alter as to complete the magnetic circuit as much as possible, it is evident that the electro-magnet will turn until the gaps are reduced to a minimum If at this point the current is cut off, the electro-magnet. will be carried on over the dead points, and may be again switched (automatically) into circuit, to be again attracted forward, and

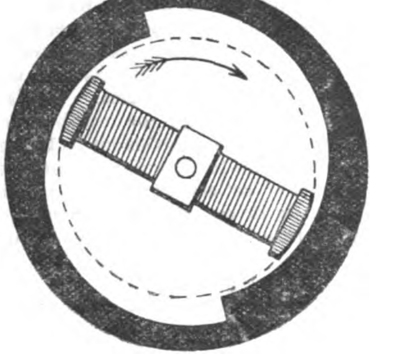


Fig. 11.

so forth. The analogy between this piece of magnetic mechanism, and the familiar mechanical device known as the cam, will be at once apparent. This is by no means the only instance of an electro-magnetic cam to be found amongst the practical applications of the science. All the electro-magnetic devices for distributing the pull of an electro-magnet, whether they consist in shaping the pole-pieces or the armatures, or whether they consist in constraining or pivoting the armature or the electro-magnet in the modes previously suggested, may be considered magnetically as either cams, wedges, or inclined planes.

*Pivoted Mechanisms.*

Beside the devices which I have already mentioned there are several for producing movement about or upon an axis. Some of these are designed for telegraphic purposes. For example, in Fig. 12 is depicted the method adopted by Siemens 40 years ago for pivoting an armature, A A, between the two pole-pieces, P P, attached to the ends of the core, C C, of a horse-shoe electro-magnet. The particular form chosen leaves very narrow gaps in the

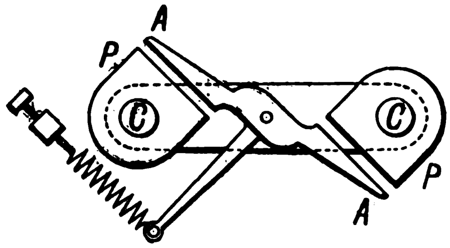



Fig. 12.

magnetic circuit, which, therefore, requires little current to magnetise it, making the arrangement very sensitive. Compare with this a device due to Waterhouse, of New York, shown in Fig. 13, who pivots one of the two cylindrical cores of the electro-magnet, furnished with a projecting tongue, A. The other core, B, is provided with a larger tongue, D, of brass or other non-magnetic metal to support the lower pivot. If A is originally turned outwards, the tendency of the magnetising current will be to turn it back into parallelism with the support D.

*Mechanisms of Bells and Indicators.*

The mechanisms of electric bells, and those of the annunciators or indicators used in conjunction with electric bells, furnish a variety of examples of devices, all of which are readily comprehended by the aid of the principle of the magnetic circuit. A number of these I have upon the table. Here are a few indicators. In some of them a pendulum is drawn on one side, and then left to swing. In another a trip lever, which carries a red disc, is latched up out of sight until the electric current comes and pulls down the latch. In another, an armature pivoted between two flat polar faces is drawn up into a position where it can better carry the magnetic lines. Here is a small electric bell of unusual sensitiveness of action. It is different in construction from the ordinary type of electric trembling bell. The electro-magnet, a horse-shoe, lies horizontally. The armature is a flat plate of iron, pierced with two holes; by these it is hung upon two brass pins which stand out like two miniature hat-pegs from the polar faces of the cores. This armature is always in contact with the electro-magnet, so that the magnetic circuit is, in one sense, always closed; but the spring attached behind keeps the armature from lying flat against the pole-faces; it only touches along its edge. It can, therefore, better the circuit by tilting upon its pins, and in this manner it

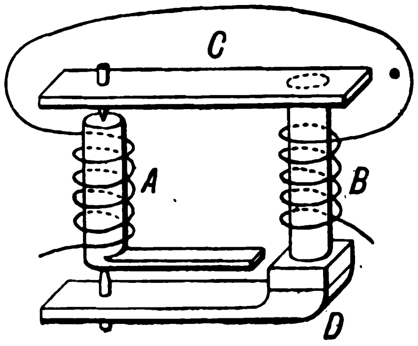



Fig. 13.

vibrates. Its great sensitiveness may be attributed to the way in which the initial position adopted aids the excitation of the magnetism.

*Polarised Mechanisms.*

There is another set of electro-magnetic mechanisms in which use is made of a permanently-magnetised steel magnet, in addition to electro-magnetic devices. One of these is illustrated by the sketch shown in Fig. 14. Here is represented an inverted horse-shoe steel magnet, its north and south poles being indicated by the letters N and S. There will be a powerful magnetic field in the space between the two limbs, where the magnetic lines pass across from one limb to the other. If a loop of copper wire is placed over one of the poles, and the electric current is sent around the loop, it will be found to be acted upon by a mechanical force tending to drag it across the magnetic lines of the field.

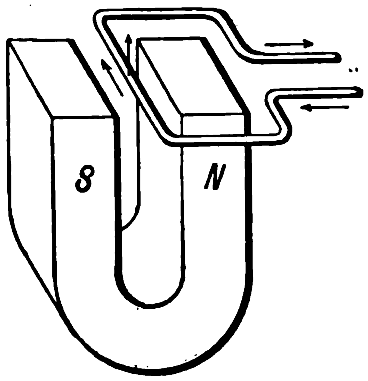



Fig. 14

In this device the direction of the motion will depend upon the sense in which the current is flowing in the loop of wire. If the sense of the flow be that indicated by the three arrows, the direction of the motion will be upward, as indicated by the fourth arrow. If the current were reversed the direction of the motion will reverse. Now, this is quite different from the action of the ordinary electro-magnet of soft iron, for in that case the core pulls at the armature in the same direction, no matter which way the current is flowing around its coils. To distinguish between the two cases it is usual to refer to those devices in which a permanent magnet comes into use as *polarised* mechanisms, whilst the ordinary electro-magnets are *non-polarised*. One result of using a polarised mechanism is to secure uni-directionality of motion in correspondence with the current. The single-acting mechanism is thus made into a double-acting mechanism, a point the possible advantage of which every engineer will at once grasp. Sturgeon, the inventor of the original electro-magnet, was himself the inventor also of a

Digitized by Google

polarised mechanism intended to be used as an electro-magnetic telegraph. It is shown in Fig. 15, and consists simply of a permanently magnetised steel compass needle placed with one pole between the poles of a soft iron horse-shoe electro-magnet. If the current is sent around the spiral coil from N to S, the left hand pole will become a north pole and the right hand pole a south pole, with the result that the north pole of the compass needle will turn to the right. On reversing the sense of the current the needle will of course turn to the left. It is strange that this invention, which Sturgeon gave to the world unpatented in 1836, was never brought into commercial use as a telegraph at a time when telegraphs were almost a monopoly in the hands of a few interested persons. Perhaps like some other unpatented inventions of which Hughes's microphone is a notable example—it was appropriated by some other inventor by judicial stretching of his patent to cover what he never dreamed of inventing.

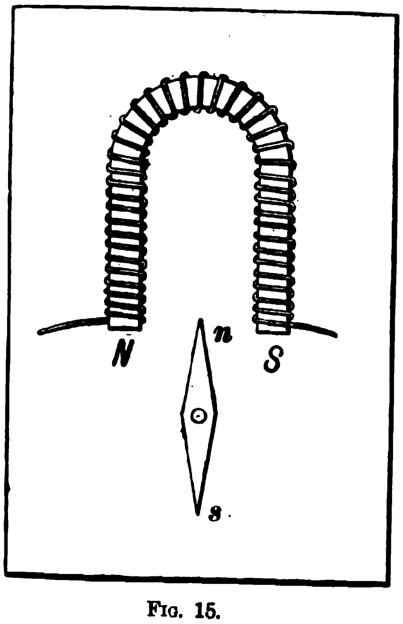



Fig. 15.

Another form of polarised mechanism is used in an electric bell upon the table, one of that species of electric bell which is worked without any battery by means of a little alternate current dynamo machine turned by a crank, and known as a "magneto-generator."

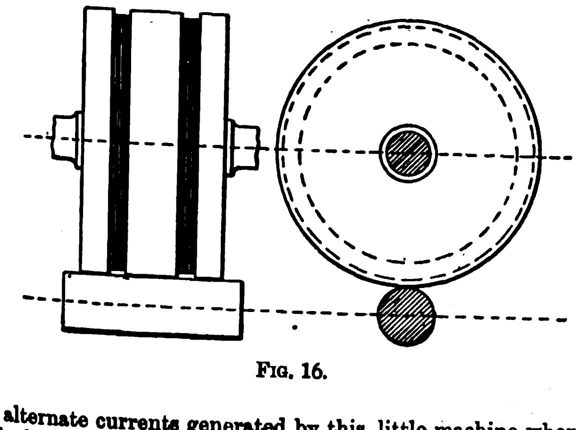


Fig. 16.

The alternate currents generated by this little machine when they reach the bell throw its polarised armature over alternately right and left, so that its rate of trembling depends on the rapidity with which the alternations succeed one another.

*Vibratory Mechanism*

The mention of electric bells suggests to me that there are numerous devices for producing a vibratory movement by electro-magnetic means. Such are to be found not only in bells, but in the automatic breaks of induction coils and of electrically-driven tuning-forks. To enter upon a discussion of these would lead me too far afield.

*Rotatory Devices and Electro-Magnetic Motors.*

Similarly, I must pass over the enticing topic of the rotatory devices used in electric moters, to one class of which, namely, those working by oblique approach, I alluded a little time back. But this class of motor is adapted only for use on a very small scale—practically only for toys. The larger motors, which, indeed, are nothing else than dynamo-machines arranged to be used in the inverse function of doing mechanical work when supplied with electric energy through a wire, are never built on this plan. In these, the rotating armature is usually a complex electro-magnet, built up symmetrically around an axis, with a core of laminated iron, and a peculiarly wound coil in which the current circulates in a manner governed by a commutator. I would that time allowed me to dwell on the electro-magnetic motor, and on the points of correspondence and of contrast between it and the steam engine. But no, your patience will not last for ever, not even till midnight. So I must dismiss the motor with the remark that so long as designers of electric motors adhered too closely to the plan of steam engines, seeking to produce first a reciprocating action, and then to convert this by a crank into a rotatory motion, so long was the electric motor a mere toy, and that the real advance came when the lines of steam-engine design were abandoned, and a true rotatory form of electro-magnetic apparatus was adopted. But, strange to say, this advance came about in the hands of inventors who were not trying to invent a motor at all, but who, in perfecting the dynamo machine for producing electric light, found themselves in possession of a far better electric motor than any that had been specially designed as such.

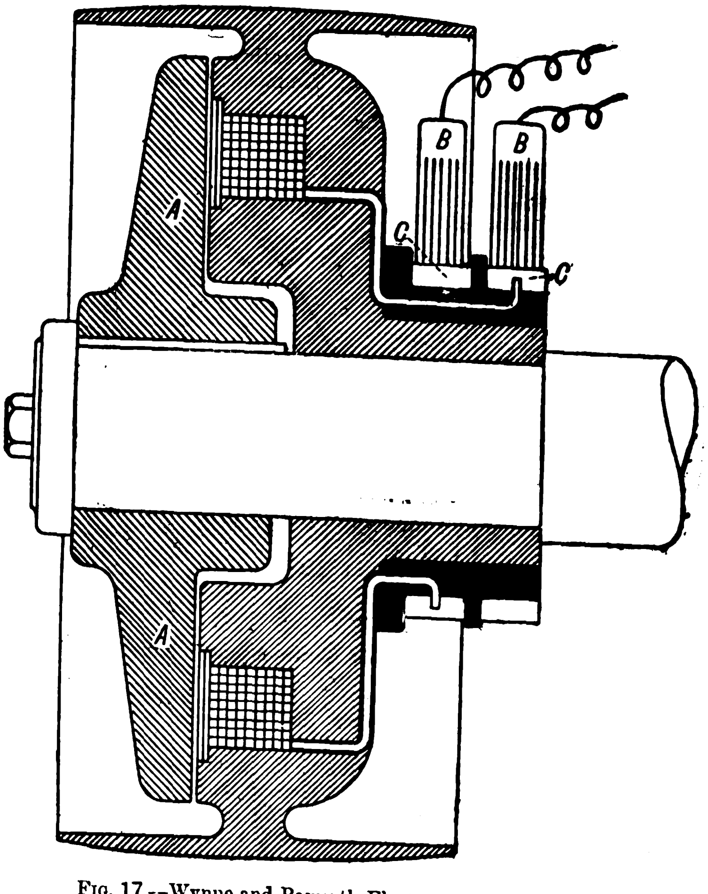



Fig. 17.—Wynne and Raworth Electro-magnetic Clutch.

*An Electro-magnetic Separator.*

Before closing this review of electro-magnetic mechanisms in general, I must, however, describe some recent devices that are worthy of the attention of the engineer. The first of these is a *separator* or *sorter* for separating pieces of iron from any non-magnetic materials. Many such have been tried in industries of very various kinds: for preventing iron particles from getting into white china clay, for sorting iron filings from brass filings, for catching nuts and nails and other such things which are liable to stray into the disintegrators used by the manufacturer of artificial guano, for selecting iron ore from mere earthy matters. The particular sorter that I have to describe to you is merely a revolving electro-magnet of a peculiar circular type, invented long ago by Prof. Weber (Fig. 16), in which the coils are wound in grooves in an iron drum. This electro-magnet is shown as being used with a cylindrical iron armature as a kind of rolling gear. In the separator in question there is no such armature; the drum merely rotates by steam in a sort of bed-plate; any iron scraps amongst the refuse that is thrown on to it being carried over to the other side, where they are removed mechanically.

Digitized by Google

*An Electro-magnetic Clutch.*

The next device that I shall allude to is an electro-magnetic clutch (Fig. 17) constructed by the Brush Electric Engineering Company, under the patents of Wynne and Raworth. This clutch consists of a peculiar form of ironclad electro-magnet, being in fact, a loose iron pulley with an unusually solid body, in the face of which a deep and broad rim has been turned to receive the coils of insulated copper wire. Opposite this, acting as the armature, is a stout disc of soft iron, A, firmly keyed upon the shaft. The electric current is conveyed in and out of the coils by means of two metal brushes, B B, shown on the right, which press against two gun-metal collars, C C, embedded in insulating fibre, and which are connected respectively to the two ends of the coil. When it is desired to throw the clutch into gear, all that is needful is to turn on the current, when the electro-magnet-pulley at once grips the iron disc with a grip that may easily be made as much as 100lb. per square inch of surface of contact, and the pulley forthwith turns solidly on the shaft. As the switch for turning on and off the electric current may be placed in any convenient position, either near or far away, it is obvious that this clutch presents many advantages over the mechanical clutches—whether friction-clutches or claw-clutches—that need some kind of striking gear to be affixed to them. For clutches in inaccessible positions on a line of shafting this device is indeed superior to anything ever previously imagined.

*An Electro-magnetic Railway Brake.*

The last contrivance that I shall describe is shown in Fig. 18. This is the electro-magnetic railway brake devised by Prof. George Forbes and Mr. J. Timmis. The ironclad electro-

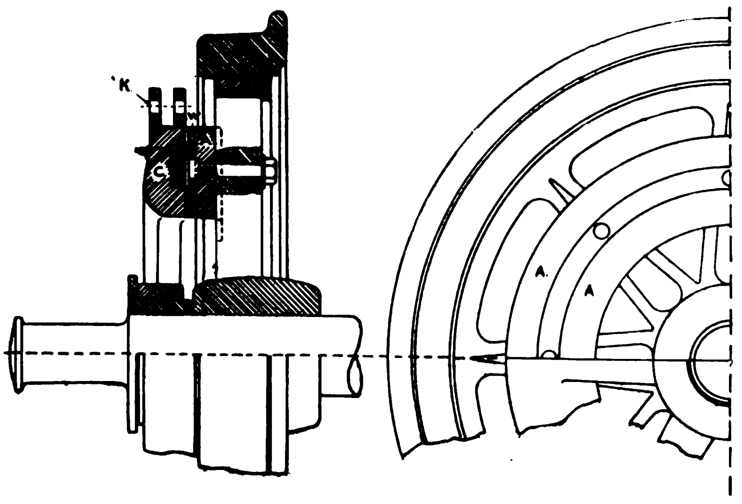



FIG. 18.—Forbes and Timmis' Electro-magnetic Railway Brake.

magnet closely resembles that just described: the core C is a ring of wrought iron, bolted securely to the axle-box by bolts passing through the holes K, and constructed with a deep groove to contain the coils. The armature A A is another ring of iron bolted to the carriage wheel. As in this case there will be much wear of the surfaces in contact, a renewable pair of iron washers, W, in two parts are interposed to serve as pole-pieces. If every wheel of every carriage of a train were provided with such a brake, these could be simultaneously thrown into action by merely turning on the electric current to the whole of them at once.

*Miscellaneous Electro-magnetic Mechanisms.*

Amongst the mechanisms that I shall not attempt to describe are those applied in electric locks, in the keyboards of electrically-worked organs, in the electric weaving machinery, which will, I believe, ere long quite supplant the Jacquard loom, and in various other industrial applications. In all this I have said nothing about the peculiar properties of the alternate current electro-magnet, a topic too vast to be entered upon here.

*Electro-magnetic Machine Tools.*

Nor have I time to do more than allude to the subject of electro-magnetic machine tools, a subject which is destined to come to the front very shortly, now that the industrial supply of electricity is spreading so quickly. Upon the table are a number of blue prints and drawings relating to the machine tools of this class—electro-magnetic drills, electro-magnetic rivetters, and the like—invented by Mr. F. J. Rowan, of Glasgow. Perhaps at some not very distant date it may be the lot of a future president of your Society to award its medal to some one of your members now present for a Paper on electro-magnetic machine tools, even as this year your medal has been awarded for one on hydraulic machine tools.

*Classification of Electro-magnetic Mechanisms.*

Now this wide topic of electro-magnetic mechanism, into which I have endeavoured to give you some insight, is one that requires to be reduced to a system. A classification I have, indeed, attempted, but it is as yet little more than an enumeration of the various forms. Such as it is I will print it with this address (see Appendix), that you may at least know in outline what has been done in the way of classification. I have already gone further, and have attempted to aid the analytical and synthetical study of the subject by a sort of notation, which, however, is not yet in a shape fit for publication. The fact is that we want some one to do for the subject of electro-magnetic mechanism what Willis and Reuleaux achieved for the subject of mechanical mechanism. It is nigh fifty years since Willis at Cambridge reduced to something like a system the subject of mechanism in general, which previously to his time had been subjected to no such systematic treatment. And it is nearly five-and-twenty years since Reuleaux, of whom your former President, Prof. Kennedy, is the exponent in this country, produced that wonderful book, "The Kinematics of Machinery," in which all possible mechanical combinations are reduced to a system of kinematical pairs and chains. I am, as yet, very far from having analysed down the topic of electro-magnetic mechanism to a consistent system; and it is quite possible that I may not succeed in doing so. Yet, whenever the man and the hour arrive that shall achieve this, there will have been achieved a work of no little importance. For the systematisation of knowledge is a work that brings in its own abundant reward in the fact that it always renders further practical advances possible in the not distant future.

APPENDIX.

*Enumeration of Electro-magnetic Mechanisms.*

I. *Electro-magnets*—
- A. Fixed coil and core; moving armature.
  1. Short compact magnetic circuit, for traction in contact.
  2. Elongated circuit and heavier coil, for attraction at distance.
  3. Special forms: Iron-clad, club-footed, laminated, consequent, multipolar, &c.
- B. Fixed tubular coil and moving plunger.
  1. Plunger longer than coil.
  2. Plunger shorter than coil.
  3. Special forms of plunger, coned, laminated, &c.
  4. Coil constructed in sections for successive action.
- C. Intermediate forms.
- D. Fixed tubular coil and movable coil.

II. *Electro-magnets with Opposing Forces*—
1. Counterpoise springs.
2. Counterpoise weights.

III. *Equalisers for Electro-magnets*—
1. Electrical equalisers.
2. Set-up springs.
3. Rocking levers.
4. Linkage movements.
5. Cam equalisers with shaped polar faces.

IV. *Electro-magnetic Cams.* Devices depending on the lateral approach of a shaped polar surface.

V. *Electro-magnetic Linkages.* Devices depending upon the mutual interaction of two or more separate electro-magnets.

VI. *Apparatus Depending on Electro-magnetic Repulsion*—
1. Mutual repulsion of parallel cores.
2. Elongation of jointed or tubular cores.

VII. *Polarised Electro-magnetic Devices*—
1. Electro-magnet with parallel polarised armature.
2. Electro-magnet with transverse polarised armature.
3. Coil with polarised plunger.
4. Polarised electro-magnet with counterpoise spring (Hughes magnet)

VIII. *Electro-magnetic Vibrators*—
- A. Non-polarised.
  1. Break-circuit.
  2. Short-circuit.
  3. Differentially-wound.
- B. Polarised.
  1. Single acting.
  2. Moving part polarised.
  3. Fixed part polarised'

Digitized by Google

IX. *Rotatory Electro-magnetic Devices*—

1. Coil fixed, needle moving.
2. Magnet fixed, coil moving.
3. Coil fixed, coil moving.
4. Electro-magnet with obliquely pivoted armature.
5. Wire rotating round magnet pole.
6. Copper disc rotating between magnet poles.
7. Pole rotating round conducting wire.
8. Magnet rotating on itself when carrying current.
9. Curved tubular coil and S-shaped plunger,
10. Oblique approach of armature.

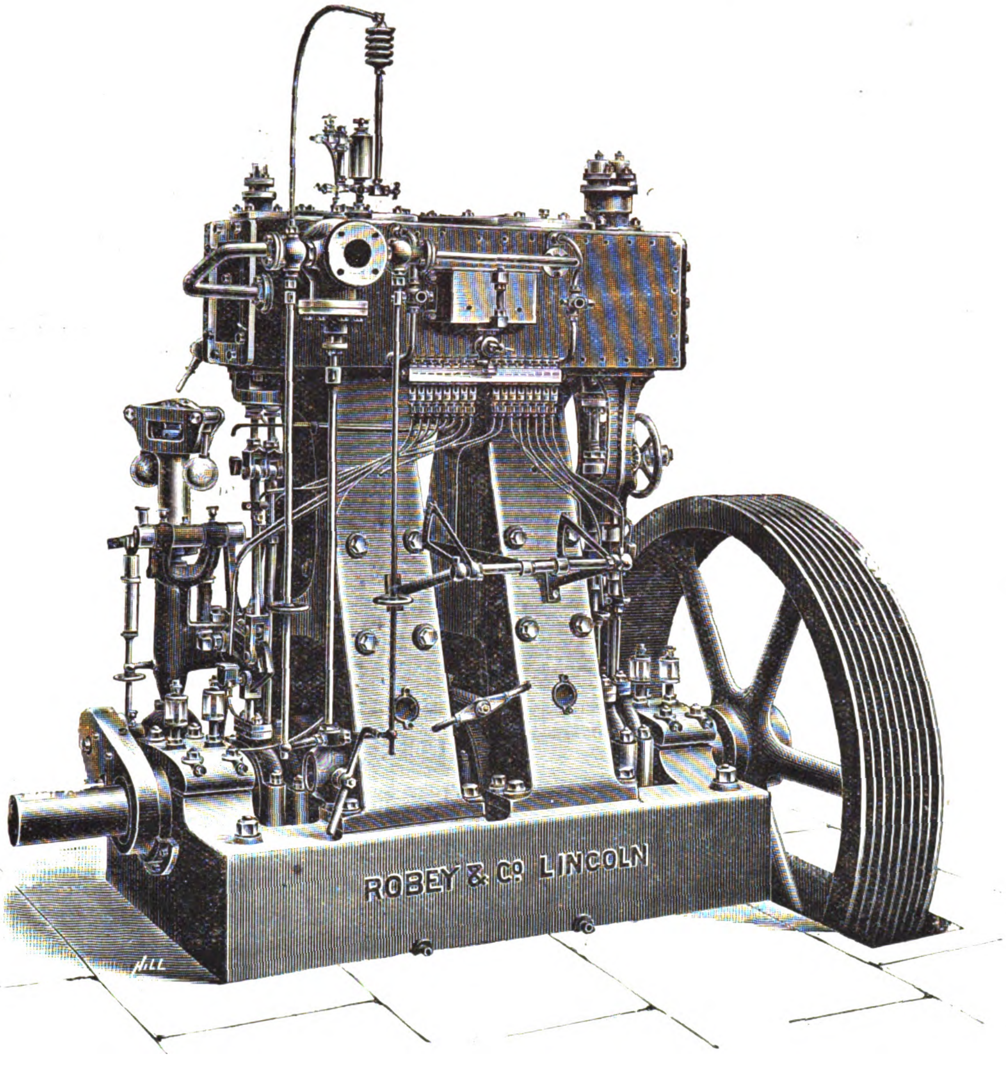
10*a*. Wheatstone's cam armature.
10*b*. Froment's armature constrained around centre.

X. *Electro-magnetic Adherence*—

1. Magnetic friction gear.
2. Magnetic brakes for vehicles.
3. Magnetic clutches.

XI. *Alternate-current Devices*—

1. Copper conductors repelled from pole.
2. Shading of pole by copper screen.
3. Vertical rotation of magnetic field by two currents at angle in different phases.




High-speed Compound Engine.

## ROBEY AND COMPANY'S HIGH-SPEED COMPOUND ENGINE.

The engine shown in the accompanying illustration has been made for the Newcastle-on-Tyne Electric Supply Company, and is used to drive a 37½ unit Mordey Victoria alternator developing 70 to 75 horse-power at 200 revolutions per minute. The high-pressure cylinder is 11in. diameter, and the low pressure is 18in., with a 12in. stroke. The shaft, which is 6in. diameter, is carried in three bearings of ample dimensions, lubricated, together with all other moving parts, by sight feeds supplied from a single oil-box fitted with a gauge. The big ends of the connecting rods are provided with centrifugal oilers, and the main standards prevent oil being flung from the cranks. The frame is very massive, and the balancing of the parts together with proper setting of the valves enable the engine to run without vibration at a high speed. All parts are easily accessible, and the handles of the various valves and levers, including the drain cocks and governor adjustment, are so arranged that they can all be manipulated from one point. The link expansion is automatically governed by a Richardson governor which permits only 2 per cent. variation of speed between full load and light running. This engine is used for the day lighting as well as in conjunction with three other engines of 200 horse-power by the same makers.

## MEETINGS OF SCIENTIFIC SOCIETIES, &c.

**TUESDAY, January 13th.**

INSTITUTION OF CIVIL ENGINEERS.

*8 p.m.* Paper to be read: "Auxiliary Engines in connection with the Modern Marine Engine," by W. H. ALLEN, A.M.I.C.E. Reception at 9 p.m.

**WEDNESDAY. January 14th.**

SOCIETY OF ARTS.

*8 p.m.* Ordinary Meeting. Paper to be read: "Steam Life-boats," by J. F. GREEN.

**THURSDAY, January 15th.**

INSTITUTION OF ELECTRICAL ENGINEERS.

*8 p.m.* General Meeting. Presidential Address, by WILLIAM CROOKES, F.R.S.

**FRIDAY, January 16th.**

PHYSICAL SOCIETY.

*5.30 p.m.* Papers to be read: "Photo Electricity," by Prof. G. W. MINCHIN, M.A.; "A Lecture Room Method of Determining 'g,' by Prof. BARRETT, B.A.; "On the Change in the Absorption Spectrum of Cobalt Glass produced by Heat," by Sir JOHN CONROY, Bart., M.A.

INSTITUTION OF CIVIL ENGINEERS.

*7.30 p.m.* Students' Meeting. Paper to be read: "On a Survey of the Bed of Sutton Pool, Plymouth," by R. G. HANSFORD WORTH, Stud. Inst. C.E.

Digitized by Google

# The Electrician.

**Published every Friday, Price Fourpence; Post Free, Fourpence Halfpenny.**
**Editorial, Publishing, and Printing Offices:**
**SALISBURY COURT, FLEET ST., LONDON, E.C.**
*Telephone No.* 2714. *Telegrams:* "ELECTRICIAN NEWSPAPER, LONDON."

*All Letters relating to Subscriptions, Advertisements and other business matters should be addressed to the Publisher,* "THE ELECTRICIAN," *Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to* "THE ELECTRICIAN" *Printing and Publishing Company, Limited, and be crossed* "*Coutts and Co.*" *All other letters to be addressed to the Editor.*

*All letters intended for insertion in* "THE ELECTRICIAN," *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

"THE ELECTRICIAN" *is published every Friday morning, in time for the morning mails. Subscribers should receive their copies by the first post on Friday morning.*

"THE ELECTRICIAN" *is on sale at the railway bookstalls throughout the Kingdom on Friday morning, and can be obtained of all Booksellers and Newsvendors; or direct from the Publishing Offices as above.*

*New Volumes of* "THE ELECTRICIAN" *commence in May and November.*

## SUBSCRIPTION RATES.

The rates for Subscriptions to "THE ELECTRICIAN" are as follows:—

| | 3 months. s. d. | 6 months. s. d. | 12 months. s. d. |
|---|---|---|---|
| For the United Kingdom | 5 0 | 10 0 | 19 6 |
| For Foreign Parts and Colonies:— | | | |
| Within Postal Union | 6 6 | 12 6 | 24 0 |
| Aden Borneo, Ceylon, China, India, Japan, Java, Labuan, Mozambique, New Caledonia, Persia, Philippine Islands, Siam, Transvaal, and Zanzibar | 7 6 | 14 6 | 28 0 |

## TO ADVERTISERS.

"THE ELECTRICIAN" *offers exceptional advantages to Advertisers.* **It has by far the largest circulation of any English Electrical paper, and circulates all over the World.**

*Particulars relating to Advertisements will be promptly forwarded on application to the Offices as above.*

TRADE ADVERTISEMENTS *intended for the current issue must reach the Offices not later than First Post on Thursday morning. Renewals of expiring advertisement orders and alterations to standing advertisements should be in the Publisher's hands by Wednesday at latest. No alteration can be made in Wrapper advertisements after Wednesday evening.*

SMALL PREPAID ADVERTISEMENTS *(for Rates see page xvii.) are accepted up to 4 p.m. on Thursday.*

## TECHNICAL PRINTING.

"THE ELECTRICIAN" PRINTING AND PUBLISHING COMPANY (LIMITED) *inform Electricians, Electric Light Engineers, &c., that they make a specialty of Technical Printing, and have a large Staff thoroughly acquainted with Electro-Technology. They can, therefore, promise Accuracy and Despatch in the Printing of Electro-Technical Literature, &c.*

## "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. (Royal 8vo.)

*Early in each year is issued* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. *The* DIRECTORY *was established in 1883, and the 1890 Edition consisted of about 850 pages of printed matter. The names and addresses of all persons engaged in the Electrical Industries at home and abroad may be relied upon as accurate. Useful Tables and Electrical Formulæ, and information specially compiled for this work are given, together with popularly-written Biographical Notices of the leading Electricians, Electrical Engineers, &c., accompanied in many cases by Portraits.*

*The 1891 Edition is now actively preparing, and Subscription and Advertisement Orders, New Names, Corrections, &c., can be received.*

## ELECTRICAL BOOKS AND PUBLICATIONS.

*All Books, Newspapers, and other publications, dealing with Electrical and kindred subjects, can be ordered direct of* "THE ELECTRICIAN" *Printing and Publishing Company, who are proprietors of the well-known* "ELECTRICIAN" *Series of Standard Electrical Works, and are agents for all the leading publishing houses at home and abroad.*

## CONTENTS OF THE CURRENT NUMBER.

NOTES ... 285
Magnetism in Iron and other Metals.—XXXIX. By Prof. J. A. Ewing, F.R.S. Illustrated. Continued ... 291
The International Telegraph Bureau at Berne ... 292
An Improved Process for the Production of Copper ... 292
Electro-Magnetic Mechanisms. By Prof. S. P. Thompson, D.Sc., B.A. Illustrated. Concluded ... 293
Robey and Company's High-speed Compound Engine. Illustrated ... 297
Meetings of Scientific Societies. 297
ALTERNATING CURRENTS AND MATHEMATICS ... 298
Electrical Distribution by Transformers from Central and Eccentric Stations. By Dr. J. A. Fleming, M.A. Illustrated. Continued ... 300
On the Measurement of Electro-Magnetic Radiation. By C. V. Boys, F.R.S., A. E. Briscoe, and W. Watson, B.Sc. Illus. 302
Inductance and its Proposed Unit the Henry. By A. E. Kennelly. Illus. Concluded 305
Lubricating Oil. By A. C. J. Charlier ... 308
The "Monarch" Magnetic Separator. By C. M. Ball. Illus. 309
The International Electrical Exhibition at Frankfort-on-Main ... 310
Some Observations on the Existence of Residual Magnetism in Telephones. By S. Kalischer ... 311
Borough of Nottingham Electric Lighting ... 311
Books Received ... 311
American Notes ... 312
Trade Notes and Notices ... 312
PATENT RECORD ... 313
COMPANIES' MEETINGS, &c.—
Eastern Telegraph Company (Limited) ... 314
Woodhouse and Rawson United (Limited) ... 314
New Companies Registered ... 314
City Notes, &c. ... 314
Companies' Share List ... 315

## SPECIAL NOTICE.

**With the Next Number of "THE ELECTRICIAN" we shall issue a fine Steel-Plate Portrait of Mr. WILLIAM CROOKES, F.R.S.**

## ALTERNATING CURRENTS AND MATHEMATICS.

That branch of electrical engineering which deals with alternating currents presents some difficulties to every non-mathematical engineer and to many students. To any of the latter who are still engaged in the lecture-room and laboratory, it all comes in the day's work, and while they cannot shirk it like the professional man, who says that he prefers continuous currents, they should realise that they have opportunities for mastering the subject which he never had. In alternating work, Ohm's law fails to be a trusty guide volts and amperes can no longer be simply multiplied together to give the watts, nor can they be measured by some of the well tried instruments. Iron wire resistances do not behave with their old regularity, and are sometimes replaced by noisy choking coils about which no text-book gives information. In alternating current work we meet with various quantities which, though they always exist, are generally negligible, since they only come in play at the make and break, or the change of strength of the current. If we look for some plain rule such as that which connects a simple current with volts and ohms we find but little comfort in the admirable equation which would have formed the last line of page 259 in our issue of January 2nd, had the column been wide enough; and whose beauty is considerably marred by being cut in two portions. This formula starts bravely, but seems to expire with a sigh, and then begins again with a minus sign, and contains the expressions $G_0$ and $H_0$ which have not been referred to before. On turning to the next page, some of the symbols are pleasantly expanded, but the $G_0$ and the $H_0$ about which the careful reader has been wondering, are found to be merely "certain complicated functions of the inductances, resistances, and capacity,"

"and $\theta$ is likewise a function of all these quantities." But why, it may be asked, should this equation be particularly comforting to the engineer who contemplates a journey into this region of ohmic anarchy, and who only dimly recognises $\sqrt{R^2+p^2 L^2}$ as an obscure obstruction called "impedance." Dr. FLEMING's opinion of its value is the answer, "this equation may be looked upon as a kind of glorified Ohm's law," by means of which all troublesome questions, whether treating of unexpected rise of pressure in FERRANTI mains, or retardation of signalling in cables, or difficulties in telephony, or, indeed, the behaviour of any apparatus joined by any kind of conductor, may be duly solved.

This formula is, we understand, the outcome of an enormous amount of work of the most arduous nature, and has entailed an expenditure of labour comparable indeed with the potential value of the result, but which at present will not be readily appreciated by everybody. It not unfrequently happens that the mathematician has not the good fortune to come into contact with practical work. He must therefore leave to others who have to use his figures the finishing touches which they need; and few will welcome more than he the practical realizations of his predictions. One reason why the busy engineer does not properly value such work as this is, that it is not left by the able analyst in a fit state for him to use. An equation containing one or two functions whose values have not been calculated is useless, and he demands a table of the constants, or clear directions for ascertaining them. To a mathematician, the formula is generally a finished piece of work, but to the engineer it is a tool. To make the tool practically useful it must be sharpened. It is the custom among tool-makers to sell their wares unground, and mathematicians not infrequently turn out their formulæ in an equally unfinished state.

Under these circumstances it is not surprising if certain electrical engineers in good practice should stoutly set their faces against this new-fangled system, and though they may not fully appreciate the demolition of Dr. FRANKLAND's complicated theory of sub-sulphates by Dr. GLADSTONE and Mr. HIBBERT, they give their adhesion to continuous currents and storage batteries, and decline to enter into any dealings with the alternating demon, merely because they are alarmed at the bristling equations and horrid formulæ.

There may exist, though we have not yet met him, a rule-of-thumb alternate-current engineer. We know plenty of continuous-current men who manage to get along pretty well although they have a remarkably small acquaintance with any kind of science or mathematics, and who do their work well, and we may say conscientiously, though it may be thought that they have no business to attempt to do work which they cannot properly understand. But is there, indeed, anything that anybody may be said to properly understand? The hope has been expressed that the spread of the alternating-current system will raise the standard of education of the electrical engineer. But some people may feel discouraged, because they know that they have neither inclination nor aptitude for such mathematical work as is to be found, for example, in the recent contributions of Mr. GLAZEBROOK, Mr. SWINBURNE, and Dr. FLEMING, and that, as the teaching of useful geometry is as yet almost unknown in this country, they cannot even appreciate the graphical methods with which Mr. KAPP and Mr. BLAKESLEY have treated the same subject. To these we would offer encouragement by quoting a passage from an essay by J. HINTON, on "The Two Sides of a Thing:" The immense number of new facts which science accumulates year by year, the unanticipated results which it meets at every turn. . . All these seem as if they would merely overwhelm the mind, and leave it utterly lost amid the wages of its own wealth. And they would assuredly have this effect if there were not another process continually going on in science, at the same time, with this multiplication of its materials and extension of its view. This process is the simplification of the ideas, around which these ever-multiplying facts are grouped. . . So constant, and, indeed, inevitable is this process, that it is no exaggeration to say that when a branch of science has attained a certain perfection, the more facts and details it contains, the easier it will be to understand. The multiplied and almost unmeaning series of phenomena receive expression in a law which most probably is self-evident, or at any rate is capable of being easily apprehended."

There are different opinions as to which of two methods is the more easy. Some persons prefer long multiplication to logarithms because they are familiar with the one and have not learned the other. Logarithms, as generally taught, are perfectly useless, and there are hundreds of school-boys who can define what a logarithm is, and can explain characteristics and mantissæ, and could calculate a simple log or two, but who have never seen a table of logarithms, and who are utterly unable to use one quickly enough for ordinary purposes. On the other hand, the majority of engineers who use them in daily work have forgotten, if they ever knew what logarithms really are, and not one in a hundred could explain how Napier arrived at the base $e$, 2·71828, or what he did with it when he got it. The common method of teaching logarithms is enough to make a student think that it is a difficult and clumsy method of multiplication. Similarly with higher mathematics. Their introduction does not really make the problem more difficult, but they make easy that which cannot be done by lower mathematics, except occasionally by lengthy roundabout ways. Algebra is a capital thing when it can be used, and geometry, in our opinion, is still better, but many problems cannot be solved by algebra alone, and geometry, as we have said, is in far too crude a state at present to be of much assistance. But before attempting any of the problems to which we refer, it is first absolutely necessary to have a clear conception of the meaning of the terms employed, and of the quantities which they denote.

We recommend to the student and to the aforesaid engineer the clear explanation of the quantity known as a time-constant in connection with Fig. 3, in Mr. KENNELLY's Paper. The expression, like those of time integral and line integral is one that falls easily from a mathematician, and unlike the use of a reflecting galvanometer for lecture purposes, is more impressive than convincing. To anyone who is not only thoroughly familiar with mathematical language, but accustomed to think of simple phenomena in a mathematical manner, to speak of the time integral of the charging current of an accumulator may be very natural. Such an one would probably condemn the expression ampere-hour as being unscientific, but at the worst it is tautological. If a real knowledge of alternate current phenomena is to spread among practical engineers, and if a number of theorists who alone can master their principles are not to spring up, it is necessary that the explanation of their development should be treated in the simple manner of Mr. KENNELLY's Paper.

In Mr. KENNELLY's present article we would observe that the symbol H, which he suggests for a "henry," too closely resembles **H**, which has been well nigh unanimously adopted as denoting magnetising force, having superseded the $\mathfrak{H}$ which was used by MAXWELL and others, and that the symbol L is always used in this country for inductance, or self-induction as it was called before Mr. HEAVISIDE gave us the shorter

Digitized by Google

and more general name. Some months ago Prof. Ayrton rose at a meeting and held up a coil of wire and asked who could express its self-induction in terms of a length. The idea was then comparatively new, nor have secohms and quadrants since that date been often heard of outside the lecture rooms and mathematical papers. But now that the expression is beginning to come into use under the name "henry," the time has come for it to take its place among ohms and volts. Engineers who have no time for higher mathematics, do not willingly accept expressions of which they cannot grasp the common-sense meaning, and Mr. Kennelly supplies this want by a large number of instances from practice of the value of the inductance in "henrys" of various well-known instruments. To facilitate a more common acquaintance with the "henry," we have extracted these values and have placed them in our Notes column. Mr. Kennelly is inclined to think that because millihenrys are more frequently to be found in practice than whole henrys, the henry should be the thousandth of an earth quadrant; but we are glad to see that in spite of this suggestion, he respects the resolution of the Paris Congress that the practical unit should be a thousandth million centimetres, and the resolution of the American Institute which has adopted that length under the name "henry."

## ELECTRICAL DISTRIBUTION BY TRANSFORMERS FROM CENTRAL AND ECCENTRIC STATIONS.*

BY DR. J. A. FLEMING, M.A.

*(Continued from page 257.)*

### Station Appliances in the Thomson-Houston System.

*Earth Detector.*—Every switch-board is provided with an earth-detector, by means of which an "earth" or "ground" may be detected if it exists on the primary mains. This apparatus is shown in Fig. 19. It consists of a small transformer, mounted on a board with a lamp on its secondary circuit and a two-way switch. One end of the primary wire of this small transformer is permanently connected "to earth," and the other primary terminal can be connected by the switch to one or other of the two primary mains at pleasure. If an earth exists on one side of the main primary circuit then when the testing transformer has its one pole put on to the other main, the lamp in its secondary circuit will light up, because the current finds its way across the earth and flows through the primary coil of the testing transformer. The lighting of the lamp when the switch has one position or the other not only indicates a "ground," but shows which primary main it is on, provided that the fault is of sufficient magnitude to let out primary current enough to operate the lamp on the secondary of the testing transformer.

*Station Transformers.*—On the switchboard is also mounted a transformer which provides current for lamps to light the switchboard, and also by connection with a voltmeter, enables the primary pressure in the station to be measured.

*Lightning Arrestors.*—All overhead primary circuits are provided with lightning arrestors, both at the station end of the line and at the transformers. The principle of these instruments, of which the station lightning arrestor is shown in perspective in Fig. 20, is the same as that of the well-known Thomson-Houston lightning arrestor which has been so long and successfully used in connection with the arc-light system of the Thomson-Houston Company. This arc-circuit lightning arrestor is shown in Fig. 21, and consists of an electro-magnet, the coils of which are in series with arc-light circuit. In part of the poles of this magnet, but well insulated from them, are a pair of curved metallic horns.* One of these horns is in connection with the line and the other in connection with the earth. If a lighting discharge strikes the line, the inductance of the electro-magnet blocks the path of the discharge, and it leaps across the air space between the horns and goes to earth. In doing this, it would start an arc between the horns, were it not for the fact that a strong magnetic field is produced by the electromagnet in this air space, the lines of force of which are perpendicular to the path of the discharge. The arc is, therefore, pushed forward along the curved horns, and finally blown out or extinguished. This highly ingenious apparatus stands guard over the arc-light dynamo; and, by placing one on each end of the arc line, the dynamo and switchboard is effectually protected from discharge of lightning. Quite the same principle is applied in the station and transformer lightning guards shown in Figs. 20 and 22. The connections of the transformer guard are shown in Fig. 22. The two primary wires proceeding to a transformer enter the lightning protector at the terminals *a b*, and are connected with the transformer through the pipe *c*. To each of the terminals *a* and *b* is connected one end of the coil of an electro-magnet *d*, the other

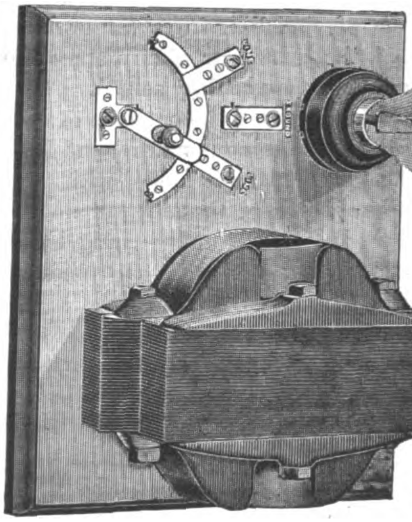


Fig. 19.—Ground Detector.

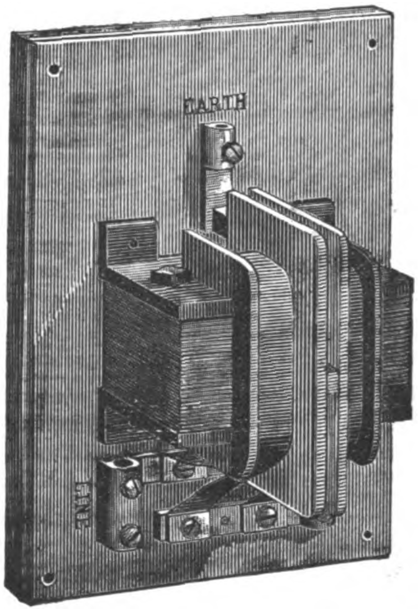



Fig. 20.—Station Lightning Arrester.

* All rights are reserved.

* For the use of this block (Fig. 21) the writer is indebted to Messrs. Laing, Wharton, and Down, and he takes the opportunity at the same time of acknowledging the kindness of Mr. J. W. Kirkland, of the Thomson-Houston Electric Light Company, in the United States, in furnishing, by permission of Prof. Elihu Thomson, sketches and detailed information on the Thomson-Houston system, which has rendered it possible to make the above descriptions much more complete than they would otherwise have been.

Digitized by Google

end of which is attached to a terminal placed near to a metal plate connected to earth. If a lightning discharge strikes the line it could cause an arc to start between the earth plate and each of the terminals of the electro-magnet coils near it. These magnets are, however, so arranged that the magnetic field created by the current then started through them will blow out the arc and stop the discharge. All transformers which are fed from overhead primary lines are protected in this manner.

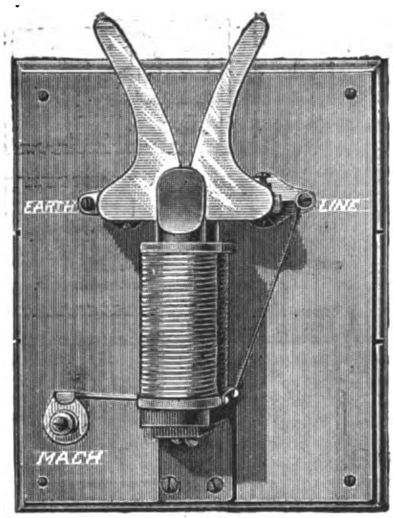



Fig. 21.—Thomson-Houston Arc-Line Lightning Protector.

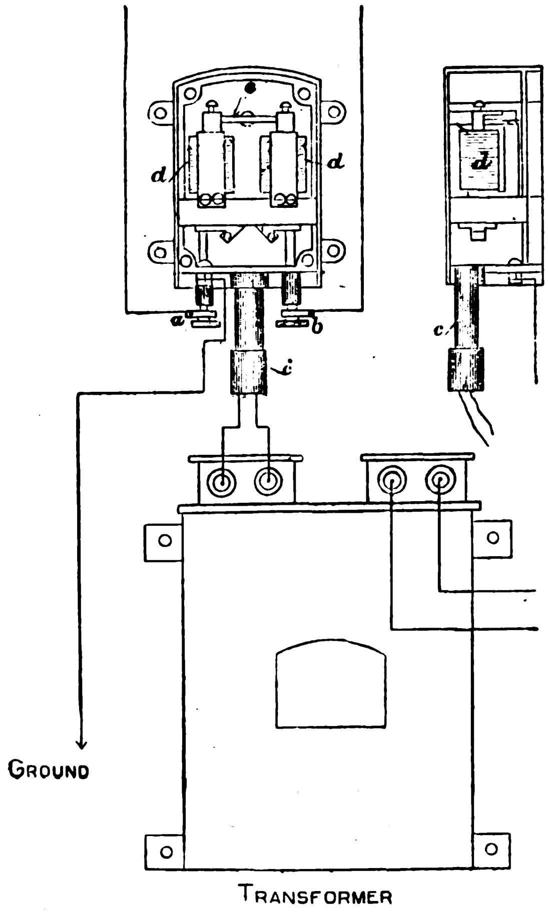



Fig. 22.—Connections of Transformer Lightning Arrestor.

*Distribution System.*—A very large portion of the transformer lighting of the Thomson-Houston Company in the United States is carried on by means of overhead or aerial primary lines. The usual working pressure on the primary circuits is 1,000 volts. In setting out these lines several main primary lines are run to iron feeder boxes (*see* Fig. 23) and from these boxes distribution primary lines are run to groups of transformers. Fuse wires or cut-outs are inserted in the feeder boxes. The transformers are placed in the buildings or are attached to the external walls of buildings, and these transformers are enclosed in cast-iron boxes which have weather, tight lids at both ends covering receptacles in which are placed the primary and secondary fuse wires of the transformers. The secondary fuse wires are generally mounted on a porcelain base and the primary on an ebonite slab. A special switch permits the transformer to be cut out of circuit whilst changing the fuses.

A general plan of an installation of alternating current apparatus is shown in Fig. 24. Starting from the station the wiring is as follows:—

The primary lines, protected by station lightning arrestors, are run from the dynamo to the centres of distribution where feeder boxes containing the necessary safety fuses are interposed, and from which run the mains for the supply of the transformers and lamps.

Before the current for any group of lamps is taken to the transformer, it passes through a junction box, from which the lines lead directly to the primary connections of the transformer. To the secondaries of the transformers, the wires for the direct supply of the lamps are attached. Before the current reaches the lamps it passes a double pole cut-out box provided with safety fuses and the automatic protection device.

In every installation of alternating current apparatus, use is made of transformer lightning arrestors, connected as shown in the diagram. Each feeder box has a sliding glass cover, which

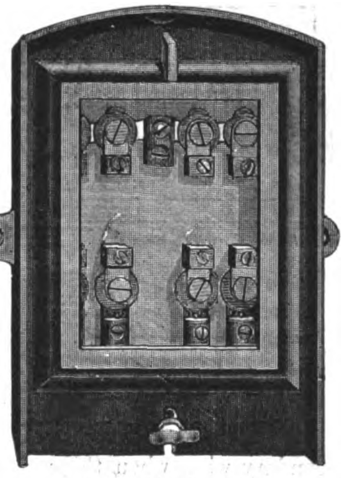


Fig. 23.—Feeder Box.

can be easily removed to replace or change fuses, and permits of a ready examination of the interior. The connections are so arranged that the box may be cut completely out of circuit during such changes.

The Thomson-Houston Electric Company, in all installations of alternating current apparatus for incandescent lighting, employs the Thomson Protective Device (shown in Fig. 25). It is a simple but effective appliance for removing the possibility of accident which might arise from contact with the secondary circuit.

There are three conditions which must be simultaneously satisfied before this possibility can be said to exist.

1. There must be a ground on the primary wires.
2. There must be a contact between the primary and secondary coil in the transformer.
3. The person must be in contact with the secondary and with the earth at the same time.

The fulfilment of the first of the above conditions is of not uncommon occurrence, but the presence of a ground can be easily detected, and means can be at once taken to remedy the trouble.

The second condition is met with seldom, and is only liable to occur when transformers are injured or subjected to rough usage in shipment.

The remoteness of liability to accident is quite apparent when it is remembered that these conditions must be simultaneously satisfied, and even then the extent of the injury

Digitized by Google

depends upon the relative position of the contacts with reference to the two primaries.

As the fulfilment of the above conditions is, of course, not beyond the range of possibility, the device herewith described has been designed to prevent any injury resulting from a contact with the secondary wires when these requirements are fulfilled. It consists of three base terminals, to the central one of which is rigidly attached a flat brass spring pressing against the two outside terminals, but normally held out of contact with them by slips of Thomson paper film. This paper film is very carefully prepared so that it readily withstands the pressure of the spring, but is instantly ruptured when the first and second conditions, mentioned above, are satisfied. To the central terminal is attached, by means of a binding screw, a wire connected with the earth. To the outside terminals the secondaries are led directly from the transformer. The paper film is perfectly insulating for the pressure of the secondary current, but if the difference of potential between the earth, with which the brass spring is in contact, and either one of the terminals, to which the secondaries are attached, should rise beyond the normal pressure, the paper film is at once punctured. This results in short-circuiting the secondary, which causes the primary fuse to blow, thereby cutting out the entire circuit.

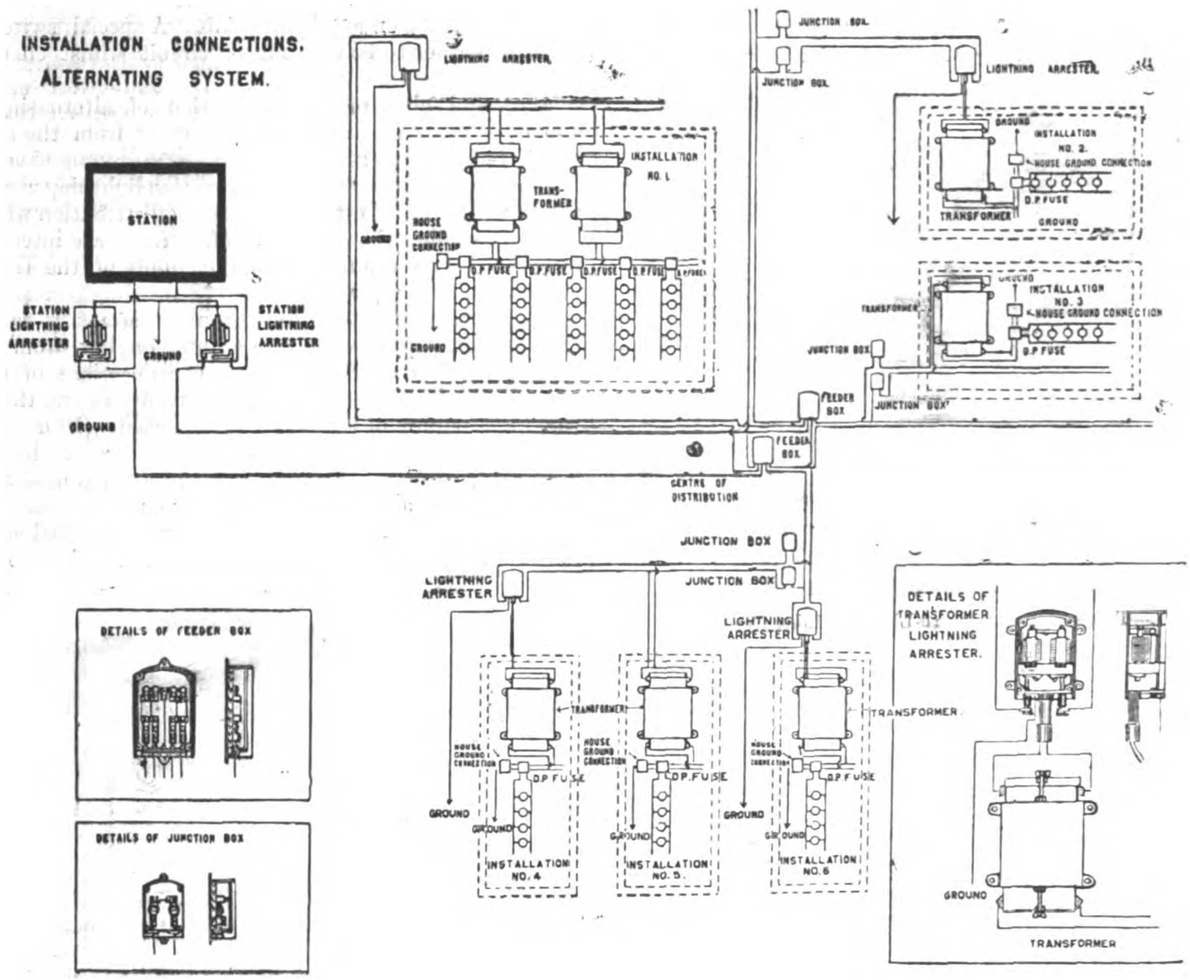



Fig. 24.

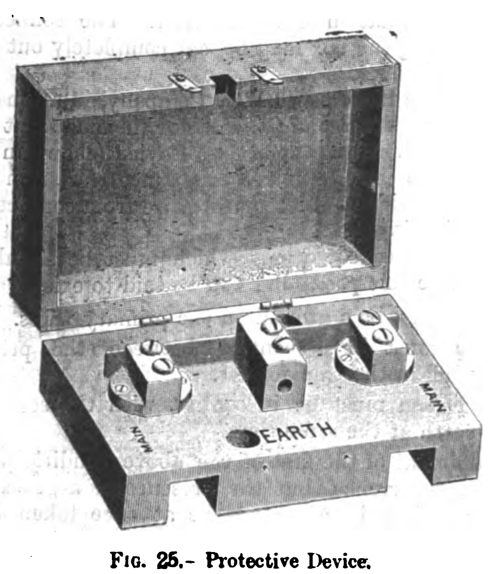



Fig. 25.- Protective Device.

(*To be continued.*)

## ON THE MEASUREMENT OF ELECTRO-MAGNETIC RADIATION.*

BY C. V. BOYS, F.R.S., A. E. BRISCOE, AND W. WATSON, B.SC.

At the time that Mr. Gregory described and exhibited his "Electric Radiation Meter" †, which indicated and measured electro-magnetic radiation by the increase in length of a fine platinum wire stretched in a glass tube in consequence of the heat developed by the induced currents within it, one of us expressed the view that it would be interesting to confirm by some independent method the conclusion that the wire was lengthened by heat, as it was not absolutely certain, though exceedingly probable, that the increase in length might not be apparent only and not real.

The following is an account of experiments made by two independent methods, with the view of finding whether the expansion observed by Mr. Gregory was such as might be expected from the induced currents.

* From the *Phil. Mag.*, communicated by the Physical Society; read June 20, 1890.

† *Phil. Mag.*, January, 1890; *Electrician*, Vol. XXIV., p. 16.

Digitized by Google

FIRST METHOD.

Imagine two straight wires parallel and near together, but not touching one another or any conductor. Let them be placed parallel to and at a convenient distance from a cylindrical rod of the same length as either of the wires. Then, if electrical oscillations are started in this rod by any well-known method, the two wires will act as resonators, and induced oscillations will occur in them, not necessarily in absolutely the opposite phase to the oscillations in the primary, but at any rate in the same phase in the two wires, so that the electricity in each will surge up and down at the same time. If, then, the ordinary theories of electro-dynamic and electrostatic action apply in the present case, which may be true or may not, then the currents going up together and down together will attract one another, while the charges resting chiefly at the two ends, being at one moment + above and − below, and at the next moment reversed, will repel one another. Owing to the harmonic distributions of the current and the charges, the electro-dynamic attraction will be mainly in the middle parts, while the electrostatic repulsion will be mainly at the two ends. Further, both these distributions vary harmonically with the time, and are a quarter-period removed from one another; but the integral effect of each is equivalent to a steady force, and the quarter-period difference of phase has no influence as far as forces are concerned.

In order to realise what these forces are, and what are the relations between them, it will be necessary to consider them separately.

(1) *Electro-dynamic Attraction.*—Let the wires be supposed to be very close together, so that the force felt by any element is almost entirely due to those elements of the other wire which are so close to it that the variation of the current strength in those elements along the wire is inconsiderable. Now, if the distance apart is $d$,

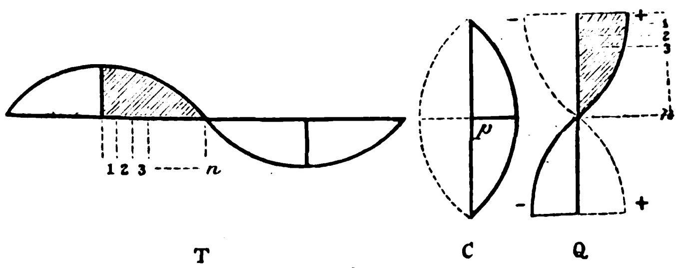



FIG. 1.

if $c$ is the strength of the current at any moment (measured electro dynamically), and if $l$ is the length of the element, the force exerted by the other wire on this element will be $2\frac{c^2 l}{d}$ dynes. But as the current at any point varies harmonically with the time, the average force will be necessarily half the maximum force; therefore the average force on the centre elements will be $\frac{c^2 l}{d}$, if $c$ is the maximum current at the centre.

Since, also, the current varies harmonically along the wire, the average force per unit length over the whole wire will be half that at the centre; so that the attraction between the wires will be $\frac{c^2 L}{2d}$, where L is the whole length of the wire.

(2) *Electrostatic Repulsion.*—In the same way, if $q$ is the quantity of electricity (measured electrostatically) on unit length at any part of the wire, the force of repulsion upon an element at any moment will be $2\frac{q^2 l}{d}$, the average force on this element will be $\frac{q^2 l}{d}$, and the total repulsion between the wires will be $\frac{q^2 L}{2d}$.

Now to find the relation between these it is necessary to remember that the wires are resonators; that is, the oscillations follow the natural period and are not forced. Also that the total quantity of electricity on one half of the wire is the integral of the current that has passed the middle point. Although there is no difficulty in finding the relation between the attraction and repulsion, the following graphic method may be worth giving. In order to simplify matters, the resonator will at first be supposed of such a length that the oscillations occur at the rate of one a second, *i.e.*, it will be supposed to be $\frac{1}{2}$ of $3 \times 10^{10}$ centim. long; also the maximum current at the centre will be supposed unity. Now let the vertical line in C (Fig. 1) represent the wire, and the distance of the harmonic curve from it at any point the strength of the current at that point when it is at a maximum.

In the same way, let the distance of the harmonic curve in Q from the wire at any point represent the charge at that point a quarter-period later, at which time it is at a maximum; then the total quantity on one end, represented by the shaded area, is the integral of the current which has passed the middle point $p$. Now this current varies harmonically with the time, as shown in the time-diagram T. This is divided into four equal parts. Thus the first represents (say) an upward current rising from zero to its maximum; this just neutralises the previously charged wire. Then, in the second period, the continuation of the current produces an equal and opposite charge, which is a maximum when the current has become zero. In the third period, the current in the opposite direction has again neutralised the charges by the time that it is a maximum; and in the fourth period, it charges the upper end negatively and has ceased to flow when the negative charge is a maximum.

Now divide the second period of the time-diagram of current T, into $n$ ($=\frac{1}{4}$ of $3 \times 10^{10}$) elements, and the upper half of the wire in the quantity-diagram, Q, into the same number of equal parts, which will therefore each be one centimetre long. Now, since the total quantity of electricity represented by the shaded part in Q is equal to the time-integral of the current which is represented by the shaded part in diagram T; and since, also, each of these is bounded by a quarter period of a sine curve, and is divided into an equal number of elements, it is clear that each space-element in Q, 1, 2, 3,......$n$, must equal the corresponding time-element in T; or, in words, though the quantity of electricity that has passed the point $p$ in the first element of time is spread over the upper half of the wire in Q, and so on, yetat the $n$th element we may consider that that which passed during the first element of time is stored on the element 1; that which passed during the second element of time is stored on the element 2, and so on. Now, since the current-strength in the first element of time is 1, and since this element of time has been made equal to $1/(\frac{1}{4} \times 10^{10})$ second, the quantity of electricity on the end centimetre of wire is $1/(\frac{1}{4} \times 10^{10})$ electro-dynamic unit, or 1 electrostatic unit. This will be repelled by the wire opposite with the same force as that with which the current in the centre element of one wire will be attracted by that in the other wire, both when each is at a maximum and through all the harmonic variations. In the same way, the next element near the end in Q will correspond to the next element near the middle in C, and so on over the whole length of each; and so, since the electro-dynamic attraction over every element in time and space is equal to the electrostatic repulsion in the corresponding element, removed both in time and space by a quarter-period, the total force due to one is equal to the total force due to the other. If any other length of wire is taken, and of course its corresponding period, since the number or length of the elements in both T and Q must vary together, the same result will follow; and if any other strength of maximum current is taken, the attractions and repulsions will be changed to an equal extent, and therefore, if two straight wires are placed so close together that the distance between them is very small compared to their length, they will, when their natural electrical oscillations are induced in them, on the whole neither attract nor repel one another.

It follows from this that, if the oscillations be forced and made too slow, the accumulation of charge on the ends will be greater for a given maximum current than it would be if the period were natural, and therefore the repulsion should overpower the attraction. In the same way, with too rapid vibrations the attraction should overbalance the repulsion. Also since, if the wires are not close together, the electrostatic repulsion will have fallen away in a higher ratio than the electro-dynamic attraction, it would appear that resonators which balance when close should attract one another when at a distance, or that resonators subject to forced oscillations which repel when near might attract at a distance.

Prof. Fitzgerald, when the above theory of the mutual action of resonators was put to him, at once suggested that if the molecules of a body were subject to electrical oscillations it would be possible to imagine a physical cause for their supposed attraction when far, and repulsion when close.

In order to test the matter experimentally, the wires were made of a cranked form, as shown in Fig. 2, so that the ends were on one side of a vertical axis (dotted), and the middle part on the other side. Then, if one is held close to the other, and if the second one is free to turn about the vertical axis, the attraction of the centre and the repulsion of the ends should conspire to produce rotation in the same direction.*

* It may be worth mentioning that the invention of this method was made in a particularly vivid dream, in which I found myself at the black board in the physical lecture-room, explaining that if the two wires were close together, the currents in each would be going up and down together, and so would attract one another, and that in order to make this attraction evident, the wire should be suspended near the axis of rotation, for the reason that where quartz-fibres can be employed there is a greater gain owing to the reduction of moment of inertia than loss by reduction of statical moment. I did not in the dream see that the charges should repel, or the necessity for the cranked form of wire. I may say that this was after Mr. Gregory had described his instrument, but the idea of looking for mutual attraction between a pair of resonators had not before occurred to me.—C. V. B.

Digitized by Google

The first experiment was made with a pair of copper wires each one foot long, bent so that the end parts were each 2½in., the middle part 5in., and the horizontal part 1in. This was suspended in a glass jar by a quartz fibre, so that the vertical axis of rotation was halfway between the ends and the middle portion. An ordinary galvanometer mirror was attached to the rigid glass hook from which the wire was suspended, and this could be seen through a plate-glass window in a torsion-box above the jar. The oscillator consisted of two pieces of brass tube half an inch in diameter with hemispherical ends, each 6in. long in all. This was placed in a vertical position two or three feet away from the wires, and in the plane of the suspended wire, so that it should not act directly upon it. The two parts of the oscillator were connected by very fine wires with the terminals of a Voss machine. Then it was found that when the halves of the oscillator were separated too far for a spark to pass, there was no deflection, while when they were gradually made to approach one another, no motion was visible on the scale until sparks passed, and then the motion was evident enough, the light even going in favourable cases off the scale in the right direction.

However, this was only a preliminary experiment made with materials at hand. It was clear that the material which was most suitable was that which had the highest conductivity for its density, namely, aluminium, and that only the outer surface of the wire could be efficacious, since the oscillations were at the rate of about 500,000,000 a second. Accordingly, thick aluminium wire was rolled into thin ribbon, which was then drawn through successive holes in a draw-plate until a perfect tube, cracked down one side of course, was formed.

We used resonators made of this material in the next experiments, which were made with the view of seeing whether the couple observed was due equally to the repulsion of the ends and attraction of the centre, or if one preponderated over the other. The fixed

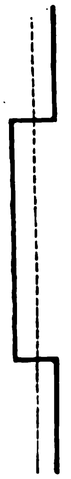


Fig. 2.—One quarter full size.

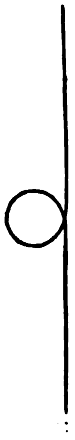


Fig. 3.

cranked resonator was then replaced by a straight one, which was held at first close and opposite to the ends of the suspended cranked resonator, when a strong repulsion was observed, as expected. It was then held in the corresponding position opposite the centre part, when, instead of the expected attraction, feeble repulsion was observed; and finally, on being placed equidistant from the two, the ends were repelled away.

Since this appeared to show that the electrostatic repulsion was much greater than the electro-dynamic attraction, we tried the following experiment, in which the electrostatic action was reduced to practically nothing. A pair of resonators were made of the form shown in Fig. 3, and one was weighted with a non-conductor and suspended so that the straight part was in the axis of rotation. The other was then held with the curl close and parallel to the curl of the other, and so that at first the current in each should go round the same way, and then in opposite ways. No action was observed in either case. When also cranked or straight resonators were entirely immersed in water no effect at all was observed.

We have given a short account of the early experiments because at first they were so completely in accord with the result of the theory put forward, though the action was more powerful than had been expected, that for a time we were deceived as to the real cause, and we wish to guard others from falling into what is after all a very obvious error. The later experiments showed either that the theory was only true as regards electrostatical repulsion, the electro-dynamic attraction of the momentary currents being *nil*, or else that the results already obtained were spurious.

We have stated that the two resonators were suspended in a glass jar, outside which the primary oscillator was placed, and that while no repulsion was observed during the gradual charging of the oscillator-ends to a higher potential than that employed with the sparks, yet the moment the sparks passed when the ends were nearer together, the suspended resonator was observed to move in the expected direction. Now if the glass jar were a conductor, the oscillator-ends might be charged to any extent and no action would be felt inside; if, on the other hand, it were a perfect insulator, then during the charging of the oscillator-ends before the spark the resonators would have induced charges in their ends which would make them repel one another. The glass jar exposed to the moisture of the air was a sufficiently good conductor, on its outer surface at any rate, to be able to screen the statical action of the charges on the oscillator-ends which were by the arrangement only slowly made to vary, and so the repulsion which might have been looked for was not observed; but the moment a spark passed in the primary, the conditions were changed. The fall of potential was instantaneous, but the screening charge on the glass surface, which the previous moment produced within the jar an effect equal and opposite to that of the charges on the oscillator-ends, was unable instantly to disappear owing to the imperfectly conducting surface of the damp glass, and thus at this moment the resonators were in the condition that they would have been in had there been suddenly developed on the oscillator-ends equal and opposite charges, but with no glass jar between. This, then, was the cause of the repulsive impulse which was observed at each spark when they followed one another at intervals. When, however, a torrent of sparks was produced, the glass surface would take up a screening charge equivalent to the mean charge on the oscillator-ends; then, when the oscillator-ends had charges either above or below the mean charge, the statical action on the resonators would be the same as that due to the excess or defect on the oscillator, so that the steady repulsion observed was due to induction alone, and had nothing whatever to do with electrical oscillations proper.

In order to perfectly screen off this induction effect, and yet leave the action of the true electrical oscillations, it was necessary to so increase the conductivity of the surface of the glass jar that it would have time to acquire a screening charge which should follow variations of potential accompanying the sparks at the rate of, say, 10 or 20 a second, and yet leave it so imperfect as to be practically an insulator to oscillations at the rate of 500,000,000 a second, which corresponded to the apparatus in use.

Prof. J. J. Thomson has shown* that the conductivity of liquids may be determined by finding what thickness of a sheet of liquid is just sufficient to prevent oscillations of a known rate from exciting a resonator on the other side, and that the thickness must be proportional to the specific resistance. For instance, he found that a layer of dilute sulphuric acid three or four millimetres thick was just opaque to oscillations at the rate of 100,000,000 a second. It would, therefore, require a greater thickness to be opaque to oscillations of 500,000,000 a second, and a very much greater thickness for water to be opaque to oscillations of this rate. A duster, therefore, soaked in water, though it might reflect some fraction of this radiation, should be practically transparent to it. Nevertheless, a wet duster would be amply sufficient to screen the action of true harmonic variation of potential of the frequency of the sparks, *i.e.*, 10 or 20 a second. As a matter of fact, these variations of potential are not simply harmonic, but since by Fourier's principle the non-harmonic periodic change is equivalent to a series of true harmonic changes at successively higher rates all superposed, the wet duster should completely screen all the lower of these components up to a certain point, and probably far enough. On wrapping up the jar with a wet duster all effect was found to cease, and the spurious character of the deflections was demonstrated. It is possible that these are not the only experiments with electrical oscillations in which a wet duster or its equivalent might be found of service.

The apparatus was then re-made with the view of obtaining very great delicacy. To make the resonators aluminium wire was rolled into ribbon of $\cdot 2 \times \cdot 001$ centim., so that each centimetre in length weighed only half a milligram. Two pieces 30 centim. long were fastened in the cranked form previously described on very light frames made by cementing to almost capillary thin glass tubes cross bars cut from microscope cover-glass, so that the ends of these cross bars held the corners of the cranked pieces of aluminium ribbon. One of these was suspended in the same apparatus by a fine quartz fibre, and all was arranged with the view of obtaining a delicacy comparable with that employed by one of us in the Cavendish experiment. It was now impossible to keep the spot of light at rest, owing mainly to air-currents in the jar set up by differences in temperature of the sides of the jar which could not be avoided in the schools, and also to the perpetual tremor. In the winter, however, the elementary laboratory on the other side of the Exhibition-road was not being used, and so everything was transferred to a small room there, where a fair degree of quiet and uniformity of temperature could be obtained. The Voss machine was replaced by a large induction-coil, which gave a greater torrent of sparks. Then, to get more energy in each spark, the primary oscillator, made of 12 millim. tube, was replaced by a pair of

* *Proc.* Roy. Soc., Vol. XLV., p. 269.

Digitized by Google

spheres 100 millim. in diameter, with small spheres on short sliding rods, between which the sparks passed. The scale was placed at a distance of 281 centim. from the mirror. Then, when the wet duster was placed round the jar and the sparks made to pass, deflections of five to 10 millim. were observed. Fearing, however, that even the wet duster failed to completely screen the induction-effects due to the rise and fall of potential of the primary, or rather some of the higher harmonics already alluded to, we soaked it in dilute sulphuric acid instead of water, so that no doubt should exist as to its sufficient conductivity to quench the sham effect while it still remained unable to stop more than a small proportion of the waves of 500,000,000 a second. With this precaution all definite movement of the spot of light ceased. It was seldom that air-currents did not cause a gentle hovering of the index a few millimetres either way, which, however, had no relation to the starting or stopping of the sparks; on one or two frosty days, however, when the temperature was very uniform, there being no fire, the spot of light was so steady that a movement of even one-tenth millim. on the scale would have been observed, but we have based our calculation on the certainty that the deflection was not one-fifth millim.

In order to make sure that this was a true negative result the duster was removed, when at once the index was driven violently off the scale, and then a Hertz resonator tuned to the oscillations of the primary was placed in the jar and surrounded by the same acid duster when the sparks in the gap were evident, showing that the proper electro-magnetic waves did penetrate into the jar as supposed.

The turning moment corresponding to a deflexion of $\frac{1}{5}$ millim. may be found from the following particulars:—

Period of oscillation of mirror and stem (oscillator removed), ·947 second.

Period of oscillation with wire ring hung on, 4·13 second.

(Wire ring 1·6 centimetre diameter outside, made of wire ·122 centimetres in diameter; mass ·4635 gramme.)

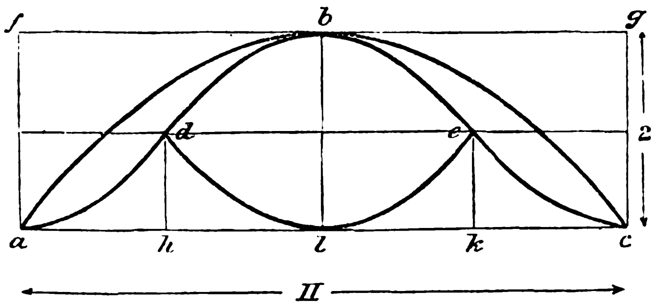



Fig. 4.

Hence couple $= 1{\cdot}1 \times 10^{-5}$ C.-G.-S. units, and average value of couple $= 3{\cdot}7 \times 10^{-7}$ C.-G.-S. units per centimetre of wire of resonator, which corresponds to a force of about $3 \times 10^{-7}$ dynes, since the distance from the axis is $1\frac{1}{4}$ centimetre. This is less than a two-hundred-millionth of the weight of a grain, or a three-thousand-millionth of the weight of a gramme.

Since the wires were only ·2 centimetre apart, this shows that, if the currents in the wires, instead of being oscillating, had been simply ordinary steady currents, those currents could not have reached the value of ·0017 C.-G.-S. electro-magnetic unit or ·0017 ampere.

Now the moment, if the theory advanced is correct, is due partly to the electrostatic repulsion and to electro-dynamic attraction which are equal to one another, but owing to the harmonic distribution of both, both in time and in position, and owing to the fact that the weaker part of each of these forces is tending to counteract the stronger part, the total average resultant force is by no means double or even equal to that due to a steady current alone of a strength equal to the actual maximum.

To find the relation it is necessary to first consider the effect of the harmonic distribution of either, say the current, along the wire. The square of this at any point is a measure of the force at that point, so that the force varies from zero at the ends to its full value in the middle, having passed its half value at the points where the wire crosses the axis of rotation.

Thus, in Fig. 4, the ordinates of the upper curve *a b c*, which is half a sine curve, represent current strength, those of the lower curve *a d b e c*, which is a complete sine curve on half the scale, but shifted vertically by the amount of its own maximum ordinate, since

$$\sin^2 a = \frac{1 - \cos 2a}{2},$$

represent the force due to the current at each point. The rectangular area *f g c a*, equal to $2\pi$, measures the total force due to a uniform current of the maximum value. The areas *a d h* and *c k e* are the forces due to the ends of the wires in the wrong direction, and these together

$$= \frac{\pi}{2} - \int_0^{\pi/2} \sin\theta \, d\theta = \frac{\pi}{2} - 1.$$

The area *h d b e k* is the force due to the middle half of the wire in the right direction, and this

$$= \frac{\pi}{2} + \int_0^{\pi/2} \sin\theta \, d\theta = \frac{\pi}{2} + 1.$$

The difference of these, which is the area *d b e l*, the balance in the right direction, and this = 2. But the force due to a current of the maximum strength over the whole length of the wire is $2\pi$, so the force in the crank conductor due to the harmonically distributed current and the opposite effect of the ends is $\frac{1}{\pi}$ × that due to uniform maximum current over the whole wire. The current is not steady, but varies harmonically with the time, so on this account the value must be halved again, but this halving is exactly balanced by the doubling which results from the fact that the electrostatic exactly equals the electro-dynamic effect.

We have seen that the force was not so great as that due to a steady uniform current of ·0017 ampere; therefore, the maximum current in the centre could not, if the oscillations continued uninterruptedly, have reached the value of $\sqrt{\pi} \times {\cdot}0017$ or ·003 amperes. Since in the most violent torrent of sparks that can be produced the time during which the oscillations last is very small compared to the interval between two sparks, it is quite possible, and even probable, that the actual current during the earlier part of each spark greatly exceeded this, but this is a superior limit to the value of the square root of the mean square of the strength of the current in the particular case.

It should be noted that two errors, each of which is numerically insignificant, have, for convenience, been made. One is the supposition that the forces on the elements near the ends of the resonators are the same as though they were continued together with the stationary wave. As a matter of fact, it is only the last few millimetres for which there is a falling off. The second error is made by supposing that the middle half of the wire is all at one distance from the axis on one side, and the two end quarters at an equal distance from the axis on the other side. As a matter of fact, the wire has to cross over, but as the two forces almost exactly balance on the small part which crosses the axis, it was not worth while to complicate the simple statement of conditions illustrated by Fig. 4 for the sake of an imaginary degree of accuracy which the nature of the observations would not justify.

*(To be continued.)*

## INDUCTANCE AND ITS PROPOSED UNIT THE HENRY.*

BY A. E. KENNELLY.

*(Concluded from page 267.)*

### Submarine Telegraphy.

**The inductance of a mirror-speaking galvanometer of the ordinary type having 2,250 ohms was found to be 3·6 henrys.**

### Telephony.

**The inductances met with in the ordinary long-distance telephone apparatus are as follows:—**

**The call bell 80 ohms and 1·4 henrys.**

**The magneto armature 550 ohms, and from 2·7 henrys with the plane of the coil in the line joining the poles, to 7·3 henrys when the iron core joins the poles, the plane of the coil being then at right angles to the magnetic flux.**

**The induction coil primary 0·28 ohm and 3·5 millihenrys.**

**Secondary 164 ohms, and 734 millihenrys.**

**The mutual induction between the coils 60 millihenrys.**

**The Bell telephone receiver 75 ohms and from 75 to 100 millihenrys. The removal of the diaphragm from an ordinary telephone of this type reduces the inductance about 35 per cent. All these inductances are to currents of a few milliamperes only. As regards the inductance of aerial line wires, it is to be regretted that measurements are not yet forthcoming, and, indeed, the experimental determination is attended with some difficulty, owing to static capacity and imperfect insulation. In the absence of direct measurements, theory indicates that the inductance of overhead copper**

* A Paper read at the fifty-second meeting of the American Institute of Electrical Engineers, New York, December 16, 1890.

Digitized by Google

wires depends upon the elevation above the ground as well as upon the diameter. In the case of iron wires as used in telegraphy, the permeability of the iron enters as an additional factor. The following table of inductances for copper wires is based upon a formula first given by Clerk Maxwell.* It is to be hoped that experimental evidence may shortly be collected corroborating these results :—

**Table** *of Inductances of Copper Ærial Line Wire, per Kilometre and Mile, for Different Diameters, and Elevations above the Ground.*:—

| Diameter of wire. | | Elevation above ground 400 cms or 13·1ft. | | Elevation above ground 700 cms or 23ft. | | Elevation above ground 1000 cms or 32·8ft. | | Elevation above ground 1300 cms or 42·7ft. | |
|---|---|---|---|---|---|---|---|---|---|
| | | Millihenrys or myriametres. | | Millihenrys or myriametres. | | Millihenrys or myriametres. | | Millihenrys or Myriametres. | |
| Centimetre. | Inches. | Per kilometre. | Per mile. | Per kilometre. | Per mile. | Per kilometre. | Per mile. | Per kilometre. | Per mile. |
| 0·10 | 0·039 | 1·986 | 3·196 | 2·109 | 3·393 | 2·170 | 3·493 | 2·222 | 3·576 |
| 0·20 | 0·079 | 1·848 | 2·974 | 1·960 | 3·154 | 2·031 | 3·268 | 2·083 | 3·352 |
| 0·30 | 0·118 | 1·766 | 2·842 | 1·878 | 3·022 | 1·950 | 3·138 | 2·002 | 3·222 |
| 0·40 | 0·158 | 1·709 | 2·750 | 1·821 | 2·930 | 1·892 | 3·045 | 1·945 | 3·130 |
| 0·50 | 0·197 | 1·664 | 2·678 | 1·776 | 2·858 | 1·847 | 2·973 | 1·900 | 3·058 |
| 0·60 | 0·236 | 1·628 | 2·621 | 1·740 | 2·800 | 1·811 | 2·914 | 1·863 | 2·998 |
| 0·70 | 0·276 | 1·596 | 2·569 | 1·709 | 2·750 | 1·780 | 2·865 | 1·833 | 2·950 |
| 0·80 | 0·315 | 1·570 | 2·527 | 1·682 | 2·706 | 1·754 | 2·823 | 1·806 | 2·906 |
| 0·90 | 0·354 | 1·547 | 2·489 | 1·659 | 2·669 | 1·730 | 2·785 | 1·783 | 2·870 |
| 1·00 | 0·394 | 1·526 | 2·456 | 1·638 | 2·635 | 1·709 | 2·750 | 1·761 | 2·834 |

The inductance of iron wires, in the absence of measurements, is almost too doubtful to justify calculation, being perhaps 10 times more than the inductance of copper wires under similar conditions. The difficulty in their case lies in assigning the proper value of permeability.

### Electric Light and Power.

Dynamos and dynamo-electric machinery are, of course, generally characterised by large inductances.

The inductance of the field-magnets of a dynamo may have any value depending on the size and voltage of the machine from one henry up to 900 henrys.

The inductance of an armature may similarly vary from 20 millihenrys up to 50 henrys between brushes. One millihenry is a fair average value of the inductance of one section of an armature. Armature inductances depend not only on the strength of the measuring current, but also upon the strength of the field, and whatever influences the permeability of the core.

The inductance of an alternating transformer varies from a primary of 400 millihenrys, a secondary of one millihenry and mutually 20 millihenrys with a transformation ratio of 20, up to corresponding values, perhaps one hundred times as great.

### Apparatus. The Inductance of Ruhmkorff Coils.

The smallest medical coil in ordinary use has five millihenrys in its primary, 100 millihenrys in its secondary, and 20 millihenrys mutually between them.

A large induction coil, 19in. long and 8in. in diameter, has 0·145 ohms and 13 millihenrys in its primary, 30,600 ohms and 2,000 henrys (by two concordant methods of measurement) in its secondary, and 163 henrys mutually between them.

The inductance of a mirror galvanometer may vary from a few millihenrys up to 10 or more henrys according to its resistance. Two henrys is a fair average for an astatic mirror galvanometer of 5,000 ohms.

An ordinary electric bell of 2·5 ohms resistance was found to have an inductance of 12 millihenrys.

There is one point in connection with the self and mutual inductance of induction coils and transformers that deserves attention, owing to the confusion that occasionally arises concerning it. It may be, perhaps, best represented by a numerical example. Let a closed Faraday ring of iron 100 centimetres in mean circumference and 20 square centimetres in uniform cross section, be closely wound with a primary coil of 2,500 turns in one layer, followed by a secondary coil of 7,500 turns also in one layer. If now two amperes be maintained steadily through the primary, the magnetic force in the iron will be $4\pi/10$ times the ampere-turns per centimetre of the iron circuit or $4\pi/10 \times 2 \times 2{,}500 \div 100$ or 62·85. The permeability of wrought iron at this force being, say 250, the induction developed per square centimetre will be $250 \times 62 \cdot 85$ or 15,713 lines, and the total induction enclosed by the primary coil, neglecting the space occupied by the wire itself will be $20 \times 15{,}713$ or 314,250 lines which traverse every turn of both windings. The linkages with the primary will be 2,500 $\times$ 314,250, or in round numbers 786,000,000 and referred to one ampere, half this number, or an inductance of 393 million centimetres, that is 393 millihenrys. Similarly, the linkages of these lines with the secondary will be 23,580 millions, and per ampere of primary current 11·79 millions of centimetres mutual inductance or 11·79 henrys. Next suppose the primary current interrupted, and a current steadily established in the secondary sufficient to produce the same magnetic force in the iron, thus avoiding the complication of a changing permeability. As the secondary has three times as many turns, the current effecting this will be two-thirds of one ampere. The total induction through the iron will now be the same as before, and therefore the linkages will be equally numerous. The self-inductance of the secondary will be $2{,}358{,}000{,}000 \div 2/30$, or 35,370,000,000 centimetres ; that is, 35·37 henrys. The mutual inductance will similarly be $7{,}860{,}000{,}000 \div 2/30$, or 11·79 henrys as before. It will be found, on carrying the reckoning to the necessary degree of accuracy, that this mutual induction 11·79 is the square root of the product of the two self-inductances, $0 \cdot 393 \times 35 \cdot 37$.

Examination of the steps in this calculation will show that this proposition must hold for all closed magnetic circuits uniformly magnetised to the same degree when the space occupied by the windings is not taken into account. Under the opposite conditions of open and especially of short iron cores, with large winding spaces, the condition usually fails, and the mutual inductance may be greater or less than the square root of the self-inductances multiplied together.

Another reason in favour of selecting 1,000 million centimetres as the value of the practical unit or henry, is the desirability of having the time-constant of an electro-magnet circuit expressed directly in seconds by its practical units as in the case of electrostatic circuits, rather than revert to a unit of inductance that would yield the time constant in milliseconds or other fractional period of time. The time constant of a simple electro-magnetic circuit, a circuit having inductance and resistance but negligibly small electrostatic capacity, is defined as the ratio of its inductance to its resistance, that is of its henrys to its ohms. It is an important function, and its consideration presents some remarkable analogies between inductance and electrostatic capacity that it is interesting to trace.

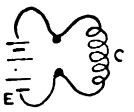



Fig. 2.

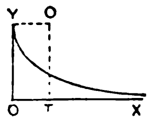



Fig. 3.

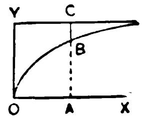



Fig. 4.

Imagine au inductance coil, C, without iron to be supplied with a steady current from an electromotive force, E, of 50 volts. Let the inductance of the coil be three henrys, and its resistance 10 ohms. (Fig. 2.) Ohm's law determines the strength of the current to be five amperes. Now short-circuit the terminals of the coils very suddenly by a wire across its terminals of negligible resistance. The current in the coil C does not stop instantly, but under the name of extra current is maintained in the coil by reason of its inductance. According to theory, the last dregs of the current will never entirely vanish from the coil, although after the first few seconds the remainder is exceedingly small. The very first instant after short-circuiting the current continues at five amperes by its electro-magnetic momentum, but being unsupported its energy is lost thermally in overcoming the coil's resistance, and it immediately falls. In falling, the lines of force linked with the circuit and sustained by the current, are drawn in, cutting the coil as they recede, thus creating a counter E.M.F. tending to prolong the current, and this process of dwindling current with reduction of opposition from the reserve of inductance, descend together. The total quantity of electricity that will flow through the circuit under the conditions specified, may fairly be called the charge or discharge of the coil, and it can be readily proved that this charge is equal to the quantity that would be conveyed by the initial discharging current, acting uniformly during a time equal to the time-constant of the circuit. In this case the discharge commenced at five amperes, and the time-constant is 0·3 second, so that the total discharge will be that due to the flow of this current in 0·3 seconds, that is 1·5 coulombs.

To represent the case graphically, suppose the curve of discharge in time to be plotted as in the figure. Let the axis OX be divided off into seconds, and the axis OY into amperes. (Fig. 3.) The discharge commences at five amperes, subsides rapidly at first, but at last so slowly that an indefinitely long time must elapse before it altogether disappears. The area enclosed between the curve and the axes represents ampere-seconds or coulombs to the amount of the total charge, and the proposition just stated asserts that if the current had continued at five amperes steadily for 0·3 seconds, the area of the dotted rectangle so generated, YDTO, would be equal to the total area enclosed between the curves and the axes prolonged to the ultimate point of union.

* Clerk Maxwell, "Electricity and Magnetism," 2nd Edition. Vol. I. p. 293.

Digitized by Google

Curiously enough, exactly the same law applies to the discharge of a condenser through a circuit of resistance but negligibly small inductance. The time-constant of the circuit in this case, however, being its capacity in farads multiplied by its resistance in ohms.

The curve of discharge is of the same type for inductances or capacities. It is logarithmic, and finds its prototype in the case of the discharge of water in time, from a tank having a faucet at the base, assuming that the rate of escape through the faucet at any moment is directly proportional to the pressure or level of water then remaining in the tank.

The laws which control the outline of this discharge curve are identical for condensers or short-circuited inductances, and are combined in the following enunciation:—

The natural logarithm of the ratio of the $\left\{\frac{\text{full charge}}{\text{initial current}}\right\}$ to the $\left\{\frac{\text{residual charge}}{\text{discharging current}}\right\}$ at any instant is the quotient of the the time during which discharge has been in progress by the time-constant of the circuit.

In this statement two reservations are necessary.

The electrostatic circuit must be free from all appreciable inductance, and the electro-magnetic circuit must contain negligibly small electrostatic capacity. It was first pointed out by Sir William Thomson that the discharge of a condenser through an inductance circuit becomes oscillatory when the inductance exceeds a certain critical value.

When an inductance discharges through a break instead of a closed circuit, the conditions become complicated to a degree that eludes complete practical solution in the present state of knowledge.

At the period of natural discharge equal to the time-constant, an inductance or capacity charge or current will have fallen to 36·8 per cent. of its initial value.

Similar propositions relate to the charging currents and quantities. In the above instance, after the coil has completely discharged, remove the short-circuiting wire. The current will immediately enter the coil, and the curve of its arrival in time is represented in Fig. 4, this curve being only an inversion of the preceding. For this reason it is evident that the area above the curve now represents the charge, and by an extension of meaning, the deficit from full current, such as B C, may be called the charging current, since on discharge and reversal of the diagram, this will be the discharging current at the same lapse of time. In fact, the current A C is doing work in heating the coil, the deficit from ultimate current B C being only active in increasing the electro-magnetic momentum of the circuit, and work is really stored in the coil as though the deficit current did exist. A similar but inverted curve of current in time represents the charge of a condenser. In each case, and under the above restrictions, the following propositions hold:—

The natural logarithm of the ratio of the $\left\{\frac{\text{full charge}}{\text{initial current}}\right\}$ to the $\left\{\frac{\text{deficit from full charge}}{\text{charging current}}\right\}$ at any instant is the quotient of the time during which the charge has been in progress by the time-constant of the circuit.

When the charging interval reaches the time-constant, the charge will have attained 63·2 per cent. of its full value.

Another relation between simple electrostatic or electro-magnetic circuits and their time-constants is in their stores of energy. The energy of the charge in each case is half the energy that would be developed by the initial charging or discharging current against the ohmic resistance of the circuit in the time equal to the time-constant. In the above instance, for example, five amperes being the initial charging or discharging current, and the resistance 10 ohms, the circuit energy of this current per second would be $5 \times 5 \times 10 = 250$ joules, and during half the time-constant the energy thus developed would amount to $0·3 \times 250 \div 2$ or 37·5 joules. This is the electro-magnetic energy stored up in the charge.

These are not the only analogies that exists between inductance and capacity, but there are remarkable points of diversity. The discharge of extra current of a coil is in the same direction as the circuit current, with the condenser it is the reverse. In a great many practical instances, the electro-magnet and the condenser are used to annul each other's influence.

The time-constant of an inductance circuit is generally small, for the reason that a coil of large inductance has generally many turns, and, therefore, high resistance, so that the ultimate ratio of the henrys to the ohms is not large. For example, the time-constant of a Bell telephone, considered in itself or on short circuit, is from the measurement above described, about $0·09 \div 75$ or 0·0012 seconds, and therefore a steady E.M.F. of, say, two volts, impressed directly upon such a telephone would produce in this interval of time 63·2 per cent. of 2/75 amperes, namely, 169 milliamperes. By adding inductance less resistance to the circuit, however, and raising the E.M.F. proportionately, the time-constant would be lessened, and the arrival of current accelerated. Strictly speaking, this reasoning is inaccurate, since the telephone coil surronnds iron, but with the small currents usually employed the iron probably does not greatly influence the arrival curve. In the case of dynamo field-magnets, and large ironclad inductances generally, the divergence of the arrival curve from that of a corresponding simple electro-magnetic circuit is considerable.

There are several methods by which self and mutual inductance can be measured, the selection depending on the magnitude to be determined and its nature. The Ayrton and Perry secohmmeter, or double revolving commutator, is, perhaps, the most generally useful. It may be employed in connection with a standard condenser, a standard inductance, or apparent change of resistance with speed. Being used in the Wheatstone bridge, the currents it can alternate are necessarily limited in strength.

For small inductances,* say less than one-tenth of a millihenry, the method of Prof. Hughes,† or its modification by Lord Rayleigh, is probably best suited, using two coils of mutual inductance and a telephone as the observing instrument.

The inductance coils are usually in the form of two concentric rings, the inner being capable of rotation about the common vertical. The mutual inductance of such a pair of coils is a complex function of the dimensions and the angle between the planes at which the coils may be set. It is usual to calibrate the instrument by separate measurements of the inductance at different angles. A simpler arrangement, however, for mutual inductance is a short solenoid in the bridge circuit superposed coaxially upon a long solenoid in the battery circuit. Adjustment to silence in the telephone for interrupted currents is then made by including in the bridge circuit a greater or less number of turns in the outer solenoid. The mutual inductance is then very nearly proportional to the number of turns so included, and by suitable proportions in construction the accuracy can be carried as far as the telephone for the receiver will permit.

For the measurement of inductance in coils on iron machinery, the ballistic galvanometer is frequently employed, either by the method of discharge for self-inductances, or induced quantity with mutual inductances. Mutual inductances connected by closed iron circuits present no difficulty when great accuracy is not required, since, as already observed, the self-inductances are calculable in these cases when the mutual inductance and the number of turns in the coils are known. It is much more difficult, however, to measure the self-inductance of the field-magnet of a dynamo when the armature is removed, and when currents of the normal exciting strength are used in the measurement. The best attempt has been made, apparently, by observing the discharge effects of gradual small changes of a strong current passing through the coil, in circuit with a specially arranged Wheatstone bridge.‡ If it were of sufficient practical importance, however, to measure such inductances with powerful currents, a recording instrument might be tried, having a very light and swiftly-moving pointer, leaving a trace of its motion on a strip of moving paper like Sir William Thomson's syphon recorder. If such a pointer were arranged to give an amplitude of movement at right angles to the paper strip, in proportion to the current traversing the coil, it would register the curve of discharge when the coil was short-circuited, in the manner described above. On a sufficiently enlarged scale, corrected, perhaps, for residual inertia in the moving parts, this curve would give, not only the total quantity of discharge, but its deviation from the logarithmic line of simple electro-magnetic discharge, would give the means of determining the characteristic of magnetisation in the iron.

Of far lesser importance than the selection of the practical inductance unit, but still well worthy of separate consideration, is the selection of appropriate symbols to represent the unit briefly. It might, perhaps, be advantageous to represent the henry by a capital H, and the millihenry by the plain letter h. This notation would enable such an inductance as 50 henrys to be written as 50 H, and 50 millihenry as 50 h. The microhenry occurs so seldom that it would probably not need a symbol.

All measurements of precision should employ true ohms and not legal ohms in the computations. The best existing value of the true ohm is 1·0028 legal ohms.‖

The correction it practically so small that it can best be carried out by altering the nominal standard temperature of the resistance coils adopted. These temperatures should be increased by 9·4°C. for platinum-silver, 6·5°C. for German-silver, and 13·5°C. for platinoid. Thus, a resistance box with platinum coils standardised for legal ohms (of 106·0 cms.) at 15°C. would give true ohms of 106·3 cms. at 24·4°C. as the best approximation, and this would be the standard temperature of the box for use in precise measurements of inductance.

* *Journal of Institution of Electrical Engineers*, London Journal, January, 1886.

† For another method of measuring small inductances with an alternating current, see an article by C. Steinmetz in the *Electrical Engineer*, of New York, Vol. X., Nos. 130, 131, November, 1890.

‡ *Phil. Mag.*, February, 1889. Dr. Sumpner.

‖ Report of the Committee on Electrical Standards read before the British Association, September, 1890. (*See* the London *Electrician* of September 26, 1890.)

Digitized by Google

## LUBRICATING OIL.*

BY A. C. J. CHARLIER.

During the last few years great improvements have been introduced in the manufacture of lubricating oils. Looking back some twenty years, we find that the users of lubricants could not be persuaded to use anything but castor or sperm oils ; but gradually, from the researches and investigations made by specialists in this class of oils, compounds and carefully prepared mineral oils have been introduced which far surpass the old lubricants both in price and quality. In order to be able to determine the utility of the great number of these lubricants now in the market, and in order to determine the proper lubricant to choose for the different classes of work, it is more than ever necessary for users to become acquainted with easy methods of analysis and examination, as well as to know the nature and general qualities of the oils of which the compounds generally consist.

Before dealing with the oils used for lubrication, it is necessary to consider what constitutes an efficient lubricator. A good lubricating oil must have sufficient body to keep the surfaces between which it flows from coming into contact, hence the reason why high gravity oils are now so much used on all classes of machinery; but at the same time everything depends on the class of work on which the oil is to be employed. If for light machinery, a very heavy oil would have a tendency to clog the bearings, thus impeding the speed ; therefore for all ordinary machinery an oil ranging in gravity from ·850 to ·890 should be employed ; whilst for heavy machinery, oils ranging from ·900 and·980 should be chosen.

Another important feature is to obtain oils having the greatest amount of fluidity consistent with body. Many oils are selected because they are apparently of high gravity, but such in reality is not always the case. The commonest paraffin burning oils can now be given an artificial gravity resembling castor oil, and yet immediately they become heated, even to a moderate temperature, they run off the bearings like water. Many of the Russian mineral oils now on the market have a gravity of about ·920, are very highly refined, and of a splendid colour, and yet when heat is applied they instantly lose their gravity, become limpid, and are quite useless for the purpose for which they are required. But still it must be mentioned here *en passant* that these Russian oils are very useful in making up compounds with oils not affected by temperature, as they then supply body to an oil which, although an excellent lubricant, could not be used for heavy machinery on account of its low gravity.

Another point to be considered is to find an oil with a maximum capacity for receiving and distributing heat, together with a freedom from tendency to gum or oxidise, hence none of the drying oils should be used for lubricating purposes, and under this head users of lubricants must be warned against a process which has lately been discovered of adulterating lubricating oils with soap, by which is produced a very fine sparkling oil of gravity higher than castor, but at the same time utterly useless for lubrication. Users of lubricating oils often lay far too much stress on the colour of the oil, but with many methods now known of giving any oils, good or indifferent, any colour, either ruby, golden or black, by the addition of the smallest percentage of the many aniline colours soluble in oils, the colour should no longer be taken as a test of quality, all that is required being that the oil should be bright and free from insoluble matter. It is essential that a lubricating oil should be neutral—that is, it should neither be acid nor alkaline. In the refining of many kinds of oil, mineral acids and alkaline earths are used, and, especially in the cheaper oils sufficient care is seldom exercised in washing them free from all traces of acid ; and then, again, it is well known that manufacturers often leave a large portion of alkali in the oils, as this greatly helps to make up their gravity.

Having now dwelt on what are the requirements of a good lubricant, the next step will be to describe several ready tests by which the utility of the oils can be quickly determined ; not tests and analyses which can only be worked by competent chemists, but ready methods which can be employed by any ordinary user of machinery. With regard to the gravity, this is an essential step, and in order to find this we have gravity bottles, Sprengel's tubes, &c., all of which necessitate the use of a balance. The simplest method is therefore to use an ordinary hydrometer. The oil is placed in a cylindrical glass vessel, and the hydrometer floating in the oil marks immediately the gravity, taking water as 1,000. This method is very useful, because the gravity of the oil can be determined at any temperature ; whilst by the more complicated methods it is very difficult to determine the gravity at any other temperature than that of the ordinary atmosphere ; but with the hydrometer the glass vessel can be heated in a water bath, and the gravity taken by placing the hydrometer in the oil at any moment. By this means it can be seen if the sample retains its original gravity when heated.

* From the *Engineer*.

The "flashing point" of an oil is understood to mean the temperature at which the escaping vapour will momentarily ignite. The standard animal and vegetable lubricating oils, and all mineral oils of good body and high gravity, decompose or vaporise only at temperatures exceeding that of steam in ordinary engines, but nevertheless many of the lubricating oils now in the market are so worthless that it is very essential to know a ready means of ascertaining their flashing point. Many very good forms of testers, such as Abel's, Bernstein's, or Bailey's, are used, and they are more or less on the same plan, namely, consisting of a metal receptacle for containing the oil surrounded by a water-bath with a lamp for heating the bath. The vessel containing the oil is closed, with the exception of a small aperture through which the vapour ascends ; a small gas jet is continually played over this aperture, and instantly the vapour flames the temperature is noted, this constituting the flashing point of the oil. But all these testers require very careful manipulation, and the writer, therefore, suggests a simple apparatus, which can be worked very easily, and at the same time gives very accurate results. A small glass beaker is fitted into a larger one by means of a cork or india-rubber band ; the former is to contain the oil, the latter serves as a water bath. The smaller beaker is closed at the top by means of a cork, through which is inserted a thermometer dipping well into the oil, and a small piece of glass tubing tapering to a point, through which the vapour ascends. The oil should be on an exact level with the water in the outer vessel, so that the same pressure exists in both vessels ; and when an oil to be tested is supposed to have a flashing point above that of boiling water, an oil bath should be used in place of water. Everything being ready, the apparatus is stood on a sand bath, under which is placed a spirit lamp, and gradually heated. A lighted taper is applied continually to the aperture through which the vapour from the oil is ascending, and immediately a small blue flame appears the temperature is noted, and the flashing point of the oil under examination thus determined. Any oil having a flashing point below 300deg. Fah. should be at once discarded as useless.

Another very important test is the viscosity or fluidity of an oil, and here again we have some very elaborate apparatus recommended to us, but an engineer is in want of ready and quick tests, not such as would take him perhaps a day to work out, but one that can be worked in a few minutes, and at the same time give him accurate results. A very simple and general test of fluidity is to dip blotting paper in the oil and hold it up to drain ; symmetrical drops indicate good fluidity, a spreading tendency viscosity. Again, an ordinary glass tube having a diameter of half an inch, tapering to a point at one end, and marked into divisions of 1in., will answer all ordinary purposes for testing the viscosity of an oil. The oil to be tested is placed in this tube up to a given mark, and is then allowed to run out at the tapered end of the tube, and the time taken is noted. This is compared with the time taken by standard oils previously ascertained in the same tube, and thus the viscosity of the oil can be determined. Sometimes it is necessary to take the viscosity at different temperatures, and in this case the glass tube can be fitted into an outer jacket containing water heated up to the required temperature. For all light machinery running at high speed, low gravity oils having a low fluidity should be looked for, whilst for heavy machinery of all kinds high gravity oils, with a moderate fluidity, should be employed.

An oil evaporating more than 5 per cent. in twelve hours, at a temperature of 140deg. Fah., is useless, as the evaporation creates a viscous residue, or leaves the bearings dry. To test for this, a weighed quantity of the oil should be placed in a porcelain dish and heated for the requisite time, then cooled and weighed and subtracted from the original quantity ; the difference in weights constitutes the loss by evaporation.

The best lubricating oil is that which has the greatest adhesion to metallic surfaces, and the least cohesion in its own particles, and bearing this in mind, there is no doubt but that mineral oils come first, sperm oil second, neatsfoot oil third, and lard oil fourth, hence the finest mineral oils are best for light bearings and high velocities, and to give body to mineral oils fine sperm oil is used, or when greater tenacity is required, lard and neatsfoot oils may replace sperm oil, and for the heaviest machinery mineral oils alone cannot be recommended, on account of want of body and higher degree of inflammability.

At the present time, it is not so much a matter of quality which troubles the engineer, but it is the question of cost. Lubricants answering in every way what is required of them can be obtained, but their cost is far too high for the ordinary consumer, and it therefore necessitates producers to search for compounds which will give to cheap oils the same properties as sperm, lard, &c., and be able to sell them at about half the price. Mineral oils are the cheapest lubricants known, and yet they are often discarded for one reason, because they do not possess the same body as many of the vegetable and animal oils, and hence require a larger quantity to be used to do the same work ; but, if double the quantity of mineral oil is required to do the work done by other oils, the price of the former is only one-quarter that of the latter ; hence the mineral oils are still by far the most profitable to be used.

Digitized by Google

Oleate or stearate of alumina is now greatly used for giving a body to light gravity mineral oils. It is a very cheap compound, and can be added at a very small cost. The production of this "metal soap," as it is called, is well worthy of consideration, and can be well classed as a very successful issue to a lot of research work recently done by several chemists in endeavouring to produce cheap lubricants. The high-class animal and vegetable oils in such high favour amongst engineers for their lubricating powers consist principally of olein and stearin, and these two substances, which give to these oils their high lubricating powers, can now be introduced into cheap mineral oils, thereby converting them into the finest lubricants at a cost far below that paid for castor, sperm, and such like oils. The oleic and stearic acid is obtained in the usual way from any of the oils rich in olein and stearin, and is then precipitated with alum in the presence of caustic soda, thus forming oleate and stearate of alumina. A very small percentage of this metal soap dissolved with warming in light gravity mineral oils will increase their gravity some 50 or 60deg., will greatly improve their lubricating properties, and after filtering through fine copper gauze, will give them a brilliancy not surpassed by any of the finest animal oils in the market, and at the same time not increase their cost of production more than 20s. per ton. Some manufacturers use now a process of thickening their oils with ordinary soft soap, but this adulteration can be easily detected by adding glacial acetic acid and warming, when the soap will at once separate out. The writer recently examined a very fine-looking sample of lubricating oil, resembling in appearance castor oil, and found on estimation that as much as 60 per cent. of soap had been introduced into the oil. Any oil found to contain such soap should be at once rejected. Lardine and blown rape oil are now also largely used for giving body to lubricating oils. The former consists principally of cotton oil, which has been heated in the presence of a strong blast of air, somewhat similar to the process employed for thickening linseed oil, whilst the latter consists principally of colza oil treated in a similar manner. The presence of these "thickeners," as they are termed in the trade, cannot be said to visibly deteriorate the lubricating powers of the oil with which they are mixed; but they certainly do not improve it, and unfortunately they quickly become dull and cloudy, and in order to prevent this rosin oil must be used in conjunction with them. A small percentage of, say, 1 per cent. of rosin oil does not deteriorate the lubricating properties of an oil; but one containing above this percentage cannot be recommended for lubricating purposes. The presence of rosin oil can be detected in mineral oils by treating a small portion of the sample with an alcoholic solution of caustic soda, heating on a water-bath and evaporating nearly to dryness, then add a large quantity of distilled water and boil for some time, when a milky liquid will be formed; now add more water and warm, and notice the colour of the oil that separates out, if clear, then mineral oil is only present; a brown colour denoting the presence of rosin oil. As a confirmatory test, draw off the aqueous liquid from beneath and make it acid with sulphuric acid, if no precipitate, the oil was all mineral, as a precipitate collecting on warming in brown viscous drops confirms the presence of rosin oil. But now, if instead of a milky liquid a semi-frosty mass is obtained after having added the distilled water to the evaporated solution, a fatty oil is evidently also present with the mineral and rosin oil, add more water, when the mineral oil will float to the top if present. Now draw off the aqueous liquid, and shake it up with amylic alcohol. If the alcohol separates in a brown layer, rosin oil is present. Again draw off the aqueous liquid, acidulate with hydrochloric acid and warm, when the separation of oleic acid, with its characteristic odour of fat, will show the presence of a fatty oil, either lard, neatsfoot, or cotton oil.

For the lubrication of bearings of the largest size on which, either from the weight of the shaft or fly-wheel, or from the drag of belts or ropes or from the formation of the bearing, very great pressure per square inch has to be resisted, castor oil up to the present appears to have no equal; and, in order to keep such bearings cool, it is very essential that this oil should not be adulterated. The adulterants to be looked for in castor are principally lard oil and colza, and they can be at once recognised by its density. The specific gravity of castor oil is ·960; lard oil, ·916; rape oil, ·912; therefore if the gravity is below ·955, this alone proves the presence of one of these oils. Again, another very characteristic test of castor oil is by the addition of zinc chloride. If pure it becomes yellow; if lard oil be present it becomes milky, and if colza be present a green coloration is obtained. Again, sperm oil is still very largely used by the leading cotton spinners, and the reason for this is that it leaves no stain, and does not thicken by age or friction. Here again, on account of the high price of this oil it is often adulterated, and generally with seal oil, cotton, and mineral oils. These adulterants can also be easily detected with zinc chloride; if pure sperm oil a milky solution is obtained, and when adulterated with any of the above-mentioned oils a brown coloration is obtained.

This article would not be complete without noticing the qualities of tallow as a lubricant, and there is no doubt but that, while in every case hydrocarbon oils are safer, and in the majority of cases are better and cheaper lubricants than tallow, even of the best quality, there are a number of cases in which engineers, although fully alive to the trouble and danger which are inseparably connected with the use of tallow, are constrained to use it, having failed to find any sufficient substitute. The great fault with tallow is that it corrodes metal, and often leaves a kind of deposit; and, again, it almost always contains free acids, as much as 25 per cent. of free fatty acid having been found in a sample of town tallow. Large proportions of free acid are apt to be due to the tallow being adulterated with wool grease acids, or stearic acids from cotton-seed oil. Tallow, again, frequently contains more or less water, infusible matters, and mineral impurities, and has been often purposely adulterated with starch, China clay, whiting, &c. For the detection of these mineral impurities, a small sample of the tallow should be dissolved in petroleum spirit, filtered, the residue washed with a little ether, and dried at a moderate temperature. Boil the residue in water, and add iodine, a blue coloration is obtained, proving the presence of starch; again, any effervescence of the residue on addition of hydrochloric acid proves the presence of whiting.

## THE "MONARCH" MAGNETIC SEPARATOR.*

BY C. M. BALL.

The magnetic concentration of iron-ores has been so often and so widely studied and discussed among the members of the Institute that any remarks concerning its general importance, from an economic standpoint, would be superfluous; but it is thought that a description of the Ball and Norton ore-separator, designed for cobbing and separating magnetic iron-ores, indicating its essential differences from other machines and the advantages claimed for it, together with some account of recent results obtained in its application to the concentration of such ores, will prove of interest.

The accompanying illustration represents a longitudinal vertical section of the perfected Monarch ore-separator, adapted for separating fine ore.

The apparatus consists of a partially-closed chest, having an opening at *f*, from the feed hopper *h*, through which the ore is delivered to the machine from a storage-bin provided with means for regulating the flow of ore, so that, when the machine is in operation, the hopper is kept always full. Other openings are provided for the discharge, at *t*, of tailings; at *m*, of middlings; and at *c*, of concentrates; also at *e*, for allowing free ingress of air to the chest at that point, and at *s*, where a powerful exhaust-fan is connected. The openings at *t* and *m* are kept sealed against ingress of air at those points by means of the hinged and weighted valves, *v*, *v*, which discharge the products from the hoppers *p* and *k* continuously, and in the same proportion as received from above, when a sufficient weight has accumulated upon the inside to cause the contents of the hoppers to leak by the valves. The machine is also provided, as shown, with two drums, Nos. 1 and 2, turning upon the shafts *i* and *j*. These shafts, together with the magnets *a* and *b*, which they also serve to support, stand still while the drums may be rapidly revolved around the magnets and out of contact therewith. The magnet is so constructed as to present a series of poles of alternately opposite polarity near the inner surface of the drum. Any magnetisable matter brought near the outer surface of the drum, within the arc covered by the magnet, will be powerfully attracted and drawn into firm contact with the outer surface of the drum.

These drums are composed of a non-metallic material, such as wood, paper, &c., and they turn in the direction indicated by the arrows. Just below the feed-hopper an apron of neutral metal, No. 3, is arranged, curving downward and forward in the direction of the rotation of the drum, its lower portion describing a short arc concentric to the surface of the drum. This serves as a shoot to direct the stream of ore falling from the feed-hopper within the influence of the first two or three poles of the magnet. A similar but somewhat shorter apron, No. 4, is arranged in like relation to the second drum, and magnet *b*.

Attention is called to the provisions for applying and directing the air-current, which fulfils an important function in the process of separating ore as developed in this apparatus. The air may enter freely at the openings *c* and *e*, and is drawn through and out of the chest by the action of a powerful exhaust-fan connected at *s*. The air which passes through the chest follows the course indicated by the arrows in the space below the drums.

When the machine is put in operation, and the magnets are excited, the drums are revolved in the direction before indicated, and the air-current is established through the machine in a direction opposite to that of the rotation of the drums, ore being supplied through the feed-hopper, which is kept always full. The ore

* Paper read before the American Institute of Mining Engineers, New York, September 30, 1890.

Digitized by Google

passes down the shoot under the first drum, and, as soon as it comes within the influence of the magnet, the magnetisable portions are drawn into contact with the drum, and, through friction upon its surface, take on the forward movement of the drum. At this stage, a curious and important result takes place. The particles simultaneously influenced by the same pole, form tufts standing out from the pole. As they are drawn along, however, by friction against the moving drum, when they get to a point midway between two poles they lie down flat against the surface of the drum, and, as they are drawn still further along, they again stand on end—but this time the other end out. So, in passing through the magnetic field, they are tumbled end over end as many times as there are poles in the field. The result is, that every time they are reversed in position opportunity is afforded for any non-magnetic particles of gangue, which may have been entangled with the ore, to fall away from the tufts of magnetite; and this result is still further facilitated by the centrifugal tendency and by the counter current of air. When the ore reaches the limit of the arc covered by the magnetic field it is no longer attracted, and takes on a tangential movement, which carries it away from the drum. It has now, however, passed the edge of the second apron, and, on leaving the first drum, comes within the influence of the magnet of the second drum, where similar operations are repeated, a portion being finally discharged as concentrate at c.

The separation of the middlings from the mass delivered to the second drum may be effected in two ways: If the drums have the same speed of rotation, a weaker magnetism in the second magnet will allow these less magnetic particles to drop away; or, if the magnets have approximately the same force in the two drums, a higher speed of rotation of the second drum will throw these particles off by reason of the centrifugal force overpowering the centripetal magnetic attraction, the magnet having the smallest influence upon the leaner portions of the mass.

Modifications of this apparatus have been designed, which adapt it for use in conjunction with a stream of water mingled with the ore, so constituting a wet process.

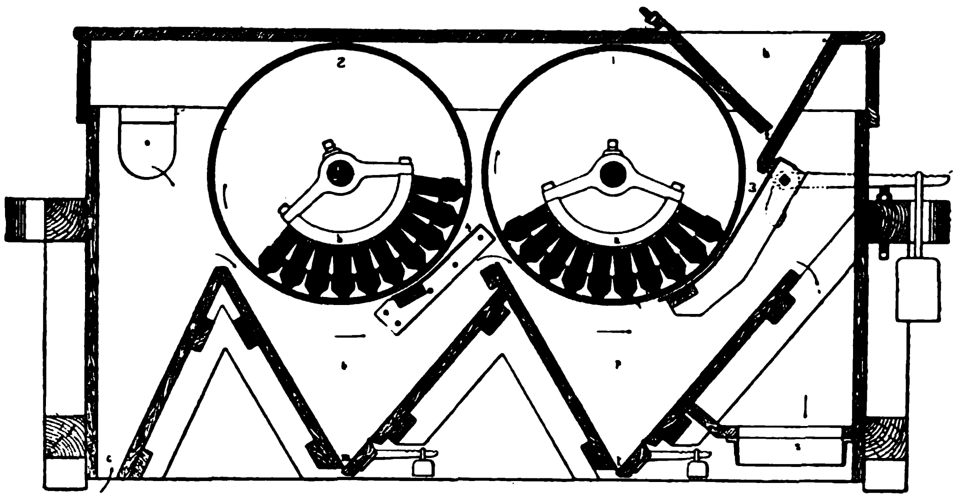
The importance and special efficiency of the means provided for suppressing the movement and discharge, along with the ore, of the finer particles of gangue, and of the means for differentiating the product into several portions graded according to the percentage of iron in each portion, and its magnetic susceptibility should not be overlooked. It is upon the application of these means that the ability depends to perform the critical operation of converting non-Bessemer into Bessemer ores by the elimination of phosphorus, sulphur, and titanium-bearing compounds.

In the concentration of ores by the dry process the treatment of the dust developed in the rapid movement of large quantities of ore is generally difficult. When the ore reaches this machine, the finer portions of the material are as readily and perfectly dealt with and separated as the coarser, the concentrates, however, finely pulverised, being delivered from the machine in an absolutely clean condition, and free from non-magnetic dust, and the dust carried away by the air current being also as wholly free from any magnetic material.

The positive character of the functions above enumerated renders it possible to make an effective separation under the conditions of a very heavy supply of ore to the machine. The easy working capacity of a machine having drums of 24 inches diameter, and 24 inches working-face is from 15 to 20 tons per hour of ore granulated to pass 16 to 20-mesh screens. The power required is from 1 to 1½ horse-power in electricity for each drum, and ½ to ¾ horse-power to drive the machine.

These machines have been applied to the treatment of a considerable number of ores with good results. The most remarkable of these was the conversion of Port Henry Old Bed ore into a Bessemer ore carrying Fe. 71·10, P. 0·037. This concentration was made from the crude ore, carrying Fe. 58·7. $P_2O$ 2·25, the Bessemer concentrate representing about 65 per cent. of the original mass. An earlier type of this machine was in use during nearly the whole of the year 1889, at Benson Mines, St. Lawrence County, N.Y., concentrating the lean magnetite mined there, which in the crude ore carries about 40 per cent. Fe., and is above the Bessemer limit in both phosphorus and sulphur. The concentrated product found a market at Pittsburg, Pa. The new works at the Benson Mine are provided with crushing machinery having sufficient capacity to crush daily 800 to 1,000 tons of ore, sized to 16-mesh, and finer, and the separation of this quantity of ore is to be effected at the outset with three separators, having a working face on the drums of 24 inches.

In the minds of some persons who have been studying the general subject of ore-concentration, and employing the apparatus hitherto available, inability to convert some of the well-known ores high in phosphorus and sulphur, such as Port Henry Old Bed, Little River, Croton, etc., from non-Bessemer into Bessemer ores, has led to the inference that some as yet undiscovered refinement of preparation was essential to their successful treatment. The entirely successful and economical management of these ores with this machine has proved that the essential matter in the problem was to provide a separator that would separate ore that had been properly prepared.



Section of the Ball Magnetic Ore Separator.

## THE INTERNATIONAL ELECTRICAL EXHIBITION AT FRANKFORT-ON-MAIN.

The exhibits at this year's Electrical Exhibition at Frankfort will be divided into 11 sections. In the section devoted to railway appliances the Prussian and Bavarian State Railway Departments will both send exhibits of signalling and lighting apparatus. In this section will also be found four electric railways, illustrating the overhead and underground conductor systems, and also accumulator working. In the telephone and telegraph sections, the German Government will show a historical collection of apparatus. The Bavarian, and probably the English Governments, as well as a large number of private firms, will send examples of the latest forms of apparatus. Messrs. Siemens and Halske's exchange instrument, which works a number of type-writers from a central station, will be shown, and also Messrs. Mix and Genest's telephone automaton. Special rooms will be provided containing telephones connected with concert-halls in Frankfort, Wiesbaden, and Münich. The electro-chemical section will contain exhibits from 14 firms. Amongst other processes one for obtaining pure copper from its ores will be shown. The Aluminium Company of Neuhausen will have a good show of specimens of aluminium and its alloys. Amongst the exhibits in the medical section will be the arrangement adopted by Hertz in his researches on the nature of electricity, and numerous specimens of laboratory apparatus, sent both by scientific institutions and by private firms. Messrs. Hartmann and Braun and Messrs. Siemens and Halske in particular are sending interesting collections.

In the boiler-house and machine-room 60 exhibitors are represented. Boilers on 20 different systems, with a total heating surface of 2,400 square metres, will be at work, while 56 steam and other motors from ½ to 600 horse-power, the total being 3,900 horse-

Digitized by Google

power, will be put down. These will include, besides compound, tandem and triple expansion engines, several locomotive engines up to 100 horse-power, as well as many small engines, worked with steam, petroleum, coal gas and Dowson gas.

Twenty-two firms are sending dynamos. Some 600 horse-power dynamos (the largest hitherto built in Germany) are to be included. A large number of alternators will be shown and methods of transmitting power by the alternating current will be illustrated. About 500 horse-power are to be transmitted to the exhibition by electricity. Of this total 100 horse-power are to be brought from the Palmengarten, 100 horse-power from Offenbach, and 300 horse-power from Lauffen-on-Neckar, 100 miles away. At a conference recently held at Münich, between the Allgemeine Elektricitäts Gesellschaft, the Maschinenfabrik Oerlikon, and the Lauffen Cement Works satisfactory arrangements were concluded with regard to the division of the cost of this transmission. The carrying out of the scheme only depends now upon the action of the German Postal authorities, who have been asked by the joint committee of the three firms to lend the necessary telegraph posts and fittings. There will also be six batteries of accumulators capable of furnishing 400 horse-power.

In the distribution room a large collection of apparatus will be in use. Messrs. Siemens Brothers are laying down a cable to carry a current at a pressure of 20,000 volts. In this room the current will be supplied to the lighting and the power mains. Electric motors will drive 5 pumps, taking in all 250 horse-power, to supply water from the river Main to the Exhibition. Power from the same source will also be used to work a fire engine, a glow lamp factory, a mill, and mining machinery. In the installation apparatus room 75 firms are represented.

A committee composed of representatives from the various States will carry out tests on the apparatus exhibited, and the results will be subsequently published.

## SOME OBSERVATIONS ON THE EXISTENCE OF RESIDUAL MAGNETISM IN TELEPHONES.*

BY S. KALISCHER.

In December last the author observed that a Siemens telephone, the two ends of the winding of which were insulated from each other, gave out a sound if an induction apparatus in proximity to it was at work. The axis of the telephone was horizontal and at right angles to that of the coils of the apparatus. If the telephone was turned on its axis, or the coils on it short-circuited by a short wire, the sound diminished, and even became inaudible. If the axis of the telephone was parallel to the axis of the coils, no difference was noticeable in the intensity of the sound, whether the telephone circuit was open or closed.

In order to study this interesting phenomenon, some thick wire was coiled in a single layer round a bundle of iron wires as a core. Two Tudor accumulators supplied the current, and a Wagner key placed outside the laboratory served to interrupt the current. Results similar in kind to those above recorded, though varying in intensity, were again observed. When the axis of the telephone was placed at right angles to that of the inducing coil, minima appeared when the limbs of the magnet were one above the other; maxima when they were side by side. When the telephone circuit was open, the sound was always louder than when it was closed.

The telephone circuit being open, the sounds could not be due to any current induced in its coils, so that the phenomenon is not electrical, but magnetic in its nature. This can also be proved directly by the employment of a telephone without coils, when a sound of the same character as before may be heard.

The reason why a telephone with its circuit closed gives out a less loud sound than one in which it is open is not clear, and the difference does not appear in telephones of some forms. Several considerations, however, concur to prove that the iron membrane is the cause of the sound. To test this the magnet was removed from the telephone, leaving the membrane still free to work. The same sound was still observed, and was even increased in intensity. If the membrane was turned about a vertical diameter the loudness of the sound was changed, and in general it was easy to distinguish two positions of minima, the angle between them being 180 deg., and two of maxima, 90 deg. from each position of minimum. Maxima occurred when that diameter of the membrane which was parallel to the line joining the poles of the magnet was parallel to the axis of the induction coils, and minima when these two lines were at right angles to one another. It may, therefore, be concluded that the phenomenon is due to residual magnetism in the membrane. In order to prove this, membranes of tinned sheet iron were used which had never been in contact with a magnet. These gave no sound, but as soon as they had been magnetised the effect described could be observed. Apparently, this gives a very sensitive method of detecting traces of residual magnetism in such plates.

It seems that the above phenomenon is quite independent of the direction in which the current flows through the inducing coil.

* Wiedemann's *Annalen*. Vol. XLI., Part 11.

## BOROUGH OF NOTTINGHAM ELECTRIC LIGHTING.

**The following are the particulars issued to contractors who are tendering for the public lighting of the borough of Nottingham:—**

The Corporation of Nottingham have appointed an Electric Lighting Committee to carry out a Provisional Order, granted to the Corporation on August 4, 1890, for supplying the borough of Nottingham with electricity.

By Clause 59 of the Order, the Corporation are empowered to transfer their powers, duties, and liabilities to any company or person with the approval of the Board of Trade, and the Committee are desirous of adopting this method of working the Order.

By Clause 17 of the Order, the undertakers are compelled, within two years from August 4, 1890, to lay down proper mains for the purposes of general supply throughout the streets shown in the plan and thereon marked with a red line. Subsequently the undertakers have to supply such other parts of the borough (edged with pink colour on the same plan) as they may be required to do in pursuance of the usual requisitions of owners or occupiers, and on proper guarantees being given by them. The undertakers may appeal to the Board of Trade if they consider that any such requisitions are unreasonable.

Companies or persons prepared to contract and find the necessary capital for working the Order and relieving the Corporation of all responsibilities thereunder are requested to submit tenders to the Committee stating fully:—

(1) The terms and conditions on which they would work the Order under such transfer, and particularly—

(*a*) What advantages would be offered to the Corporation for the transfer?

In case a share of the profits be proposed, what percentage of profits above a certain limit would be given to the Corporation, and what would be such limit?

(*b*) What concessions would be made in favour of the Corporation in mitigation of the provisions of Section 2 of the Electric Lighting Act, 1888, in the event of the Corporation desiring to re-purchase the undertaking?

(*c*) For what period would the transfer be taken?

(*d*) Would the extra expenses thrown upon the Corporation staff, or otherwise, be borne by the transferees?

The transferees must pay the cost of the Electric Inspector to be appointed under the Order.

Would they indemnify the Corporation from all consequences whilst working the Order?

(2) The security to be given for working the Order properly, or in the case of a company, particulars of capital paid up, and uncalled and the amount available and proposed to be spent for the carrying out of the Order.

(3) The system of supply to be adopted (which has to be approved by the Board of Trade).

(4) The provisions to be made for ensuring the safety of the public from contact with wires, &c. No overhead wires will be allowed.

(5) Nature of the works which would be executed. The Corporation are prepared to negotiate for the sale or lease of a centrally situated property which they think would be suitable for a central station. If the company would provide their own site its proposed position and area must be stated.

(6) The price proposed to be charged for energy per Board of Trade unit per quarter; the maximum charge allowed by the Order is for any amount up to 20 units 13s. 4d., and for each unit over 20 units 8d.

(7) References to places where previous work of the contractors in electrical installation on the system proposed to be adopted in Nottingham can be inspected by the Committee.

(8) The Corporation will reserve all powers given by the Order to the undertakers of breaking up or interfering with any streets, and will execute such necessary works in connection therewith as may be properly required by the transferees, and charge the costs thereof to the transferees, who must in the first instance make a sufficient deposit to secure such costs.

(9) The transfer will be made subject to the provisions of Clause 59 of the Order.

Copies of the Provisional Order may be obtained from Messrs. Sharpe, Parker, and Co., 12, New-court, Carey-street, London.

Sealed tenders must be sent to the undersigned, marked "Electric Lighting Tender," on or before February 1, 1891. The Committee are not bound to accept the lowest or any tender.

## BOOKS, &c., RECEIVED.

"The Comprehensive International Wire Table." Wilfrid S. Boult, A.M.I.C.E. (Liverpool).

"Electric Transmission of Energy." By Gisbert Kapp, C.E. Third Edition, revised. (London: Whittaker and Co.)

Digitized by Google

## AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *December* 26, 1890.

**The Baxter Traction Motor.**—A new electric railway company is about to enter the field with a complete system of its own. It is the Baxter Company of Baltimore, which is one of the old established stationary motor companies. Until the present time it has done nothing in the way of railway work, but it is just now getting ready to exploit a railway motor vigorously. To-morrow the Company holds a test at its factory, at which the new machinery will be exhibited to a large number of prominent electricians. It is understood that the special feature of the Baxter system is a slow speed motor.

**Edison Mining Plant.**—The Edison Company has been doing no small amount of business among the Western mines within the past few months. Mining operators are rapidly coming to realise the advantages of electric lighting and power for their particular branch of engineering, and it is believed that a wide field has been opened for applied electricity. Mine equipments include tramways, electric hoists, electric pumps, electric drills, general lighting, and transmission of power. The Company is making especial efforts to devise a thoroughly practical and successful electric drill, and claims that such a one will be put on the market at an early date. It is for long-distance transmission of power, as in deep and extensive mines, where it is difficult to have steam-power within a reasonable distance of the point where drills must be used, that electricity offers peculiar advantages, both from its convenience and from its economy, and therefore the advent of a thoroughly practical electric drill is much to be desired.

**The New York Electric Club.**—An interesting lecture was recently delivered at the New York Electric Club by Prof. F. B. Crocker, on the subject of "Electrical Units of the Present and Future." It was a clear and popular account of the origin, derivation, and meaning of the principal electrical units in use and to be desired, and has attracted a great deal of attention from electricians in this city. A large audience was present, and the lecture was most enthusiastically greeted. The Electric Club is doing excellent work in bringing a large body of active electricians into daily contact with each other, and establishing pleasant and harmonious relations between them. At its rooms are given, during the winter, a considerable number of lectures by well-known scientific men; besides these, there are less technical gatherings, receptions, dinners, and the like.

**The American Bell Telephone Company.**—Rumours have been started that the Bell Telephone Company on the expiration of its fundamental patents intends to push the telegraph companies in very vigorous style. To this end it is rapidly extending its long-distance lines, and it is apparent to every one that, in spite of the expiration of the patents, the Company will continue its extraordinary prosperity. It is even hinted that at some future day, when its network of lines become more extensive, it may also assume the functions of a telegraph Company. A long-distance telephone wire equipped with Wheatstone transmitters would be a considerable factor in the telegraphic intercourse between two large cities, and whether the Bell Company intends to do such work or not it will be in a position to undertake it if it is desirable.

## TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

TENDERS WANTED.—The Barnsley Town Council invite tenders for the erection of buildings for a general electric light station in Midland-street and Queen's-road. Particulars are to be obtained after the 9th inst., on personal application, to Mr. J. H. Taylor, the architect, St. Mary's-place, Barnsley, to whom tenders are to be delivered by 3 p.m. on the 16th inst.

VACANT APPOINTMENT.—The India Office requires an assistant engineer for the Ishapore Gunpowder Factory. The selected candidate must have an efficient knowledge of electrical engineering, &c. Some details will be found in our advertisement columns, and full particulars will be given to applicants at the Offices of the Director-General of Stores, India Office, Whitehall, S.W.

SALE BY AUCTION.—Wheatley Kirk, Price, and Goulty announce the sale by auction, on Friday, January 23rd (commencing at 10 for 11 o'clock prompt), at Atlantic Works, City-road, Manchester, of a large quantity of valuable and nearly new high-class engineering tools and machinery by eminent makers. The whole may be viewed on Wednesday and Thursday, January 21st and 22nd, and on the morning of sale. Catalogues can be had at the works, and from the auctioneers' offices in Manchester and London. Further particulars are given in our advertisement columns, and all information will be supplied by the auctioneers.

ELECTRICAL ENGINEERING CORPORATION (LIMITED).—An announcement appears in our advertisement pages of a destructive fire having taken place at the Corporation's Works at West Drayton. It will be seen, however, that the fire will not interfere with the progress of business, the Corporation being able to provide for all contingencies from its own resources.

TRANSFER OF BUSINESS.—The well-known electrical instrument business carried on for so many years by Mr. Richard Theiler, at 86, Canonbury-road, N., under the style of Theiler and Sons, has recently been transferred to Mr. Elphinstone, late assistant to Mr. S. Z. de Ferranti, and the business will be carried on in future by him under its old style and title. We regret to say that the cause of Mr. Theiler's retirement is failing health. It is Mr. Elphinstone's intention to continue to manufacture goods of the best quality, and generally to conduct the business on the lines which have been so successful under Mr. Theiler's proprietorship.

THE FOWLER-WARING CABLES COMPANY.—This Company have removed their general offices from 85, Queen-street, London, E.C., to No. 4, Victoria Mansions, Victoria-street, Westminster, S.W.

PERSONAL.—Mr. W. A. Perry, late manager for Messrs. H. H. Vivian and Co. (Limited), Birmingham, has been appointed the manager of the Phosphor Bronze Company's rolling and wire drawing mills at Aston-road and Bagot-street, Birmingham.

NEW TELEPHONE COMPANY (IN LIQUIDATION).—Notice is given by Mr. W. S. Ogle, the liquidator, whose address is 90, Cannon-street, E.C., that a dividend of two shillings in the pound has been declared in this liquidation, and the same will be paid at the above address any day between 10 a.m. and 2 p.m.

STANDARD ELECTRIC LIGHT AND POWER COMPANY (LIMITED) (IN LIQUIDATION).—A meeting of the shareholders is to be held at Mr. H. Brown's, 13, Victoria-street, London, S.W., on February 12th, at 2 p.m., to receive an account of this liquidation.

THE ELECTRICAL ACCESSORIES COMPANY.—This Company have sent us their illustrated price list, in which their sunk switches appear to be a very useful speciality. The illustration represents

one of these, or rather all that is to be seen of the switch when fixed. It is a common complaint that switches are a serious disfigurement to a well decorated house, and the ornamentation often applied to china switch covers in no wise improves them. The switch itself is sunk in a box suitably constructed to prevent the penetration of moisture, and if it be found that this desirable end is attained in practice, this form of switch should meet with great success.

THE GENERAL ELECTRIC POWER AND TRACTION COMPANY.—About the middle of this year the business of Messrs. M. Immisch and Co. was amalgamated with that of the Electric Traction Company, and the two firms now trade under the title of the General Electric Power and Traction Company (Limited). Work in the Company's mining department has been exceptionally brisk, and installations have been erected in England, Wales, Scotland, the Continent, Asia, Africa, and Australia. The aggregate horse-power supplied during 1890 in dynamos and motors for this purpose is very nearly 1,000 horse-power. In tram-car work, although no new lines have been laid down this year by the Company, they have made considerable progress in the general details of accumulator

Digitized by Google

work, and have successfully run their cars on the North Metropolitan Tramway Company's lines at Barking during the whole of the year. In the electric launch department during the past summer the Company had launches both on the Thames and on the Union Canal at Edinburgh during the late Exhibition. The total number of passengers carried at Edinburgh was 100,000, and the result commercially was thoroughly satisfactory. On the Thames some 12 launches were kept for hire, and although the season was a bad one, yet they were patronised by the public to a large extent. The general work of the Company during the past year was far in excess of that of the previous year, and shows a large increase in the demand for motors suitable for central stations, and motors for special machine tools have been in fair demand. A large number of dynamos for electric lighting have also been supplied by the Company, and several important installations have been carried out, amongst others may be mentioned Tatton Hall, Knutsford, the residence of Lord Egerton of Tatton. The prospect for 1891 is decidedly good, and the Company starts the new year with a large number of contracts in hand. Several important mining plants are now in course of erection, and others are in negotiation.

Messrs. Sharp and Kent.—This firm report a greatly increased business for the past year and good prospects for 1891. Amongst the principal orders the firm have executed may be mentioned the installation at the Houses of Parliament, the plant consisting of 160 horse-power boilers, engines, dynamos, pumps, and feed-water heaters, and 8 underground mains of 61/10, each containing a ton of copper. The whole of the plant was supplied, put down, erected, and started within three weeks, and ran successfully through the entire Session Messrs. Sharp and Kent have also supplied and erected for the Westminster Electric Supply Corporation at their St. John's Wharf station, Westminster, boilers of 600 horse-power, and engines and dynamos of 640 horse-power; and for the Windsor Hotel, Westminster, 160 horse-power engines and dynamos. A feature of the past year's work is the wiring for upwards of 15,000 lights. The firm have in hand engines and dynamos of 600 horse-power, pumps, tanks, &c., for the Corporation of Brighton, as well as the electrical apparatus in connection with measuring and testing instruments, switch-boards, resistances, &c., required under this contract.

Woodhouse and Rawson United.—This firm reports that in the beginning of the year they removed their head office from 11, Queen Victoria-street to extensive premises having frontages to 30, Cannon-street and 88, Queen Victoria-street respectively. Notwithstanding the size of these new premises, the Company have been obliged by business requirements to take the whole of an adjoining block of buildings. The new show rooms will be at 34, Cannon-street, and the secretary's office at 88, Queen Victoria-street. Among the developments may be mentioned the purchase and working of the engineering works at Kidsgrove, near Stoke-on-Trent, lately carried on by Messrs. Renshaw, King and Co. The important and growing business of electrical and steam launch building has been added to the other resources of the Company by the purchase of the business of Mr. W. S. Sargeant, of Chiswick. Branch offices have been opened in distant parts of the world, viz., Sydney, Melbourne, and Johannesburg, while other depôts such as Alexandria, Amsterdam, Barcelona, Bath, Bombay, Buenos Ayres, Cadiz, Cork, Dunedin, Hamburg, and Yokohama have been opened. At their Cadby Hall Works the Company have erected a huge new building to accommodate their increasing business in the manufacture of lamps and switches. In the contract department satisfactory progress has been made. In the Yorkshire districts forty installations have been carried out by the Bradford branch. In the Lancaster district, among the larger installations carried out by the Manchester branch, may be mentioned a 700-light plant for Messrs. Dobson and Barlow, Engineers, of Bolton. The central station lighting work at Barcelona has been planned out by the Company's engineers. In the supply department the turnover has increased 100 per cent. in the last twelve months. In the manufacturing department the Company holds a number of large contracts. Amongst the heavy electrical engineering work carried out at Kidsgrove may be mentioned complete electrical and mechanical plant for small central station at Palace-chambers, Westminster, and complete mechanical and electrical plant for the Woking central station. A considerable number of electrical launches have been built at the Company's yards at Chiswick, amongst them being the "Volt," and various launches from 28 to 31ft. long. For the English Government a very important departure has been made in building an electric pinnace capable of carrying 40 soldiers, another pinnace of this class having been already built for a steam yacht. As steel launch building requires special appliances, a special yard has been recently laid out for building steam launches of every description. The Company, after writing £7,000 off patents account, paid a dividend for the year of 15 per cent., put £25,000 to reserve fund, and carried forward over £16,000.

Telegraph Manufacturing Company (Limited).—The works have been extremely busy during the past twelve months. The gutta-percha wire made by this Company has been in such demand, that although the plant has been doubled, the supply has scarcely been able to keep pace with orders. It has been found necessary to erect new buildings for the battery and insulator departments and for the instrument department. The Helsby Works will be solely devoted to the electric light, telephone, and telegraph wires and cables.

Messrs. Poole and White.—This firm notify us that business is extremely active, necessitating in the near future increased manufacturing premises. They have, during the past year, added to their list of manufactures a number of articles in great demand. Their well - arranged catalogue contains exhaustive tables relating to electric wires and cables, and illustrated particulars of White's patent ceiling rose, the "Poolite," "Diamond,' and other switches, switch-boards (in which department Messrs. Poole and White have large orders on hand), safety junctions, cut-out blocks, White's patent "Simplex" wall socket, back blocks, lamp holders, shades, globes, and reflectors. The catalogue consists in all of thirty-two large quarto pages.

Messrs. O. Berend and Co.—This firm furnish the electrical trade with a variety of supplies, and report that during 1890 the demand for their special goods has been fairly active both for home and export trade. In the artistic fittings in bronze and wrought iron work, a growing demand is experienced, and for the electrical instruments, volt and ammeters, manufactured by Messrs. Hartmann and Braun, business is brisk. Messrs Berend have lately introduced a soldering lamp and automatic blowpipe for electric linemen, as well as a tool for easily and quickly trimming the ends of wires and removing the insulation without damage to the wire. Messrs. Berend report that the demand for German carbons, dynamos, and other supplies has largely increased during the year.

Mr. Carl Oppermann.—We are in receipt of the illustrated price list and particulars of the dynamos, &c., manufactured by Mr. Oppermann. The list is accompanied by a number of testimonials from users of the machine. Mr. Oppermann has recently completed an installation of the electric light at the works of the Fitch Typewriter-Company, in Clerkenwell-road, E.C., consisting of 80 incandescent 16 candle-power 110 volt lamps, distributed over the six-floor building. The lamps are fed by an upright-type self-regulating Oppermann dynamo, driven by a Griffin gas engine. Mr. Oppermann has also fitted up a plating department, wherein the parts of the type-writers manufactured by the Fitch Company are nickel-plated. The current for the plating machine is supplied by an Oppermann slow-speed plating dynamo.

Calendars, &c.—We have received a very useful and handsome memorandum tablet of china, with a movable weekly calendar, from Messrs. Appleton, Burbey, and Williamson, of 91, Queen Victoria-street, E.C.

——— Messrs. Crompton and Co. send us a blotting pad with calendar. A useful set of tables of weights and measures are arranged on the flap covering the calendar. Each year the calendars issued by this firm increase in usefulness.

# PATENT RECORD.

## APPLICATIONS FOR PATENTS.

**Note.**—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

December 13, 1890.

20,360. S. L. Tomkins, of the Electric Meter Company, Limited. London. Improvements in electric meters.

20,372. C. H. Cathcart. London. Improvements in electrical switches.

20,379. J. P. Bayly. London. Improved underground electric conduit (C. E. Loth, United States).

20,401. E. Andreoli. London. Improvements in the electrolysis of chloride and other solutions.

December 15, 1890.

20,424. M. von Dolivo Dobrowolsky and the Company Allgemeine Elektricitäts Gesellschaft. London. Improvements in alternating current motors.

20,425. M. von Dolivo-Dobrowolsky and the Company Allgemeine Elektricitäts Gesellschaft. London. Improvements in the regulation of the speed and power of alternating current motors.

## SPECIFICATIONS PUBLISHED.

1889.

17,425. Harper. Electric arc lamps. (Price 8d.)

19,433. Zöpke. Conduits for subterranean electric lines. (Price 8d.)

20,244. Holmes. Electric generating machinery. (Price 11d.)

20,991. Jensen, H. P. F. and J. Electric, &c., bells. (Price 8d.)

Digitized by Google

1890.

488. Sappey. Primary batteries. (Price 8d.)
771. Oesterreich and Genest. Telephone systems. (Price 8d.)
1,068. Luckhoff and Hungerbühler. Dynamo or electro-motor conductors. (Price 6d.)
2,080. Chamberlain. Electric car storage batteries. (Price 11d.)
2,172. Boardman. Electric tell-tales. (Price 8d.)
2,503. Saunderson. Electric arc lighting. (Price 8d.)
8,853. Piat. Brake and circuit-making and breaking device for electric motors. (Price 8d.)
8,933. Felt. Depositing metals by electro-deposition. (Price 8d.)
10,445. Bayly. (Burton and Others.) Electric prod pole. (Price 8d.)
11,288. Vinicombe. Armatures for dynamos. (Price 6d.)
13,042. Van Depoele. Electric railway systems. (Price 11d.)
13,187. Moore. Electro-motors. (Price 6d.)
13,410. Stitzel and Others. Electric semaphores. (Price 8d.)
13,535. Thompson and Rew. Electrical alarms. (Price 8d.)
14,260. Hadden (Williams). Electric carrier systems. (Price 8d.)
14,613. Robinson. Electric-motor car. (Price 8d.)
16,534. Longsdon. Electrical primers, &c. (Price 6d.)
16,889. Kennedy. Electro-motors. (Price 8d.)
17,728. Dewey. Electric railways. (Price 8d.)
17,735. Cleaver and Fassold. Regulators for dynamos, &c. (Price 6d.)
18,034. Redfern (Schirner). Electric switch. (Price 6d.)
18,186. Lake (Weston). Electrical measuring instruments. (Price 8d.)
18,247. Andrews. Electric lamps. (Price 6d.)

## COMPANIES' MEETINGS & REPORTS.

### The Eastern Telegraph Company (Limited).

The following is the report and accounts of the Directors of the Company for the half-year ended September 30, 1890, to be presented to the thirty-seventh half-yearly ordinary general meeting, to be held at Winchester House, Old Broad-street, E C., on Thursday, the 15th inst., at one o'clock:—

The revenue for the period amounted to £352,873. 11s. 1d., from which are deducted £91,723. 11s. 7d. for the ordinary expenses and £31,477. 17s. 9d. for expenditure relating to repairs and renewals of cables, &c., during the half-year. After providing £5,212. 8s. 2d. for income-tax, there remains a balance of £224,459. 13s. 7d., to which is added £2,484. 9s. 7d. brought from the preceding half-year, making a total available balance of £226,944. 3s. 2d.

From this balance there have been paid:—

| | £ | s. | d. |
|---|---|---|---|
| Interest on Debentures and Debenture Stock ... | 28,274 | 13 | 0 |
| Dividend on Preference shares........................ | 20,474 | 3 | 9 |
| Two interim dividends of 2s. 6d. per share each on ordinary shares ................................ | 100,000 | 0 | 0 |
| | £148,748 | 16 | 9 |

leaving a balance of £78,195. 6s. 5d., which is carried forward to the next account.

The revenue includes £33,455. 17s. 8d. dividends for the half-year upon the Company's shares in the Eastern and South African, the Black Sea, the Direct Spanish, and the African Direct Telegraph Companies.

The Directors learn that the negotiations referred to at the last general meeting with certain of the Australasian Colonies for effecting a reduction in the tariff will be speedily concluded, and the new rates will be brought into operation at an early date.

The Directors have decided, in view of a largely increased traffic with Australasia, to lay a triplicate line from Aden to Bombay, and have entered into a contract with the Telegraph Construction and Maintenance Company for the manufacture and laying of the cable early in the present year.

The new Red Sea cable connecting Suez, Perim, and Aden, referred to in the last report, was successfully laid by the contractors in November last. Arrangements have been made to take the direct Suez-Aden 1876 cable into Suakim, thus duplicating the Suakim-Suez section, and adding to the security of submarine telegraph communication with that port.

In accordance with the Articles of Association, two of the Directors, Sir John Pender, K.C.M.G., and the Marquis of Tweeddale, retire by rotation at this meeting, and, being eligible, offer themselves for re-election. The auditors, Mr. Henry Dever and Messrs. Welton, Jones, and Co. retire, and offer themselves for re-election.

### Woodhouse and Rawson United (Limited).

An extraordinary general meeting of this Company will be held at Winchester House, Old Broad-street, E.C., this day (the 9th inst.), at 12 o'clock noon, for the purpose of considering, and, if thought fit, passing the subjoined extraordinary resolutions:

1. *That the Directors be authorised to enter into such arrangement as they shall think advisable with the Liquidators of Woodhouse and Rawson (Limited), for the immediate or early repayment to such Liquidators of the sum of* £75,000, *or any part thereof, deposited with the Company on the terms that it should be retained till the* 1st *of July,* 1892, *as a Dividend Guarantee Fund.*

2. *That the capital of the Company be increased to* £550,000 *by the creation of* 40,000 *new shares of* £5 *each, of which* 20,000 *shares shall be Preference Shares, which shall be entitled to the same preferential dividend and rights, other than the benefit of the dividend guarantee fund, and shall be subject to the same conditions as and rank for all purposes* pari passu *with the existing issue of* 30,000 *Preference Shares of* £5 *each of the Company, the remaining* 20,000 *shares shall be ordinary shares, and shall be entitled to the same dividends and rights, other than the benefit of the dividend guarantee fund, and shall be subject to the same conditions as, and rank for all purposes* pari passu *with the existing* 40,000 *ordinary shares of the Company.*

Should the second of the above extraordinary resolutions be passed by the required majority, it will be submitted for confirmation as a special resolution to a second extraordinary meeting, which will be subsequently convened.

## NEW COMPANIES REGISTERED.

**Birmingham Telegraph Factory (Limited).**—This Company was registered on the 31st ult., with a capital of £50,000, in £10 shares, to carry on business as telegraph and telephone engineers and contractors, and manufacturers of appliances and apparatus. The subscribers are:—Harold Mason, M.R.C.S., Leamington; *E. W. Lancaster, Edgbaston, Birmingham, electrical engineer; P. C. Bytheway, Wednesbury; *J. Slater Lewis, Yardley, near Birmingham, telegraph engineer; Arthur Mason, Leamington; Wm. Fowler, 69, Temple-row, Birmingham, land agent; *G. V. Fowler, Longbridge, Warwick, electrical engineer. The number of Directors is not to be less than 2, nor more than 4; qualification, 50 shares; the

PATENT

SILICIUM BRONZE AND SILICIUM COPPER WIRE.

The best for overhead Telephone and Telegraph Lines,

AND ALL ELECTRICAL PURPOSES.

Hard Drawn High Conductivity Copper Wire.

ROLLED AND DRAWN PHOSPHOR BRONZE.

PHOSPHOR BRONZE — VULCAN — PHOSPHOR — DURO METAL

PHOSPHOR BRONZE BEARINGS, BUSHES, AND OTHER PARTS OF ELECTRICAL MACHINERY

SOLE PROPRIETORS of the British, Indian and Colonial Patents,

THE PHOSPHOR BRONZE COMPANY (Limited),

87, Sumner Street, Southwark, London, S.E.

WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

Digitized by Google

first are the subscribers denoted by an asterisk; remuneration, £250 per annum, divisible. Solicitors: Dr. E. C. Rogers, 4, Waterloo-street, Birmingham, and Messrs. E. F. Mason and Sons, Town Hall Chambers, Birmingham.

**NEW COMPANIES REGISTERED DURING DECEMBER.**—Among the new Companies registered at Somerset House during December, 1890, were the following:—

| | Capital. |
|---|---|
| Albert Hoster (Limited), £20 shares | 2,000 |
| Ateliers Hoster de St. Nicolas, £20 shares | 2,000 |
| Avon India-rubber Company, £5 shares | 50,000 |
| Birmingham Telegraph Factory Company (Limited), £10 shares... | 50,000 |
| Electric Stores (Limited), £1 shares | 15,000 |
| Foreign Electric Date and Time Stamp Company, £1 shares | 100,000 |
| London Metallurgical Company, £10 shares | 15,000 |
| New Zealand Electrical Syndicate (Limited), £10 shares | 30,000 |
| Practical Electro-plating and Enamelling Company, £5 shares | 2,000 |

**SOUTHERN RAILWAY OF PERU (LIMITED).**—Registered by Smiles, Ollard, and Yates, 15, Bedford row, W.C., with a capital of £2,600,000, in £1 shares. Object, to acquire, construct, repair, complete, equip, maintain, and work railways, tramways, telegraph and telephone lines in the Republics of Peru and Bolivia, and to acquire and exercise any rights in relation to the navigation of any lakes or rivers in those Republics, and for such purposes to acquire all or any of the rights of the Peruvian Corporation (Limited), or any other company or of any firm or person relating to any such means of communication, appliance, or rights, and to apply to the Peruvian or Bolivian or any other Government for any concessions or contracts; to carry into effect an agreement made December 29, 1890, between Charles Watson of the first part, John Larkin Thorndike of the second part, the Peruvian Corporation (Limited) of the third part, Thomas E. Webb (as trustee on behalf of this Company) of the fourth part, and Michael Paul Grace of the fifth part.

## CITY NOTES, &c.

**AUSTRIAN ELECTRICAL COMPANIES.**—The Anglo-Austrian Bank of Vienna and the firm of Siemens and Halske, of Berlin, have just formed three new electrical companies, with headquarters in the former city. The first is the Austrian General Electricity Company, constituted, with a capital of £312,000, for the purpose of constructing and working central electric light stations. The second is the Electric Tramway Company, with a capital of £312,000, for the making and working of electric tramways; and the Company have already acquired the Buda-Pesth electric tramway. The third is the International Compressed Air and Electricity Company, with the same amount of capital, and formed to work a concession obtained from the Vienna municipality for lighting the city by electricity.

**ALBERT HOSTER (LIMITED).**—This Company was registered on the 30th ult., with a capital of £2,000 in £20 shares, to take over the business of mechanical and electrical manufacturing engineer, carried on by Albert Hoster, at 51, Cannon-street. The subscribers are the same as in the Ateliers Hoster de St. Nicolas (Limited).

**ATELIERS HOSTER DE ST. NICOLAS (LIMITED).**—This Company was registered on the 30th ult., with a capital of £2,000 in £20 shares, to acquire, work, and develop the business of mechanical and electrical engineer carried on by Albert Hoster, of 51, Cannon-street, at St. Nicolas d'Aliermont, Department of Seine-Inférieure, France.

**BRAZILIAN SUBMARINE TELEGRAPH COMPANY.**—The receipts of this Company for the week ending January 2nd amounted to £4,668.

**CHANGE OF ADDRESS.**—The Empire Telephone Company has changed its offices from 60 to 171, Queen Victoria-street.

**CITY AND SOUTH LONDON RAILWAY.**—The receipts of this Company for the 14 days ended January 3rd amounted to £1,947.

**CUBA SUBMARINE TELEGRAPH COMPANY.**—The estimated traffic receipts of this Company for the month of December were £3,000, as compared with £2,995 in the corresponding month of last year.

**DIRECT SPANISH TELEGRAPH COMPANY.**—The traffic receipts of this Company for the month of December show a decrease of £57, compared with the corresponding period in 1889.

**DIRECT UNITED STATES CABLE COMPANY (LIMITED).**—The Board of Directors of this Company announce the payment of an interim dividend of 3s. 6d. per share, free of income-tax, being at the rate of 3½ per cent. per annum for the quarter ending December 31, 1890. The dividend is payable on and after the 21th instant.

**EASTERN TELEGRAPH COMPANY (LIMITED).**—The traffic receipts of this Company for the month of December, 1890, amounted to £58,058 as against £56,862 for the corresponding period of 1889, or an increase of £1,196.

**EASTERN EXTENSION TELEGRAPH COMPANY.**—The receipts of this Company for December amounted to £43,482, as against £40,362 in the corresponding period of last year, showing an increase of £3,120.

**ELMORE'S FRENCH PATENT COPPER DEPOSITING COMPANY (LIMITED).**—The share certificates are ready to be exchanged for allotment letters and all bankers' receipts.

**EXCELSIOR COPPER COMPANY (LIMITED)**—An extraordinary general meeting of this Company, held on Monday, confirmed the resolutions passed at a previous meeting winding-up the Company with a view to its reconstruction.

**GREAT NORTHERN TELEGRAPH COMPANY.**—The traffic returns of this Company are as follows:—Receipts in December, 1890, £23,600; 1st January to 31st December, 1890, £280,000; corresponding months, 1889, £274,800; corresponding months, 1888, £272,200.

**INTERNATIONAL OKONITE COMPANY (LIMITED).**—The Directors of this company have decided to pay on and after Thursday next an interim dividend of 8 per cent. on the paid up capital. This dividend is declared out of the profits of the company earned since the date of the company's registration (June 24, 1890). The notice issued by the Directors states that the profits, which were purchased by the company as from January 1st until the date of registration (£20,113), have been certified by Messrs. Price, Waterhouse, and Co. to be in excess of the sum estimated in the prospectus as likely to accrue, but the Directors are advised that this sum is not available for the purpose of the payment of dividend, which must be paid out of the actual earnings of a company The dividend now payable, after payment of interest upon debentures, is for the six months ended December 31st, and is at the rate of 8 per cent. per annum upon the preference shares and 10 per cent. per annum upon the ordinary shares of the company. The transfer books of the company will be closed from the 10th to 13th inst. inclusive. The Directors announce that the new factory at Newton Heath, Manchester, is progressing rapidly towards completion, and the machinery is nearly all ready for delivery. When this addition to the existing works comes to be fully developed, the Directors anticipate a large increase in the English business.

**PORTSMOUTH AND SOUTH HANTS ELECTRICITY SUPPLY COMPANY (LIMITED).**—At a meeting of this Company, held on December 30th, resolutions passed at a previous meeting, that the Company be voluntarily wound up, were confirmed. Mr. W. Edmonds, C.A., Portsea, was appointed liquidator.

**WEST COAST OF AMERICA TELEGRAPH COMPANY.**—The traffic receipts of this Company for the month ending December 31, 1890, amounted to £5,375.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY.**—The traffic receipts of this Company for the week ending January 2, 1891, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £3,747.

**WEST INDIA AND PANAMA TELEGRAPH COMPANY.**—The estimated traffic receipts for the half-month ended Dec. 31st show a decrease of £102, as compared with the corresponding period of 1889.


# THE NON-CONDUCTOR OF ELECTRICITY.

WAREHOUSE.

**VULCANISED FIBRE,**
PATENTED.

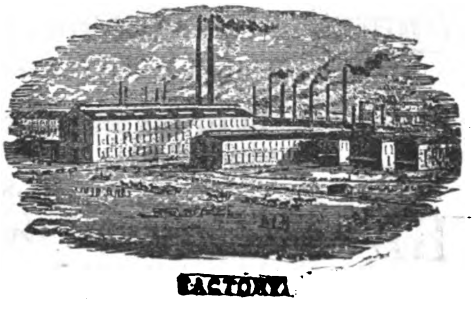
**This new material is supplied in two qualities, Flexible and Hard.**

**The FLEXIBLE is a substitute for Leather, Rubber, Gutta Percha, &c., and is extensively used by Brass Founders, Axle Makers, Hydraulic, Sanitary, and other Engineers, Pump Makers, Carriage Builders, &c.**

**It makes the best Hot and Cold Water Packings, and for Axle Washers of all kinds it is unequalled.**

**The HARD is a substitute for Metals, Hard Wood, Ivory, Vulcanite, Ebonite, &c., and is a good Insulator.**

**Sold in sheets, 5ft. 6in. by 3ft. 6in., varying in thickness from 1-50in. to 1in.**


FACTORY.

**FLEXIBLE, 2/- per lb.; HARD, 2/3 per lb.**

**MOSSES & MITCHELL, 70, Chiswell-st., London, E.C.**


Digitized by Google

# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name. | Previous Week's Price, Dec. 22. | | Price Wednesday, Jan. 7. | | Rate per Cent. Yielded. | Dividend Due. | Business Done During Week Ending Jan. 6. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **TELEGRAPHS.** | | | | | £ s. d. | | | |
| £1,381,380 | Stock | 15/0 | Anglo-American | 48½ | 49½ | 48½ | 49½ | 5 16 2 | Jan., Apr., July, Oct. | .. | .. |
| £2,809,310 | Stock | 30/0 | Do. Preferred | 84½ | 85½ | 85 | 86 | 6 13 9 | ,, ,, | 86 | 85 |
| £2,809,310 | Stock | .. | Do. Deferred | 13¼ | 13¾ | 13¼ | 13¾ | .. | ,, ,, | 13 7/16 | .. |
| £250,000 | £100 | 4% | African Direct, 4 per Cent. Debentures ........xd | 98 | 101 | 97 | 100 | 4 0 0 | January and July .. | .. | .. |
| £130,000 | 10 | 6/0 | Brazilian Submarine ........xd | 11 | 11½ | 11 | 11½ | 6 10 5 | Mar., June, Oct., Dec. | 11⅜ | 11¼ |
| £84,500 | 100 | 5% | Do. 5 per Cent. Bonds | 101 | 103 | 102 | 104 | 4 16 2 | January and July .. | .. | .. |
| £75,000 | 100 | 5% | Do. 5 per Cent. Bonds (2nd Series, 1906).... | 102 | 106 | 102 | 106 | 4 14 4 | June and December | .. | .. |
| $7,216,000 | $100 | $1½ | Commercial Cables........xd | 102 | 104 | 102 | 104 | 5 15 5 | April and October .. | .. | .. |
| £16,000 | £10 | 8/0 | Cuba Submarine | 11½ | 12 | 11½ | 12 | 7 1 8 | February and August | .. | .. |
| £6,000 | 10 | 10% | Do. Preference 10% | 17 | 18 | 16½ | 17½ | 5 14 3 | ,, ,, | 17½ | .. |
| £12,931 | 5 | 2/4¾ | Direct Spanish (£4 paid) | 3¾ | 4¼ | 3¾ | 4¼ | 5 12 11 | April and October.. | .. | .. |
| £6,000 | 5 | 10% | Do. Preference 10% | 9 | 10 | 9 | 10 | 5 0 0 | ,, ,, | 9½ | .. |
| £60,710 | 20 | 3/6 | Direct United States | 10½ | 10⅝ | 10⅛ | 10⅝ | 6 15 0 | Jan., Apr., July, Oct | 10⅜ | 10 3/16 |
| £100,000 | 10 | 2/6 | Eastern | 13¾ | 14⅛ | 14 | 14¼ | 4 11 3 | ,, ,, | 14¼ | 14 |
| £70,000 | 10 | 6% | Do. 6 per Cent. Preference | 14¾ | 15¼ | 14¾ | 15¼ | 3 18 8 | ,, ,, | 14¾ | .. |
| £1,200,000 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock...... | 104 | 107 | 104 | 107 | 3 14 9 | May and November | 106½ | 105¼ |
| £200,000 | £100 | 5% | Do. 5 per Cent Debentures, 1899 | 106 | 109 | 107 | 110 | 4 10 11 | February & August | .. | .. |
| £250,000 | 10 | 2/6 | Eastern Extension | 14 | 14¼ | 14⅛ | 14⅜ | 4 17 5 | Jan., Apr., July, Oct. | 14⅜ | 14⅛ |
| £320,000 | 100 | 6% | Do. 6 per Cent. Debentures, 1891 | 101 | 103 | 101 | 103 | 5 16 6 | February & August | .. | .. |
| £320,000 | 100 | .. | Do. 4 per Cent. Debentures | .. | | 102 | 104 | .. | .. | .. | .. |
| £91,800 | 100 | 5% | Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900 ..xd | 104 | 107 | 102 | 105 | 4 15 3 | January and July .. | .. | .. |
| £145,300 | 100 | 5% | Eastern & S. African 5 per Cent. Mor. Deb., 1900.. | 103 | 106 | 101 | 104 | 4 16 2 | ,, ,, | 102 | 101¾ |
| £180,227 | 10 | 1/9 | Globe Telegraph and Trust | 8¾ | 9 | 8¾ | 9 | 5 8 4 | Jan., Apr., July, Oct. | 9 | 8 13/16 |
| £180,042 | 10 | 6% | Do. 6 per Cent. Preference | 14½ | 14¾ | 14⅝ | 14⅞ | 4 0 8 | ,, ,, | 14¾ | 14⅝ |
| £150,000 | 10 | 5/0 | Great Northern ........xd | 16 | 16½ | 15¾ | 16¼ | 4 12 4 | Jan., April, and July | 16 3/16 | .. |
| £15,000 | 100 | 5% | Do. 5 per Cent. Debentures, 1881 ........xd | 101 | 104 | .. | | .. | January and July .. | .. | .. |
| £230,000 | 100 | 5% | Do. 5 per Cent. Debentures, 1883 | 104 | 107 | 104 | 107 | 4 13 6 | March & September | 105 | .. |
| £17,000 | 25 | 12/6 | Indo-European | 35 | 37 | 35 | 37 | 6 15 2 | May and November | 37 | .. |
| £38,348 | 10 | 4/0 | London Platino-Brazilian | 6 | 7 | 6 | 7 | 5 14 4 | ,, ,, | .. | .. |
| £100,000 | 100 | 6% | Do. 6 per Cent. Debentures | 107 | 110 | 107 | 110 | 5 9 1 | March & September | .. | .. |
| £9,000 | 8 | 4/0 | Reuter's | 8½ | 9 | 8½ | 9 | 5 11 1 | April and October.. | .. | .. |
| £3,381 | £100 Cert. | 6% | Submarine Cables Trust | 110 | 114 | 110 | 114 | 5 5 3 | ,, ,, | .. | .. |
| £15,609 | £10 | 6/6 | West African | 8 | 9 | 8 | 9 | 5 11 1 | January and July .. | .. | .. |
| £290,000 | 100 | 5% | Do. 5 per Cent. Debentures | 98 | 101 | 98 | 101 | 4 19 0 | March & September | .. | .. |
| £30,000 | 10 | 3/0 | West Coast of America | 2 | 4 | 2 | 4 | .. | January and July .. | .. | .. |
| £150,000 | 100 | 8% | Do. Debentures 8% | 97 | 102 | 97 | 102 | .. | June and December | .. | .. |
| £38,321 | 10 | Nil. | West India and Panama | 2¾ | 3 | 2¾ | 3 | .. | .. | 3 | 2 13/16 |
| £34,563 | 10 | 6/0 | Do. 1st Preference 6% | 11¼ | 11¾ | 11¼ | 11¾ | 5 2 2 | May and November | 11⅝ | 11 7/16 |
| £4,669 | 10 | £3 | Do. 6 p. c. 2nd Pref. | 11 | 12 | 11 | 12 | 5 0 0 | ,, ,, | 11½ | 10½ |
| £64,174 | 15 | 6/0 | Western and Brazilian | 10¾ | 11¼ | 10¾ | 11¼ | 5 6 8 | ,, ,, | 10 13/16 | .. |
| £27,873 | 7½ | 6/0 | Do. 5 per Cent. Cumulative Preferred | 6¼ | 6¾ | 6¼ | 6¾ | .. | — | 6 7/16 | .. |
| £27,873 | 7½ | 4/6 | Do. 5 per Cent. Deferred | 4½ | 5 | 4½ | 5 | .. | .. | .. | .. |
| £200,000 | 100 | 6% | Do. 6 per Cent. Debs., Series "A" | 103 | 106 | 103 | 106 | 5 13 2 | February & August | .. | .. |
| £250,000 | 100 | 6% | Do. 6 per Cent. Mort. Debs., Series "B".... | 103 | 106 | 103 | 106 | 5 13 2 | ,, ,, | .. | .. |
| $1,336,000 | $1,000 | 7% | Western Union 7 per Cent. 1st Mortgage | 120 | 125 | 120 | 125 | 5 12 0 | May and November | .. | .. |
| £175,100 | £100 | 6% | Do. 6 per Cent. Sterling Bonds | 99 | 103 | 99 | 103 | 5 16 0 | March & September | .. | .. |
| | | | **TELEPHONES.** | | | | | | | | |
| £224,850 | 14/0 | 0/4½ | Consolidated Telephone Const. & Maintenance. .. | 7/16 | 9/16 | 7/16 | 9/16 | .. | May and November | ½ | .. |
| £220,000 | £1 | 3% | Oriental (11s. paid) | ⅛ | ⅜ | ⅛ | ⅜ | 4 8 3 | Yearly | .. | .. |
| £138,984 | 5 | 3/0 | National | 4⅜ | 4⅝ | 4⅜ | 4⅝ | 5 18 11 | June and December | 4 11/16 | 4⅜ |
| £15,000 | 10 | 6/0 | Do. 6 per Cent. Cumulative 1st Pref. | 12 | 12½ | 12 | 12½ | 4 16 0 | ,, ,, | .. | .. |
| £15,000 | 10 | 4/9¾ | Do. 6 per Cent. Cumulative 2nd Pref. (£8 pd) .. | 9¾ | 10¼ | 10 | 10½ | 4 11 5 | ,, ,, | .. | .. |
| £209,750 | 1 | ½% | South of England, Ordinary | ⅛ | ⅜ | ⅛ | ⅜ | .. | .. | .. | .. |
| £20,000 | 5 | 2/1 | Do. 6 per Cent. Cumulative Pf. (£3 10s. pd) .. | 2½ | 3 | 2½ | 3 | .. | .. | .. | .. |
| £58,000 | 5 | 1/0 | United River Plate | 3 | 4 | 3 | 4 | .. | January and July .. | .. | .. |
| £146,128 | Stock | 5% | Do. 5 per Cent. Debenture Stock ........xd | 90 | 95 | 90 | 95 | 5 5 3 | .. | .. | .. |
| £3,200 | 100 | 7% | Do. 7 per Cent. Debentures ........xd | .. | | .. | | .. | — | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | | .. | .. |
| £200,000 | £5 | .. | London Electric Supply | 1¾ | 2 | 1¾ | 2 | .. | — | | |
| £13,900 | 10 | .. | Metropolitan Electric Supply (£8 paid) | 7½ | 8 | 7¾ | 8¼ | — | — | 8 | 7⅞ |
| £12,853 | 5 | .. | Westminster Electric Supply (£3 paid) | 2½ | 3 | 2½ | 3 | .. | .. | 2 | 1¾ |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | | | |
| £33,416 | 3 | .. | Brush Electrical Engineering | 1¼ | 1¾ | 1¾ | 2 | .. | .. | | |
| £33,416 | 2 | 0/10 | Do. 6 per Cent. Preference | 1½ | 2 | 1½ | 2 | 6 0 0 | June and December | 1¾ | .. |
| £20,000 | 5 | 7% | Crompton and Co., 7 per Cent. Pref. Shares | 5 | 5½ | 5 | 5½ | 6 7 3 | January and July .. | .. | .. |
| £17,130 | 5 | .. | Edison and Swan United | .. | | .. | | .. | .. | .. | .. |
| £15,000 | 10 | 6% | Electric Construction | 7 | 7½ | 7 | 7½ | 8 0 0 | .. | 7½ | 7⅛ |
| £70,000 | 2 | 10/0 | Elmore's Patent Copper Depositing | 3¾ | 4¼ | 4 | 4½ | .. | .. | 4¾ | 4⅜ |
| £20,000 | 5 | .. | Fowler-Waring Cables (£4 paid) | 2½ | 3½ | 2½ | 3½ | .. | .. | .. | .. |
| £41,600 | 10 | 10/0 | India Rubber, Gutta Percha & Telegraph Works... | 18½ | 19½ | 18½ | 19½ | 5 2 7 | February & August | 19 | .. |
| £200,000 | 100 | 4½% | Do. 4½ per Cent. Debentures, 1896 | 100 | 102 | 100 | 102 | 4 8 3 | March & September | .. | .. |
| £11,334 | £10 | .. | International Okonite, Ordinary | 9½ | 10 | 9½ | 10 | .. | .. | .. | .. |
| £11,334 | £10 | .. | Do. Preference | 9½ | 10 | 9½ | 10 | .. | .. | .. | .. |
| £78,949 | 5 | 10% | Swan United (£3. 10s. paid) ..10% for year | 4½ | 5 | 4½ | 5 | 6 19 10 | May and November | 5 | 4½ |
| £37,350 | 12 | 12/0 | Telegraph Construction and Maintenance | 45 | 43 | 43 | 45 | 5 6 8 | March and July..... | 45 | .. |
| £150,000 | 100 | 5% | Do. 5 per Cent. Bonds, red. 1894........xd | 100 | 102 | 100 | 102 | 4 18 0 | January and July . | | .. |


**JABLOCHKOFF'S DISTRIBUTION PATENT**

(BEING A PATENT FOR "PRODUCING AND DIVIDING ELECTRIC LIGHT," No. 1996 of 1877.)

**THE ELECTRICAL ENGINEERING CORPORATION, LIMITED,**

(STATTER'S) Are Proprietors of the above Patent, and Warn the Public against Infringement. (UNITED)

*The following are Licensees:—*

Brush Electrical Engineering Company, Limited.
Crompton & Co., Limited.
S. Z. de Ferranti.—London Electric Supply Corporation, Limited.
W. T. Goolden & Co.
Hammond & Co.
Wilson Hartnell.
Johnson & Phillips.
Laurence, Paris & Scott, Limited.
Nalder Brothers & Co.
Paterson & Cooper.
Ernest Scott & Co.
Siemens Brothers & Co., Limited.

3, PRINCE'S MANSIONS, VICTORIA STREET, WESTMINSTER

PERCY E. SCRUTTON *Secretary.*


Digitized by Google

# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 661.—Vol. XXVI. FRIDAY, JANUARY 16, 1891. Price Sixpence.

## NOTES.

One feature in Prof. Crookes' presidential address is its characteristic modesty. He does not waste a single breath in reminding his audience of some of his most important claims to scientific recognition. He passes by the spectroscopic discovery of the metal thallium—one of his own most brilliant researches—as though it were the discovery of any ordinary chemist. He ignores his own improvements of the Sprengel pump, which he described to the Physical Society in 1874; and the invention of the radiometer, which lay in the direct track to his discovery of radiant matter, is not once hinted at in this narrative of his researches.

The meeting of the Institution of Civil Engineers on Tuesday last, at which a Paper on "Auxiliary Engines in connection with the Modern Marine Engine," by W. H. Allen, was read, was followed by the first of a series of receptions. The rooms in No. 25, Great George-street, which adjoin the principal building, were thrown open, and a considerable number of very interesting exhibits were displayed, including dynamos and armatures illustrating the Paper which had just been read, a number of lighthouse-burners for gas, models of bridges, photographs, microscopes, &c. One should not look a gift horse in the mouth, and it is rarely, if ever, that those kindred societies and institutions who enjoy the privilege of using the rooms of the Institution have any cause for complaint. But the re-arrangement of the benches on a level instead of on a gentle slope seems to be a great mistake. It is not only more difficult to hear, but it is practically impossible for anyone but those on the first two rows to see any objects exhibited on the table, or any experiments carried out upon it. The Institution of Civil Engineers do not have so many experiments at their meetings as the Institution of Electrical Engineers, though objects of interest are not infrequently shown. From both the point of view of the audience and of the speakers, especially of those who take part in the discussion, the change must be very unsatisfactory; and we are sure that the case has only to be properly brought before the Council to ensure a speedy return to the old arrangement, which left little or nothing to be desired.

The Board of Trade have not been caught napping, as has been suggested, with respect to the twopenny fares of the City and South London Railway. Indeed, the only person who has made any mistake about the matter appears to be the correspondent to a financial contemporary, who discovered that "all railways shall run passenger trains at the Parliamentary fare of one penny per mile." As a matter of fact, the question was thoroughly discussed by the Parliamentary Committee, and it was decided that the novel method of uniform charges and abolition of classes were "sufficiently democratic" to warrant an exception being made to the above rule. With regard to the letter which will be found in our correspondence columns, the only point of difference between our esteemed correspondent and ourselves is as to what discount must be made in respect to the traffic returns of this line for the factor of "novelty." Our correspondent is inclined to make an allowance of some 40 per cent.; we are not. What the normal traffic will be cannot, however, be seen until the line has been in regular operation with a three-minute service for at least six months. The Company are well advised in not attempting to commence this quick service just at present; though it is obvious to anyone who has seen the generating plant that there need be but little difficulty on this score.

That the acquisition of the telegraphs by the United States Government is still within the range of practical politics may be seen from the number of opponents who think it necessary to keep on writing against every such scheme. The latest champion of the companies is Mr. Wiman, whose ideas on the subject were copied into the *Electrical World* of New York a week or two ago from Frank Leslie's *Illustrated Newspaper*. Mr. Wiman has gone into the subject pretty thoroughly, and we are not in a position to challenge his assertion that the Departmental Officials of the United States Government are inferior in capacity to the leading men who at present administer the telegraph companies' service. We have always admitted that a political system which requires every public servant to retire with his party after a four years' term of office is decidedly inimical to Governmental management of the telegraph, or of any other business whatsoever. But that is the affair of American citizens. When, however, Mr. Wiman supports his arguments by examples from this country, about which he evidently knows nothing, we have simply to remind him that the difference between the two countries in this relation is not so much one of population or of area, but of political life. The business affairs of the British nation are carried on quite independently of party, and would get along just the same if the Government changed hands every four hours, or never changed at all. It

Digitized by Google

is, perhaps, no use telling Mr. WIMAN that the telegraph service of this country is the swiftest, as well as the cheapest, in the world, or that whatever invention of value America has had to offer us we have long ago turned to the best account, or that the Americans on their part have been slow to adopt some of our most perfect appliances. He may be unable to believe all this; but he can hardly deny that the telegraph is an instrument of commerce, whereas the buying and selling of petroleum is commerce itself. Mr. WIMAN argues that if the Government buys up the telegraphs it might with just as much reason buy up all the oil wells. He might as well contend that because Governments do the letter carrying business, they ought to manufacture all the letter paper, or turn their hands to the making of paraffin lamps.

A CURIOUS commentary upon Mr. WIMAN'S disparaging remarks about the English Government telegraphs comes to us in our New York correspondent's letter this week. It appears that some recent fogs in the Middle and Western States almost completely crippled the telegraph lines; and on this our correspondent observes that "these phenomena may be more frequent with you in England, but they are almost unique here." The phenomena of fog and rain are indeed of frequent occurrence here; but interruptions on account of either would be almost unique.

THE two meters which are described in the present issue may be regarded as the latest achievements in the two classes of motor meters and pendulum meters. Those of the former class were perfectly useless until the method of compound winding was employed, by which a shunt coil gives just sufficient torque to overcome the friction while moving. If the friction of repose be only slightly higher than this, the meter will begin to register when a very small current passes through the main coils. Nor could they be considered to be in a practical form until the speed of the moving part had been considerably reduced. The pendulum meter, on the other hand, has been open to the disadvantage of requiring winding up, and to the difficulty so keenly felt by CHARLES V. of making the pendulums keep in synchronism. The adoption of the torsion principle not only diminishes the trouble of winding, but largely prevents any transmission of small impulses from one pendulum to the other, and does away with the necessity for careful levelling. This class of meter has a great advantage in the wide range within which it will work. It is a comparatively easy matter to invent meters which will record the current taken by one lamp up to ten or twelve, and there are a good many which will work from one to twenty, but beyond this few will go; and among those few will be found the meters of the future.

IN the December number of Wied. *Annalen* appears an interesting study of the phenomena of electric oscillations by Mr. LECHER, who has succeeded in introducing some improvements in one of Prof. HERTZ' experiments. The discs, which are opposed to the capacity plates of the primary oscillator, are connected with two long parallel wires. Across these a vacuum tube is placed as a delicate detector of the oscillations. The wires are also bridged across by one or more metal bars, whose position is adjusted till the vacuum tube indicates the greatest effect. The exact interpretation of some of Prof. HERTZ' experiments is still very obscure, but Mr. LECHER has followed the most satisfactory course, under the circumstances, by relying almost entirely on experiments for his guide. Starting with the assumption that the oscillations of electricity in a long wire are analogous to the sonorous oscillations of air in a tube, he has by numerous measurements with different lengths of wire and connecting bars arrived at consistent values for the wave length of the oscillations, and the velocity with which they travel. The result indicates that the velocity with which electric disturbances are propagated is very approximately the same as the velocity of light, not only in air, as HERTZ has previously shown, but also in metallic conductors. The method employed is remarkable for its freedom from extraneous disturbances, such as those caused by the presence of sparks: and the use of the vacuum tube, although not altogether novel, seems a very satisfactory feature of it.

**Ipswich.**—The Town Council has decided, by 13 votes to 7, to support the Provisional Order of Messrs. Laurence, Scott & Co.

**Transmitting Electric Signals to Montreal.**—The Greenwich authorities have found that the exact period of transmitting an electric signal to Montreal, Canada, is about $\frac{3}{4}$ of a second.

**Electric Light Mains in London.**—We shall publish in our issue of January 30th a map showing all the streets in the metropolis in which electric light mains have been laid.

**L'Elettricita.**—With the commencement of the year, our Milan contemporary, *L'Elettricità*, has become the official organ for the publications of the proceedings of the Italian Electrical Society.

**Royal Society.**—At the last meeting of this Society the following paper by Prof. J. J. Thomson was down for reading: "On the Rate of Propagation of the Luminous Discharge of Electricity through a Rarefied Gas."

**The Ferranti Effect.**—Mr. Swinburne is discussing the "Ferranti Effect" in a series of articles in *Industries*. When the series is completed we hope to have something to say on Mr. Swinburne's theory of the phenomenon.

**The Electric Lighting of the City.**—At the last meeting of Commissioners of Sewers it was moved that the question of the appointment of a permanent electrical engineer should be considered by the Streets Committee. This was agreed to.

**Hexham.**—A letter from the Northern Counties Electric Light and Power Supply Company, asking for permission to rent the water-power of the old water reservoir at Hexham as an auxiliary power, has been received by the Hexham Local Board.

**Hove.**—At their last meeting, the Hove Commissioners confirmed the proceedings of the Electric Lighting Committee, and the electric lighting of Hove will therefore be handed over to a company; Mr. R. E. Crompton acting as consulting electrical engineer to the Commissioners.

**The Brush Double Carbon Arc Lamp Patent.**—In the suit of the Brush Electric Company against the Fort Wayne Electric Company an injunction has just been granted restraining the defendants from manufacturing or selling the Wood clock-work double carbon lamp.

**The Post Office Magazine.**—This month's number is, we think, the best that has yet appeared, the articles and stories being varied in character and all of them interesting. The ghost story at the beginning is one of the cleverest we have ever read.

Digitized by Google

**The Paris Municipal Station.**—According to M. Paul Brousse, Chairman of the Electric Lighting Committee of the Paris Municipality, the expenses of the municipal central station at the Halles will amount in 1891 to £14,454, the receipts for the same period being estimated at £18,420.

**Underground Work in Chicago.**—According to Mr. F. E. Degenhardt, there is at present in successful daily operation in Chicago the following amount of underground wires:—Electric light cables, 404 miles; telephone cables, containing 6,080 miles of conductors; and telegraph wires, 650 miles.

**Institution of Civil Engineers.**—At the meeting of this Institution on Tuesday evening last, M. Carnot, the President of the French Republic, was elected by acclamation an honorary member. As a result of the ballot subsequently taken Lord Rayleigh became an honorary member, while 4 members, 31 associate members, and 2 associates were declared to have been duly elected.

**Types of Electric Meters used in London.**—According to the figures recently given by Mr. Frank Bailey, 1,573 electric meters are in use in London; of these 546 are Westinghouse meters, 508 Aron, 174 Ferranti-Wright, 136 Ferranti (mercury), 90 Hookham, 71 Lowrie-Hall, 34 Aubert, 14 Frager. Westinghouse meters thus comprise nearly 35 per cent. and Aron meters over 32 per cent. of the total.

**Mutual Telephone Company.**—It is announced by the *Manchester Guardian* that this Company will early next month open for traffic the first section of their Manchester Telephone Exchange, and that they hope to get to work in Liverpool very soon afterwards. Orders for between 1,600 and 1,700 instruments have been already obtained in Manchester, and a considerable number of orders have also been booked in Liverpool. Complete metallic circuits will be provided.

**Electric Transmission of Power in Spain.**—A few days ago an important plant for the transmission of energy by electricity was inaugurated at San Juan las Fonts, in the Province of Gerona, at the paper mill of Sres. Sucesores de Torras Hermanos, which receives 50 horse-power from a distance of about 2½ kilometers. The current is conveyed by copper wires of 8 millimeters diameter, suspended on porcelain insulators and posts. The turbines and electrical plant have been constructed by Sres. Planas, Flaquer, and Co., of Gerona.

**Honours for French Telegraph Officials.**—The Emperor of Russia has conferred the Grand Cordon of the First Class of the Order of St. Stanislas on M. de Selves, Director-General of the French Post and Telegraph Department. M. Baron, Director of Works, has received the Order of Grand Officer of the First Class of St. Stanislas; M. Ungerer, head of the telegraphic branch, has been given the Cross of Commander of the First Class of the Order of St. Stanislas, and M. Bordelongue has been made a Chevalier of the Order.

**Telegraphists' School of Science.**—On Wednesday afternoon Mr. W. H. Preece distributed at the General Post Office the medals, prizes, and certificates gained by the students of the Telegraphists' School of Science. The report showed that at the examination in technical telegraphy, held by the London Technical Institute, sixty-seven certificates were granted to the numerous schools throughout the kingdom, and of this number twenty-seven (or 40 per cent.) were awarded to the students of this school. Sixty-three per cent. of these certificates were first-class.

**Electric Cars and Snowstorms.**—The late unusually heavy snowstorms have, says the *Electrical Engineer* of New York, been very trying to the street car lines, but on the whole the electric cars have come through the ordeal very well, especially where the management of the road had been wise enough to include snow ploughs and sweepers in the equipment. Another point brought out by the visitation has been that the single-trolley roads have stood up much better than the double. It is reported that in Cincinnati the short-circuiting on the double-trolley road played havoc with the motors.

**Electric Street Railway Poles.**—At Passaic (N.J.) the objections of owners of property have led to the construction of the largest poles ever used for street railway work. The dimensions of the poles are as follows: Height, 35ft; length of arm, 32ft. 8½in.; height of arm above the ground, 20ft. 1½in. The poles are designed to carry 500lb. on the end of arm. The total weight of each pole is 2,000lb. The poles, although subjected to heavy strain, have remained, it is stated, perfectly erect. The track is on one side of the street, and owing to the above-mentioned objections the railway company was compelled to set the poles on the opposite side of the street, and throw an arm nearly 33ft. long right across.

**Woodhouse and Rawson United.**—A dinner was given to the staff of the head offices of this Company, at the Guildhall Tavern, on Tuesday evening last, Sir Rawson W. Rawson occupying the chair. More than 100 employés of the firm were present. In reply to the toast of his health, Mr. F. L. Rawson referred to the Pension Fund which had recently been established by the Board, and made reference to a profit-sharing scheme which the Board had in contemplation for the benefit of the employés. Mr. G. North, the general manager, announced that it was proposed to establish a library and reading-room at their new premises, 34, Cannon-street, E.C., and also that there would be given, on Friday evenings during the winter months, a series of free lectures on electrical subjects.

**West Metropolitan Tramways Company.** — The West Metropolitan Tramways Company, who were authorised in 1889 to construct additional tramways in Hammersmith, Chiswick, Acton, and Ealing, have deposited a Bill asking Parliament to extend, until August, 1893, the time originally granted for the construction of these lines. The Company there state that they are desirous of reconstructing their existing system in such a manner that all the tramways may be worked by electrical power, but that, owing to many unavoidable difficulties, the local authorities have not yet agreed to allow electrical power to be adopted. Owing to this delay on the part of the authorities in settling the terms upon which electricity may be used, the Company ascribe their failure to raise the required additional capital for these extensions.

**Platinum Residues.**—In the face of the present high price of platinum, says the *Chemical Trade Journal*, residues and "washes" of this metal are well worth working up. The old developing-baths for platinotype paper, odd bits of the paper itself, spoilt prints, &c., all may be reworked. Old developers may be treated with saturated solution of sulphate of iron—one part of the saturated solution to four parts of the developer will be about right. The mixture should be heated to boiling in a porcelain dish, and the precipitated metal collected on a filter. Bad prints, clippings, &c., of the paper should be placed on a tin or iron plate and burnt, the ashes collected and digested for some hours at 50-70° C. with *aqua regia*, and then the solution diluted with an equal volume of water, and the platinum precipitated with iron as above, or with ammonium, or formate of soda, or any other reducing agent.

**Arc and Incandescent Street Lighting in Paris.**—At a recent meeting of the Paris Municipal Council, M. Paul Brousse, in presenting the Electric Lighting Budget for the current year, stated that the police authorities had reported very favourably with regard to the arc lighting of the portion of the Avenue de Clichy, near the fortifications. According to the police, the arc lamps "have driven away the suspicious individuals who formerly stationed themselves at this part of the avenue, and since the adoption of this mode of lighting no nocturnal assaults nor serious accidents have been recorded." As to the incandescent lighting in the Rue Auber and the Rue des Halles, M. Paul Brousse is of opinion that it is too expensive, and suggests that it should cease, at any rate so far as the Rue Auber is concerned.

**The Duration of Telegraphic Currents.**—In a recent issue the *Zeitschrift für Elektrotechnik* remarks that a few figures with regard to the duration of currents used in telegraphy may be of interest. In ordinary Morse working the average duration of the signalling current may be taken at ·125 second; with the Hughes apparatus currents lasting only from ·04 to ·05 second are emitted, while with the Meyer multiplex apparatus currents having a duration of as little as ·007 second, and

with the Delany multiplex of ·002 second are sent to line. The lowest figure is, however, reached by the Wheatstone automatic, which, when transmitting at the rate of 600 words a minute, sends out 33,600 currents per minute, or 560 per second, each having, therefore, a duration of ·0018 second.

**Electricity in Mines.**—"We are officially advised," says the *Engineering and Mining Journal*, of New York, "that the contract for what will be the largest electric mine haulage plant has recently been given to the Edison General Electric Company by the Loyal Hanna Coal and Coke Company, of Philadelphia, Pa. This plant will consist of one locomotive, capable of delivering hourly 129 cars to the bottom of the shaft, each car containing 2½ tons of coal. This would make the output 300 tons of coal per hour, and a total work of 375 ton miles per hour; the gross weight of the trains to be hauled will be 120 tons. About 3,000 feet of gangway will be equipped with conductors at the start, but as the lengths of the gangways increase this will have to be increased to 10,000 feet, and the Company is then expected to put in a second locomotive of equal capacity to the one mentioned above."

**Festivities at Porthcurno.**—At Porthcurno, the cable station and Training College of the Eastern Telegraph Company, the usual Christmas festivities were indulged in by the members of the staff. On Boxing Night Mrs. Ash gave a general invitation to a dancing party, which was attended by almost the entire *personnel* of the staff, some few away on leave, and others necessarily on duty, being excepted. On the first day of the new year the members of the staff gave an "At Home," invitations being extended to a large number of friends in the neighbourhood. During the early part of the evening the auditorium of the Lecture Hall was tastefully arranged, and a series of amusements were provided by the "exiles" for their visitors. After supper, the "exiles" and their guests, numbering from sixty to seventy, returned to the hall, which had been cleared for dancing, and where the strains of the Penzance Town Band carried a very enjoyable time into the early hours of the morning.

**Benjamin Franklin's Will.**—The bequest by which Benjamin Franklin left to each of the cities of Boston and Philadelphia, in 1790, the sum of £1,000 sterling to be loaned out at 5 per cent. to deserving young married artificers is being disputed in the courts by his descendants. In Boston the fund has reached $400,000 and in Philadelphia $100,000. The contest is based upon several grounds, the most important of which is what is known as the rule of perpetuities in common law. The law does not provide for the vesting of a legacy beyond the period of 21 years after the lifetime of the legatee, except funds devoted to charity. It is distinctly alleged that Franklin's plan did not contemplate charity from the fact that interest was charged on the loans. The claim is also raised that the purpose of the testator has not been fulfilled, owing to the apathy and negligence of the trustees, both in Philadelphia and Boston.

**The Comparative Efficiencies of Dynamos and Thermopiles**—Two easily-remembered figures permit us, says the *Bulletin de l'Electricité*, to form a clear idea of the relative value of a thermopile and a dynamo driven by a gas engine as an apparatus for the transformation of the thermic energy of combustion of coal gas into electrical energy. In all tests of thermopiles heated by gas the consumption has up to the present exceeded 3,000 litres per kilowatt per hour (105 cub. ft. per kilowatt-hour). A good gas engine consumes from 600 to 700 litres (21 to 23·5 cub. ft.) per B.H.P., and for this consumption we may obtain 600 available watts from a dynamo heaving 85 per cent. efficiency, and this is equivalent to 1 litre (·035 cub. ft.) per watt-hour, or 1 cubic metre (35·3 cub. ft.) per kilowatt-hour. Hence for a given amount of electrical energy a good thermopile requires three times as much gas as a dynamo driven by a gas engine. We may add that no commercial thermopile exists of more than 10 or 12 watts, while 100 horse-power gas engines are now constructed.

**The Telephone at Plymouth.**—The subject of telephonic signalling from ships to the shore has come in several forms, and on frequent occasions, before the Plymouth Chamber of Commerce and its committees. Permission has been obtained for the signalmen of the Breakwater Fort to telephone to the agents of the various lines of mail steamers the arrival of such steamers in the Sound when, owing to the thick weather, they are not observable from the shore; and, as we have already announced, it has been arranged for all Government offices in the Port, including the office of the Queen's Harbourmaster, and also the Chamber of Commerce, to be connected with the Exchange. The permission obtained for the Telephone Exchange to be connected with the Coastguard signal station at Rame Head, with a view to merchant ships and ships of the Navy being reported, and signals exchanged with them, from that commanding position, will be made use of as soon as the necessary quarters have been provided for the extra signalmen. The capabilities of the telephone in this direction have, it will thus be seen, been fully taken advantage of at Plymouth.

**Railway Signalling.**—Under the auspices of the Inventors' Institute, a lecture was delivered on Wednesday night, at Lonsdale Chambers, Chancery-lane, on "The Electric Locking and Block System in use on the City and South London Electric Railway," by Mr. C. E. Spagnoletti. The lecturer at the outset gave a brief account of the construction of the railway in question. At the present time, he remarked, the trains were run every six minutes, but the traffic was so enormous—thousands of passengers having to be turned away at certain hours of the day—that the Company were going to run the trains every three minutes. Having described the electrical block system in use on several of the most important railways—the Great Western amongst others—he proceeded to explain, by use of diagrams, the mode of signalling on the City and South London Electrical Railway. Various instruments with plungers were manipulated, showing the method by which signalmen checked each other. The most ingenious feature, however, of the system appeared to be a treadle which was worked automatically by the engine, and so locked the levers that, until the train had passed a certain spot, the signals could not be dropped.

**The Schiseophone.**—Under the auspices of the South-Eastern Railway Company, a demonstration of the capabilities of the schiséophone (see *The Electrician*, Vol. XXV., p. 386) was given on Wednesday last by Captain de Place, at the Charing Cross Hotel, in the presence of several members of the Ordnance Committee and other Government officials. Among those present were Sir Frederick Bramwell, Sir Benjamin Baker, General Hay, Colonel Watkin, R.A., Colonel Bainbridge, R.A., Colonel the Hon. Reginald Talbot, Captain Domvile, R.A., Colonel Surtees, Captain Bridge, R.N., Dr. William Anderson, Sir Edward Watkin, Sir Myles Fenton, Captain H. F. Gye, R.N., Mr. Stirling, C.E., Mr. Brady, and Mr. Wainwright. Mr. Stirling, the Company's locomotive superintendent, had previously has several samples of steel, wrought iron, and cast iron prepared with hidden flaws known only to himself. The first sample tested by Captain de Place he pronounced to be bad metal throughout, which Mr. Stirling stated he knew it to be. Other samples were tested, and the flaws localised by means of the apparatus. On breaking some of the bars of wrought and cast iron, the internal flaws—the localities of which were known to Mr. Stirling by his private mark—were found to have been correctly localised by Captain de Place. On the other hand, it has to be stated that some bars were broken at points where the apparatus indicated a flaw, but where the metal proved to be perfectly sound.

**The Magnetisation of Iron by the Leyden Jar Discharge.**—The magnetising power of a Leyden jar discharge, although a somewhat complex quantity, depends for one thing on its duration. Thus, if a Leyden jar is successively given two equal charges, and in one case discharged very suddenly and in the other comparatively slowly, the magnetising effect of the latter discharge will probably be greater than that of the former. This is due to the fact that the more rapid discharge produces more powerful superficial eddy currents which effectually shield the interior portions of the bar to be magnetised. The following experiment of M. A. Marianini, which was described in a recent number of the *Nuovo Cimento*, bears on this point. In the discharge circuit of a condenser M. Marianini placed an air gap and a magnetising helix. The iron to be magnetised consisted of a glass tube filled with iron filings. He observed the devia-

Digitized by Google

tions of a magnetometer needle, due to the presence of the iron filing cylinder, after the iron had been subjected to various discharges. The air gap was at first ½mm., and after passing ten discharges the needle only deviated by 4deg. With a sparking distance of 3mm., four successive discharges resulted in a magnetisation strong enough to cause the needle to deviate 32° 30′. With a 7mm. gap, and after only one discharge, there was a deviation of 53° 30′. The same air gap was then used, but the resistance of the circuit was this time increased by introducing a tube containing water; deviations of 77° 30′ and 79° were then attained.

**New Target Board at the Chicago Telephone Exchange.**—For some time past the operators at the Chicago Telephone Exchange have been so pressed with business that it has been found impossible for them to answer in their proper order. With a view of relieving the regular operators of the duty of watching for "ring offs" a "target" board, says the *Western Electrician*, was designed. A call first comes to the regular operator on the main multiple switch-board. This operator, it will be assumed, finds the line wanted busy. She then records the number wanted on slate, and telephones it to a ticket maker at the target board. This ticket maker is given the operator's number, the number wanted, and the number of the line calling. The ticket maker records the call on a small strip of cardboard, placing the numbers in the above order. This ticket is passed from the ticket maker to an operator whose duty it is to watch for lines to become disengaged. The last-named operator has in front of her terminals of tap wires from every line running into the exchange. There are also in front of her several rows of annunciators or targets. These targets appear black when the busy line is cut out of service by the main switch-board operator. The targets are white when the line is in service. When the target-board operator receives a ticket she first places it in a little brass pocket, and then takes the plug corresponding with that particular pocket and inserts it into the socket belonging to the tap wire of the line wanted, say "1,446." When "1,446" becomes disengaged on the main board, the target shows black. The target-board operator then plugs in on a special talking wire, and tells the operator that the line wanted, "1,446," is not "busy." The main switch-board operator then takes "1,446," and the target again shows white. So long as this is so, the line is left undisturbed. When black shows again, a new ticket is taken up. This operation is continued until all tickets waiting for "1,446" are disposed of. The arrangement of circuits is such that when the line is connected with the target-board, a test-current is thrown on this line, so that operators on the main switch-board will not take it during the interval of time consumed in making the change.

**Arc Lighting in the States.**—Although it is pretty generally known that arc lighting, especially for street lighting, has a far greater vogue in the United States than with us, we think the scale on which it is actually carried out is not fully realised. The following figures from the *Electrical World* of New York, relating to the arc-light stations of the Municipal Electric Lighting and Power Company of St. Louis and of the Chicago Municipality, give a good idea of the manner in which arc lights are made use of in the States. In December, 1888, tenders were advertised for the public lighting of St. Louis, and on March 9, 1889, the contract for 2,310 2,000 candle-power arcs was awarded. In nine months from then everything was ready. The plant comprises 19 Rohan boilers of a total capacity of 6,500 horses, six 600 horse-power Hamilton-Corliss engines, and 53 60-light Wood dynamos. The boilers are in a separate house, 110ft. by 60ft. The station house is a four-floored building, 110ft. by 100ft. and 65ft. high. On the ground floor are the engines, while on the second floor is the counter-shafting, and on the third floor the dynamo plant. At present there are 88 circuits, having a total length of nearly 900 miles. One circuit is 19½ miles long, and contains 62 lights. The wires are all run overhead on white cedar poles, 10,000 of which are used. In August, 1890, the St. Louis Municipal Company acquired the St. Louis Illuminating Company, which had a capacity of 1,500 arc lights; also the Heisler incandescent lighting plant, with its 5,000 30 candle-power lamps. Since that date some of the plants have been transferred to the new station and the old stations closed, and as soon as a sufficient number of Wood dynamos are received to carry the increased load all the other stations will be abandoned, thus concentrating all the arc lighting under one roof. At the present moment more than 3,500 arc lights are controlled from this one station. Since August 600 additional lights have been ordered by the municipal authorities. On Christmas Eve the fourth electric light station of the city of Chicago was put into service. The initial capacity is 500 lights, while the building and machinery have been so designed that current can be supplied for a total of 900 lights. The four station of the city now have the machinery required to supply 4,000 lamps, 3,000 being in nightly service.

**Non-Conductors for Steam Pipes.**—The following table is taken from a report by Prof. John M. Ordway, then of the Massachusetts Institute of Technology, to the Boston Manufacturers' Mutual Fire Insurance Company. The materials which may be considered wholly free from the danger of being carbonised or ignited by slow contact with pipes or boilers are denoted by a (†). Those which are more or less liable to be carbonised are denoted by a (*). Careful experiments were made with various non-conductors, each used in a mass 1in. thick placed on a flat surface of iron kept heated by steam to 310deg. F. The following table gives the amount of heat, reckoned in pounds of water heated 10deg. F., transmitted per hour through each kind of non-conductor 1in. thick, the unit of area being one square foot of covering. The substances numbered in Roman figures were actually tried as coverings for 2in. steam pipe :—

| | Substance 1in. thick. Heat applied 310°F. | Pounds of water heated 10°F. per hour through 1 sq. foot. |
|---|---|---|
| *1. | Loose wool | 8·1 |
| *2. | Live geese feathers | 9·6 |
| *3. | Carded cotton | 10·4 |
| *4. | Hair felt | 10·3 |
| *5. | Loose lampblack | 9·8 |
| *6. | Compressed lampblack | 10·6 |
| *7. | Cork charcoal | 11·9 |
| *8. | White pine charcoal | 13·9 |
| *9. | Anthracite coal powder | 35·7 |
| †10. | Loose calcined magnesia | 12·4 |
| †11. | Compressed calcined magnesia | 42·6 |
| †12. | Light carbonate of magnesia | 13·7 |
| †13. | Compressed carbonate of magnesia | 15·4 |
| †14. | Loose fossil meal | 14·5 |
| †15. | Crowded fossil meal | 15·7 |
| †16. | Ground chalk (Paris white) | 20·6 |
| †17. | Dry plaster of Paris | 30·9 |
| †18. | Fine asbestos | 49·0 |
| †19. | Air alone | 48·0 |
| †20. | Sand | 62·1 |
| †XXI. | Best slag wool | 13·0 |
| *XXII. | Paper | 14·0 |
| *XXIII. | Blotting paper wound tight | 21·0 |
| *XXIV. | Asbestos paper wound tight | 21·7 |
| *XXV. | Cork strips bound on | 14·6 |
| *XXVI. | Straw rope wound spirally | 18·0 |
| *XXVII. | Loose rice chaff | 18·7 |
| †XXVIII. | Paste of fossil meal with hair | 16·7 |
| †XXIX. | Paste of fossil meal with asbestos | 22·0 |
| †XXX. | Loose bituminous coal ashes | 21·0 |
| †XXXI. | Loose anthracite coal ashes | 27·0 |
| †XXXII. | Paste of clay and vegetable fibre | 30·9 |
| XXXIII. | Magnesia covering (Sample I.) | 15·0 |
| XXXIV. | ,, ,, (Sample II.) | 20·0 |

"Magnesia covering," it may be mentioned, consists of carbonate of magnesia with a small percentage of good asbestos fibre. There are some mixtures of two materials which may be quite safe, although consisting in part of substances which may be carbonised. It must also be considered that a covering for a steam pipe or boiler should have some strength or elasticity, so that when even put on loosely, and holding a great deal of entrapped air, it may not be converted into a solid condition by the constant jar of the building, and then becoming rather a quick conductor. This warning may be applied especially to what is called "slag wool." Any suitable substance which is used to prevent the escape of steam heat should not be less than an inch thick.

Digitized by Google

## WILLIAM CROOKES, F.R.S.

Among contemporary men of science, few, if any, can present a more distinguished and varied career of research and discovery than the newly elected President of the Institution of Electrical Engineers, William Crookes. Though belonging by parentage, like Faraday, to Yorkshire, he was born in London in 1832, just in time, as he says, to escape having his mind ossified by examinations. His tendency to experimental science led him, when a boy, to the then comparatively virgin field of photography. In 1848 he entered the Royal College of Chemistry, as a pupil of the illustrious Dr. Hofmann. Here, at the early age of seventeen, he gained the Ashburton Scholarship. After two years' study he became first the junior and then the senior assistant to Dr. Hofmann. In 1854 he was appointed to superintend the Meteorological Department of the Radcliffe Observatory at Oxford. In the following year he became Teacher of Chemistry at the Science College, Chester. In 1859 he founded the *Chemical News*, of which he is still the proprietor, and which remains the organ of chemical science in this country. In 1864 he became editor also of the *Quarterly Journal of Science*, which he conducted down to 1880.

Prof. Crookes entered upon original research whilst still at the Royal College of Chemistry, his first results being a Paper on the Seleno-cyanides, which he communicated to the Chemical Society in 1851, and which appeared in the Journal of the Society in the same year. From this Paper, the greater part of the author's subsequent researches, multiform as they may seem, follow in legitimate filiation. His investigations on the compounds of selenium led him, in 1861, to examine certain residues from the sulphuric acid works of Tilkerode, where he met with a then unknown substance which, on thorough scrutiny, proved to be the new metallic element thallium. In June, 1862, and in February, 1863, he submitted to the Royal Society an elaborate account of the newly discovered element, its sources, distribution, the methods for its extraction and purification, as well as of its characteristics, physical and chemical. He showed its occurrence in various kinds of iron and copper pyrites, in crude sulphur as well as in flue dusts. His election as a Fellow of the Royal Society followed the same year. In 1864 he presented to the Chemical Society, of which he had been a Fellow since 1850, an exhaustive account of thallium embodying both his own researches and those of others, and including tables of the qualitative and quantitative reactions of this metal. This research necessitated delicate spectroscopic investigations, and thus led Prof. Crookes to the study of the so-called "rare earths," which has already proved so fruitful in his hands.

In 1865 he invented an improved process for the extraction of gold and silver from their ores, based on the use of sodium amalgam in place of pure mercury. We may mention that he has recently devised a further improvement in the treatment of refractory gold ores by submitting them to the action of an alternating electric current whilst in contact with mercury cyanide or other mercurial salts. In the year following he was appointed by the Government to experiment and report on the use of disinfectants for arresting the spread of the cattle-plague (rinderpest), which was at that time ravaging many parts of England and Scotland, and occasioning widespread alarm. In 1871 he was appointed a member of the English expedition to Oran, with the object of conducting a spectroscopic examination of the phenomena manifested during a total eclipse of the sun. In the following year he presented to the Royal Society a full account of his experiments for determining the atomic weight of thallium. Amongst other precautions adopted to insure accuracy, we may mention that he executed the necessary weighings by means of a balance which admitted of being manipulated in a vacuum.

In the same year he began his investigations on "Repulsion Resulting from Radiation." To this question his attention had been drawn in consequence of observations made when weighing heavy pieces of glass apparatus in his vacuum balance whilst determining the atomic weight of thallium. He communicated a memoir on this subject to the Royal Society in December, 1873, and between that time and 1880 he produced eight other Papers on collateral questions. These phenomena are manifested by means of the radiometer, otherwise known as the "light-mill." This instrument is capable of serving to measure the intensity of solar radiations, though not, it must be remembered, of light alone.

In 1875 Prof. Crookes received from the Royal Society a Royal Medal in recognition of his chemical and physical researches. In 1876 he was elected a Vice-President of the Chemical Society, and in the following year he became a member of the Council of the Royal Society. In 1877 he was remarkably active. He devised the Otheoscope, a modified form of the radiometer, and continued the study of repulsion derived from radiation, presenting his results to the Royal Society. He had succeeded in obtaining a vacuum so nearly approaching perfection that the pressure in it is only 0·4 millionth of an atmosphere. This result was effected by means of an improved Sprengel pump. The study of these high vacua led to a two-fold result: on the one hand it was found that at such extreme states of rarefaction gases lose their ordinary properties and pass into a fourth or ultra-gaseous state which Prof. Crookes has designated as that of "Radiant Matter." On the other hand, they rendered the electrical glow lamp a practical possibility. Prof. Crookes's house in Kensington-park Gardens, electrically lighted in 1881, was, we believe, the first house in London fitted up with the electric light. It may be interesting to state that the wires were chiefly laid with his own hands. To meet the difficulty of obtaining carbon filaments for the glow lamps not possessing the structure of the material from which they were made, Prof. Crookes dissolved cellulose in a strong solution of ammonium-copper sulphate, dried up the solution into sheets, dissolved out the copper, and used the horn-like material remaining for filaments. The lamps in the inventor's house fitted with such filaments remain still in good working condition. In 1881 he acted as a juror at the International Exhibition of Electricity in Paris. His system of lamps was, of course, debarred *ex officio* from competing, but his fellow-jurors remarked in their award on the four systems of lamps before them, that:—"None of them could have succeeded had it not been for those extreme vacua which Prof. Crookes has taught us to manage." The "Crookes' incandescent lamp" has, for a variety of reasons, not come into general use. The Company which undertook their manufacture had not sufficient capital to produce them on the large scale. Another company took the invention up, but further operations were stopped by the judicial decision in the Edison-Swan *v.* Brush case. We are not yet sufficiently removed from the days when a judge could rule that "*in a liberal construction, copper is tin.*"

In 1880 the French Academy of Sciences conferred upon Prof. Crookes an extraordinary prize of 3,000fr. and a gold medal in appreciation of his researches in Molecular Physics and on Radiant Matter.

On three successive occasions, namely, in 1877, 1878, and 1883, Prof. Crookes was selected by the Royal Society to deliver the Bakerian Lecture. On the first occasion he discussed the "Illumination of Lines of Molecular Pressure and the Trajectory of Molecules," his discourse being generally regarded as a model of deep thought and extreme experimental skill. His second Bakerian Lecture summarised his experiments and observations of "Radiant Matter." His third Bakerian Lecture, delivered on May 24, 1883, was devoted to "Radiant Matter Spectroscopy: A New Method of Spectrum-Analysis." This naturally leads to his researches on the rare earths, with which he has been engaged for several years, and which promise to lead to most important results. On attacking yttria by the process of "fractionation," he finds that it is resolved into at least five elements, possibly more, and there is no certainty that this analysis has reached completion. The new elements, or as Prof. Crookes calls them provisionally, "meta-elements," differ more in their physical than in their chemical properties. It is especially remarkable that substances which have been

Digitized by Google

found capable of decomposition may still possess a definite atomic weight. On studying closely the phenomena of these rare earths, Prof. Crookes has been led to the conclusion that the bodies which have generally been accepted as elements are not primordially distinct or independent, but have been formed by a process of evolution remotely analogous to that which we now recognise as having been at work in the formation of organic species. These views, a forecast of the "Chemistry of the Future," were given to the world in the presidential address which Prof. Crookes delivered before the Chemical Section of the British Association at the Birmingham meeting, under the title "The Genesis of the Elements." He further developed the same subject in his Presidential addresses to the Chemical Society in 1888 and 1889, and it constitutes without doubt his grand contribution to the philosophy of the science. In the experiments which pointed to these conclusions electricity has constantly been appealed to for the diagnosis of the new bodies encountered. In 1885, the Society of Arts awarded him a gold medal "for his improvements in apparatus for the production of high vacua, and for his invention of the radiometer." In 1888, he was awarded by the Royal Society the Davy Medal, for "his investigations on the behaviour of substances under the influence of the electric discharge in a high vacuum.

The contributions of Prof. Crookes to the literature of science have been both numerous and important. We are indebted to him for the "Third Report of the Cattle Plague Commission;" for a book on "The Manufacture of Beetroot Sugar in England" (1870), "A Handbook of Dyeing and Calico Printing" (1874), "Select Methods in Chemical Analysis" (1873; 2nd edition 1886). A manual of "Dyeing and Tissue Printing," being one of the technological handbooks prepared for the examinations of the City and Guilds of London Institute (1882). In conjunction with Prof. Odling and Dr. Tidy, he issues reports on the composition and quality of the water supplied to London (1881—1890). He has also written a "Solution of the Sewage Question," and "The Profitable Disposal of Sewage." He has edited the English version of Kerl's "Treatise on Metallurgy," and the three last editions of Mitchell's "Manual of Practical Assaying. He has translated into English and edited Reimann's "Aniline and its Derivatives;" Wagner's great work on "Chemical Technology" (a second edition of which is in course of preparation); Auerbach's "Anthracene and its Derivatives;" and Ville's "Artificial Manures," the second edition of which appeared in 1882. A list of the memoirs which he has contributed to the journals of the Royal and the Chemical Societies would far exceed our imits.

In all public questions in which science is concerned he has taken a prominent and a useful part. He is recognised as an authority on sanitary reforms, especially as regards the purification of sewage and the improvement of the condition of rivers. He has continually, and so far successfully, opposed the adoption of the arbitrary "proposals" of the Rivers Pollution Commissioners, and he sees no ground for the discontinuance of the present water supply of London. In leaders and reviews he has steadily condemned the system of examinations prevalent in England as calculated to destroy original thought. He is one of the signatories of Mr. Auberon Herbert's "Protest against the Sacrifice of Education to Examination." Wherever the claims of science or the rights of scientific men are neglected, Prof. Crookes is always ready to speak out. His career conveys an important lesson for the student. It is not merely the exceptionally suggestive character of his mind and his promptitude in appreciating every phenomenon presenting itself which have enabled Prof. Crookes to carry out such a quantity of important work. He possesses that "infinite capacity for taking pains" and that methodical spirit, without which genius and learning are thrown to waste. Every research in progress and in particular every result is duly recorded in a special note book. References to any work by other scientists bearing on the same or collateral subjects are registered, and every book in his extensive library, and every document in the pigeon-holes of his work-table is carefully indexed for reference. Without the economy of time and energy thus effected not half of his work could have been accomplished.

## INSTITUTION OF ELECTRICAL ENGINEERS.

PRESIDENTIAL ADDRESS OF PROF. WILLIAM CROOKES, F.R.S.

### Electricity in Transitu: from Plenum to Vacuum.

*Introduction.*

Whilst steadily bearing in mind that I have the honour to address a Society, not only of physicists, but of Electrical Engineers, I shall not, I hope, be out of order in venturing to call your attention to a purely abstract phase of electrical science. Numberless instances show that pure research is the abundant source from which spring endless streams of practical applications. We all know how speculative inquiry into the influence of electricity on the nervous systems of animals led to knowledge of current electricity, and ultimately to the priceless possession of the telegraph and the telephone. The abstract study of certain microscopic forms of parasitic vegetable life has enabled us to give to fermented solutions of sugar the exact flavour and aroma of the most highly prized wines, and probably, ere long, will put us in a position to increase at will the fertility of the soil. In a different direction the same class of abstract researches applied to medical science has brought us within measurable distance of the final conquest over a large class of diseases hitherto incurable; and without egotism I may, perhaps, be allowed to say that my own researches into high vacua to some extent have contributed to the present degree of perfection of the incandescence lamp. Surely, therefore, whilst eagerly reaping and storing the harvest of practical benefits, we must not neglect to scatter more seed for future results, perchance not less wonderful and valuable.

In another respect I deviate to some extent from the course taken by many of my predecessors. I am about to treat electricity, not so much as an end in itself, but rather as a tool, by whose judicious use we may gain some addition to our scanty knowledge of the atoms and molecules of matter, and of the forms of energy which by their mutual reactions constitute the universe as it is manifest to our five senses.

I will endeavour to explain what I mean by characterising electricity as a tool. When working as a chemist in the laboratory, I find the induction spark often of great service in discriminating one element from another, also in indicating the presence of hitherto unknown elements in other bodies in quantity far too minute to be recognisable by any other means. In this way chemists have discovered thallium, gallium, germanium, and numerous other elements. On the other hand, when examining electrical reactions in high vacua, various rare chemical elements become in turn tests for recognising the intensity and character of electric energy. Electricity, positive and negative, effect respectively different movements and luminosities. Hence the behaviour of the substances upon which electricity acts may indicate with which of these two kinds we have to deal. In other physical researches both electricity and chemistry come into play simply as means of exploration.

In submitting to you certain researches in which electricity is used as a tool, or as a means of bringing within scope of our senses phenomena that otherwise would be unrevealed, I must for a moment recall to your minds the now generally accepted theory of the constitution of matter.

*Kinetic Theory of Gases.*

Matter, at its ultimate degree of extension, is conjectured to be not continuous, but granular. Maxwell illustrates this view as follows:—To a railway contractor driving a tunnel through a gravel hill, the gravel may be viewed as a continuous substance. To a worm, wriggling through gravel, it makes all the difference whether the creature pushes against a piece of gravel or directs its course between the interstices. To the worm, therefore, gravel seems by no means homogeneous and continuous.

With speculations as to the constitution of liquid and solid matter I need not trouble you, but will proceed at once to the third or gaseous state of matter.

The kinetic theory of gases teaches that the constituent molecules dart in every possible direction with great but continually varying velocities, coming almost ceaselessly in mutual

Digitized by Google

collision with each other*. The distance each molecule traverses without hitting another molecule is known as its *free path*; the average distance traversed without collision by the whole number of molecules of a gas at any given pressure and temperature is called the *mean free path*. The molecules exert pressure in all directions, and are only restrained by gravitation from dissipating themselves into space. In ordinary gases, the length of the mean free path of the molecules is exceedingly small compared with the dimensions of the vessel, and the properties we then observe are such as constitute the ordinary gaseous state of matter, which depend upon constant collisions. But if we greatly reduce the number of molecules in a given extent of space the free path of the molecules under electric impulse is so long that the number of their mutual collisions in any given time in comparison with the number of times they fail to collide may be disregarded. Hence, the average molecule can carry out its own motions without interference. When the mean free path becomes comparable to the dimensions of the containing vessel, the attributes which constitute gaseity shrink to a minimum, the matter attains the ultra-gaseous or "radiant" state, and we arrive at a condition where molecular motions under electrical impulse can easily be studied.

The mean free path of the molecules of a gas increases so rapidly with progressive exhaustion, that whilst that of the molecules of air at the ordinary pressure is only 1-10,000th of a millimetre, at an exhaustion of a hundred-millionth of an atmosphere—a point (which with present appliances, is easy to attain) corresponding to the rarefaction of the air 90 miles above the earth's surface—the mean free path will be about 30ft.; whilst at 200 miles above the earth it will be 10,000,000 miles, and millions of miles out in the depths of space it will become practically infinite. I could go on speculating in spite of Aristotle, who said:—"Beyond the universe there are neither space, nor vacuum, nor time."

In discussing the motions of molecules we have to distinguish the *free* path from the *mean free path*. Nothing is yet known of the *absolute* length of the free path nor of the *absolute* velocity of a molecule. For anything we can prove to the contrary, these values may vary almost from zero to infinity. We can deal only with the *mean* free path and the *mean* velocity.

### *The Vacuum Pump.*

As most of the experiments I put before you to-night are connected with high vacua, it is not out of place to refer to the pump by means of which these tubes are exhausted. Much has been said lately in recommendation of the Geissler pump and its many improvements, but I am still strongly in favour of the Sprengel, as with it I have obtained greater exhaustion than with any other. I should like to point out that the action does not stop when we cease to see air specks passing down the tubes, but continues long after this point has been passed. Neither is the non-conducting vacuum, so easily obtained by the Sprengel pump, due in any way to the presence of mercury vapour, since non-conduction can be obtained just as rapidly when special precautions have been taken to keep mercury vapour out of the tubes.

One of the great advantages of the Sprengel pump over all others lies in the fact that its internal capacity need not exceed a few cubic centimetres, and there is, therefore, much less wall surface for gases to condense upon. I have brought the very latest modification of this form of pump here to-night, and you will have an opportunity of seeing it in action and of measuring with the McLeod gauge the rarefaction it produces.*

### *The Passage of Electricity Through Rarefied Gas.*

The various phenomena presented when an induction spark is made to pass through a gas at different degrees of exhaustion point to a modified condition of the matter at the highest exhaustions. Here are three exactly similar bulbs, the electrodes being aluminium balls, and the internal pressures being respectively 75 mm., 2 mm., and 0·1 mm. If I pass the induction current in succession through the bulbs, you will perceive in each case very different luminous phenomena. Here is a slightly exhausted tube (Fig. 1), like the first in the series just exhibited (75 mm.), the induction spark passes from one end to the other, A, B, and the luminous discharge is seen as a line of light, acting as a flexible conductor. Under the tube I have an electro-magnet, C, and on making contact the line of light dips in the centre down to the poles of the magnet, and then rising again proceeds in a straight line. On reversing the current the line of light curves upwards. Notice that the action of the magnet in this case is only local.

In a highly exhausted tube the action is quite otherwise. Such a tube is before you (Fig 2), and in it I have carried the exhaustion to a high point (0·1 mm). I pass the induction current, and you perceive the electrified molecules, like the line of light in the first tube, also move in straight lines, and make their path apparent by impinging on a phosphorescent screen, D E. If, however, I submit them to the action of a magnet, C, their behaviour is different. The line dips down to F, but does *not* recover itself. It seems that in the tube first shown we have to do with the average behaviour of the molecules of gas in its totality. In the second case, where the gas has been greatly attenuated, we are merely concerned with the behaviour of the individual molecules of which it was originally composed.

### *The Stratified Discharge.*

When the gas is rarer than is necessary to give the flexible line of light, as shown in the first experiment, the luminosity is plainly discontinuous or, as it is termed, stratified.

A very good illustration of this fact may be taken from the moving crowd in any such frequented street—say Fleet-street. If at some time when the stream of traffic runs almost equally in both directions, we take our stand at a window from which we can overlook the passing crowd, we shall notice that the throng on the foot-way is not uniformly distributed, but is made up of knots—we might almost say blocks—interrupted by spaces which are comparatively open. We may easily con-

* I speak of "collisions," as these are the generally accepted *substrata* of the kinetic theory. But Prof. Silvanus P. Thompson reminds me that Boltzmann some years ago proposed a modification of the kinetic theory which to me seems a vast improvement on the somewhat bald notion of molecular collisions. According to Boltzmann's view, in a so-called "collision" the molecules do not actually bounce against one another, but merely fly round in two interlocking hyperbolic paths. The effect, for all external purposes, will be the same as if they collided, because of the extreme minuteness of the curved part of the paths. The gain in thus regarding the matter is that such hyperbolic paths are quite consistent with obedience to the ordinary laws of gravitational attraction; whereas the collision theory needs for its explanation that when molecules come very near together they should exhibit a repulsion varying inversely as the fifth power of the distance between them.

* My measurements of high vacua have all been taken with the beautiful little gauge devised by Prof. McLeod. Unmerited discredit has recently been cast on this gauge, the principal fault alleged being its inability to distinguish between the tension of the permanent gas and that of the mercury vapour present. Now it is evident that, under ordinary circumstances, the tension of mercury vapour may be disregarded, as it will be the same on both sides of the gauge: and it will be only in cases where no mercury is present on one side of the gauge that a slight error is introduced. It is, however, very difficult to devise and successfully experiment with apparatus in which a trace of mercury vapour shall not enter, and it is not likely that an experimentalist who would be working with such mercury-free apparatus would attempt to use the gauge without remembering that in this special case the indications would be incorrect. To use the McLeod gauge requires much patience and some amount of experience, but I have always found it trustworthy to register exhaustions far beyond the millionth of an atmosphere. I can adduce circumstantial evidence of the accuracy of its readings at these high vacua. In the year 1881 I read a Paper before the Royal Society on "The Viscosity of Gases at High Exhaustions" (*Phil. Trans.*, 1881, p. 387), and illustrated my results in three large diagrams, on which I plotted the experimental results obtained at rarefactions up to the 0·02 millionth of an atmosphere, giving curves comparing the decrease in viscosity with that of the repulsion resulting from radiation, at the different pressures. Now these curves, in the case of air, for instance, are perfectly regular and uniform in their falling off, and it is evident that this could not have been the case unless the abscissæ representing viscosity and the ordinates representing pressure were equally accurate. I am satisfied that, within narrow limits, the abscissæ of viscosity are correct to the highest point, and the conformity of experiment to theory in the shape of these curves is a conclusive proof that, at as high an exhaustion as 0·02 M., the McLeod gauge is to be trusted to give accurate results within 2 per cent. of the truth. To give some idea what these high exhaustions mean, I may mention that the highest measured exhaustion—0·02 M.—bears the same proportion to the ordinary pressure of the atmosphere that a millimetre does to 30 miles, or, in point of time, that one second bears to 20 months.

Digitized by Google

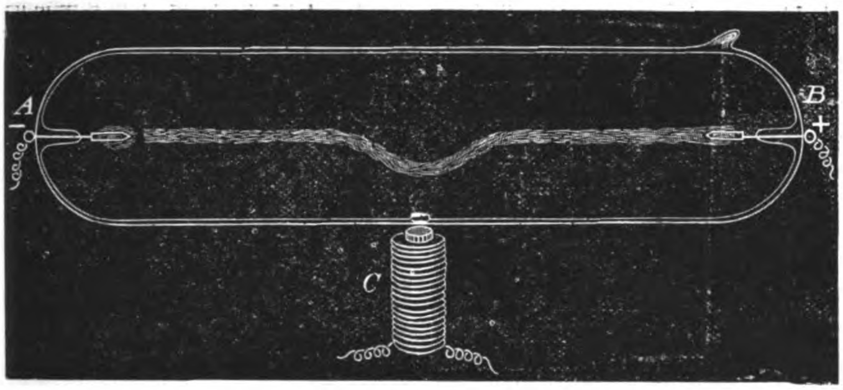



FIG. 1.—Pressure = 75 mm.

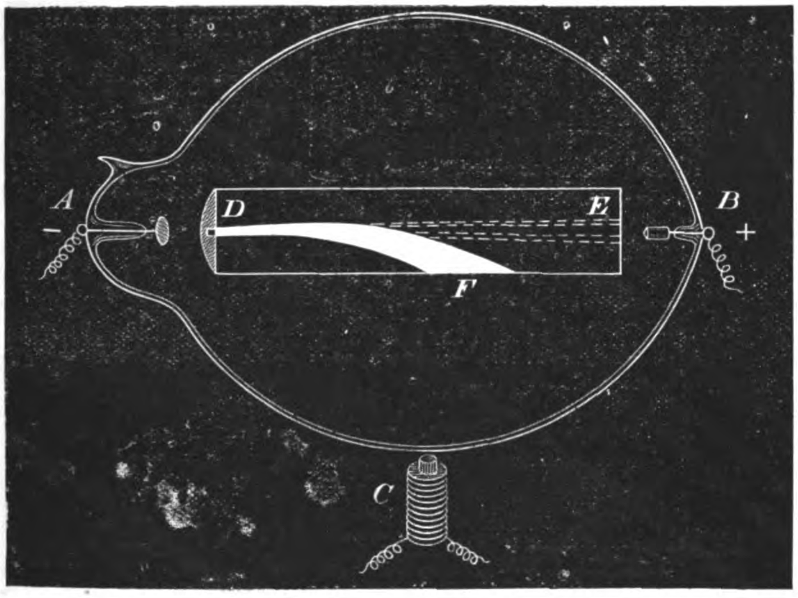



FIG. 2.—Pressure = ·1 mm. = 131·5 M.

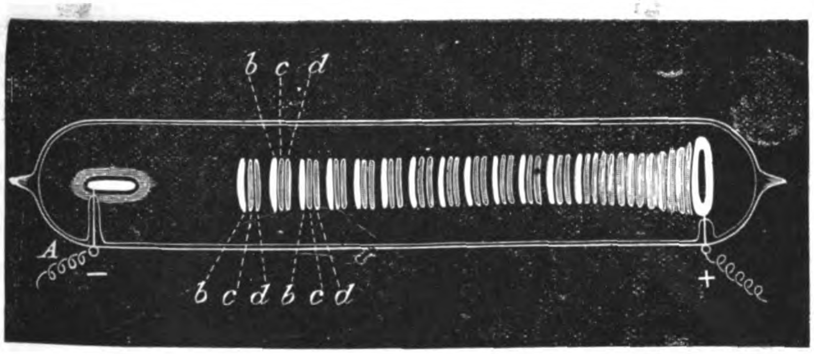



FIG. 3.—Pressure = 2 mm. = 2,630 M.

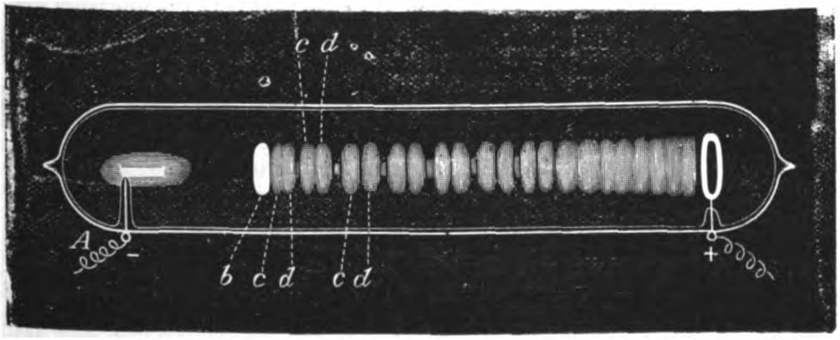



FIG. 4.—Pressure = 2mm. = 2630 M.

ceive in what manner these knots or groups are formed. Some few persons walking rather more slowly than the average rate slightly retard the movements of others whether travelling in the same or in an opposite direction. Thus a temporary obstruction is created. The passengers behind catch up to the block and increase it, and those in front, passing on unchecked at their former rate, leave a comparatively vacant space. If a crowd is moving all in the same direction the formation of these groups becomes more distinct. With vehicles in crowded streets, the result, as everyone may have remarked, will be the same.

Hence mere differences in speed suffice to resolve a multitude of passengers into alternating gaps and knots.

Instead of observing moving men and women, suppose we experiment on little particles of some substance, such as sand, approximately equal in size. If we mix the particles with water in a horizontal tube and set them in rhythmical agitation, we shall see very similar results, the powder sorting itself with regularity into alternate heaps and blank spaces.

If we pass to yet more minute substances we observe the behaviour of the molecules of a rarefied gas when submitted to an induction current. The molecules here are free, of course, from any caprice and simply follow the law I seek to illustrate, and though originally in a state of rampant disorder, yet under the influence of the electric rhythm they arrange themselves into well-defined groups or stratifications; the luminosities show where arrested motion with concomitant friction occurs, and the dark intervals indicate where the molecules travel with comparatively few collisions.

### *Party-coloured Stratifications.*

As another illustration of stratifications in a moderately-exhausted tube (P. = 2 mm.), I will take the case of hydrogen prepared from zinc and sulphuric acid after being passed through various purifying agents, dried in the usual manner, and exhausted with a mercury pump (Fig. 3). I pass the induction current, and we see that the stratifications are tricoloured, blue, pink, and grey. Next the negative pole A is a luminous layer, then comes a dark interval or Faraday's dark space (see below), and after this are the stratifications, the front component (*b*) of each group blue, the next (*c*) pink, and the third (*d*) grey. The blue discs are somewhat erratic. At a certain stage of exhaustion all the blue components of the stratifications suddenly migrate to the front, forming one bright blue disc, and leaving the pink and grey components by themselves. The tube before you (Fig. 4) is at this particular stage of exhaustion, and on passing the current you observe the blue disc only (*b*) is in front. When the tube contains a compound gaseous residue of this kind, the form of stratifications can be very considerably altered by varying the potential of the discharge. This alteration in the forms of stratification was first pointed out by Gassiot (1865, "B.A. Abstracts," p. 15), who gave very full descriptions and drawings of the alterations produced by putting in resistances of various lengths of distilled water. That the alteration depends simply upon the difference of potential the following experiment pretty clearly shows:—Here is a tube giving on my coil the coloured stratification usually attributed to

Digitized by Google

the presence of residual hydrogen, but which I find is due to a mixture of hydrogen, mercury, and hydro-carbon vapours. Now, by altering the brake so as to produce frequent discharges of lower potential, you see the stratifications gradually change in shape and become all pink; again altering the brake so as to send less rapid discharges at a much higher potential, once more we get the coloured stratifications. When in this state, if we introduce a water resistance into the circuit so as to damp down the potential, exactly the same thing happens. The blue disc is caused by mercury; its

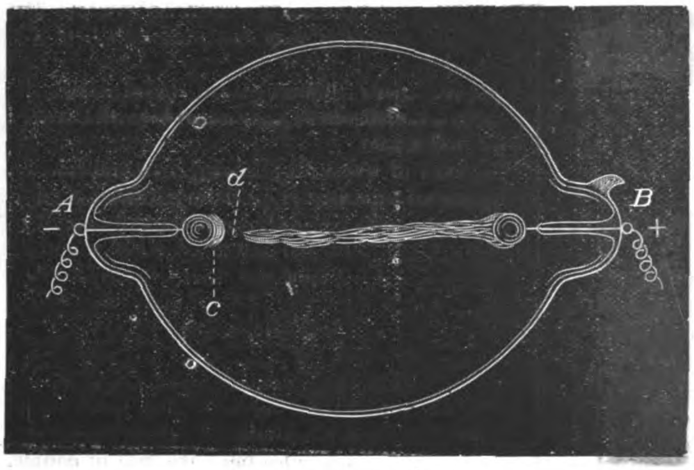



Fig. 5. - Pressure = 6mm.

spectrum is that of mercury only, without even a trace of the bright red line of hydrogen. Experiments not yet finished make it very probable that the pink discs are due to hydrogen, and that the grey discs indicate carbon. The tube you have just seen contains nothing but hydrogen, mercury, and a minute trace of carbon; but with all the resources at my command I have not been able to get hydrogen quite free from impurity. Indeed, I do not think absolutely pure hydrogen has ever yet been obtained in a vacuum tube. I have so far succeeded as to completely eliminate the mercury, and almost completely to remove the trace of carbon. On the table is such a tube giving uniformly pink stratifications, and showing no blue or grey discs with any potential of current.

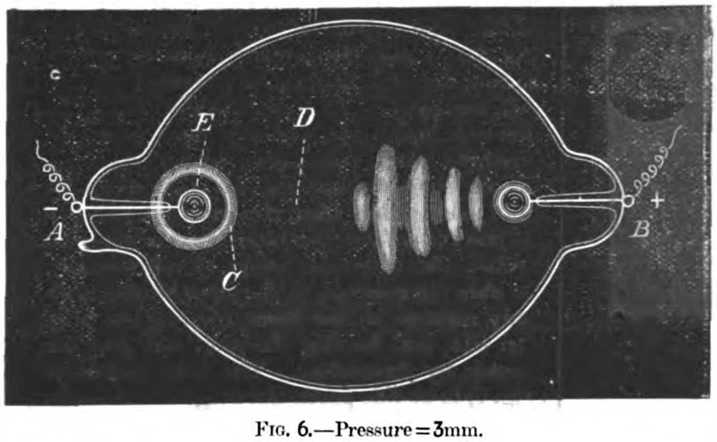



Fig. 6.—Pressure = 3mm.

*The Dark Space.*

After the stratification stage is passed, we come to a very curious phenomenon, the so-called "Dark Space." Studying electrical phenomena in gases, in the year 1838, Faraday* pointed out a break in the continuity of the luminous discharge separating the glow of the positive electrode from that of the negative. This he called "the dark space." It is seen in tubes containing gas only slightly rarefied, as in this tube (Fig. 5, P. = 6mm.), where you will observe that the positive glow, extending as a pink streak from the positive electrode, B, ends about 10 millimetres before the spot of blue light, C, representing the negative glow. This gap, or non-luminous hiatus, D, is Faraday's "dark space." Separating the negative glow from its electrode is another space. In this tube it is so small that the glow appears to be in actual contact with the electrode, but on exhausting a little further it rapidly separates; and in the next tube (Fig. 6), containing air at a little less pressure (P = 3 mm.), this dark space, E, has extended so as to remove the negative glow about four millimetres from the electrode A. It is with this second dark space that I particularly wish to deal to-night. Therefore I shall refer to it as the "dark space," meaning always that in a negative glow.

* "Experimental Researches in Electricity," 1838, par. 1,544.

In the experiment just shown with hydrogen stratifications the contents of the tube under the electric discharge still obey the laws following from the average properties of an immense number of molecules moving in every direction with velocities of all conceivable magnitudes. But if I continue exhausting, the dark space, E, round the negative pole, A, becomes visible, grows larger and larger, and at last fills up the entire tube. The molecules at this stage are in a condition different from those in a less highly exhausted tube. At low exhaustions they behave as gas in the ordinary sense of the term, but at these high exhaustions, under electric stress, they have become exalted to an *ultra-gaseous* state, in which very decided properties, hitherto masked, come into play.

The radius of the dark space varies with the degree of exhaustion, with the kind of gas in which it has been produced, with the temperature of the negative pole, and to a less extent with the intensity of the spark.

It has been erroneously assumed that I ever said the thickness of the "dark space" represents the mean free path of the molecules in their ordinary condition, and it has been pointed

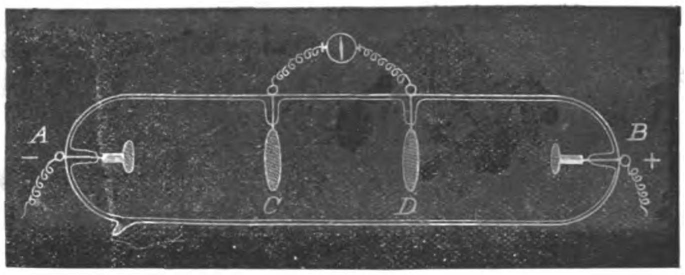



Fig. 7

out that the radius of the dark space is decidedly greater than the calculated mean free path of the molecules. I have taken accurate measurements of the radius of the dark space at different pressures, and compared it with the calculated mean free path of the gaseous molecules at corresponding pressures when not under the influence of electrical energy, and I find that they do not bear a constant relation one to the other. The length of the dark space is not twenty times the mean free path, as some have estimated, but a gradually increasing multiple must be taken as the exhaustion becomes greater.

*Exploration with Idle Poles.*

Wishing to learn something of the electrical condition of the matter within and without the dark space, I made a tube (Fig. 7), having besides the positive and negative terminals, A B, two extra intermediate poles, C and D; the tube showed that when the exhaustion was such that both the idle poles were outside the dark space, on passing the current through the tube there was a considerable difference of potential between them when measured on the galvanometer. If the exhaustion was carried so high that one of the extra poles was just on the border of the dark space, then no current passed between them. When the exhaustion was still further increased so as to enclose one of the extra poles fully in the dark space, again there was a great difference of potential between them, but the direction was reversed, the pole at highest potential now being the one formerly at lowest potential.

When the dark space has been further explored by means of a movable negative pole, I found that the effects did not depend esentially on the exhaustion, and were really due to

Digitized by Google

the position occupied by the extra poles with regard to the dark space.

These phenomena are difficult to understand from mere description, and the experiments themselves are not easy to carry out so as to be visible to many at a time. I have here, however, a working model of an apparatus which will make these puzzling indications clear to all.

A cylindrical tube (Fig. 8, *a*, *b*, and *c*, P = 0·25 mm.), furnished with the usual poles, A B at the ends, has two extra or idle poles near together at C and D. The pole A is movable along the axis of the tube, so that when exhausted the dark space can be brought to any desired position with respect to the idle poles C and D. The shading and + and − marks roughly show the distribution of positive and negative electricity inside the tube. I start with the negative pole A as far as possible from either idle pole (Fig. 8, *a*). Turning on the coil you see the dark space surrounding the pole A, and the idle poles quite outside.

The shading shows that each idle pole is in the positive area, and on testing with a gold leaf electroscope it will be seen that each is charged with positive electricity. But the shading also shows more positive at C than at D, and on connecting C and D with a galvanometer the needle indicates a rush of current from C to D, D being negative to C.

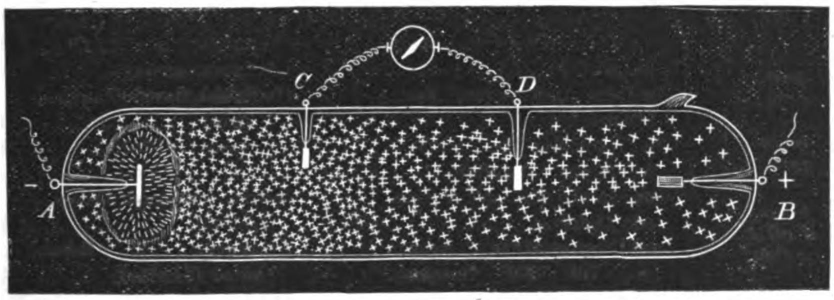



FIG. 8*a*.—·25mm. = 330 M.

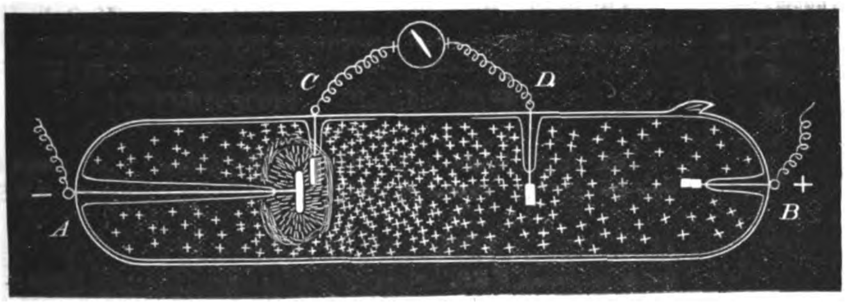



FIG. 8*b*.—·25 mm. = 330 M.

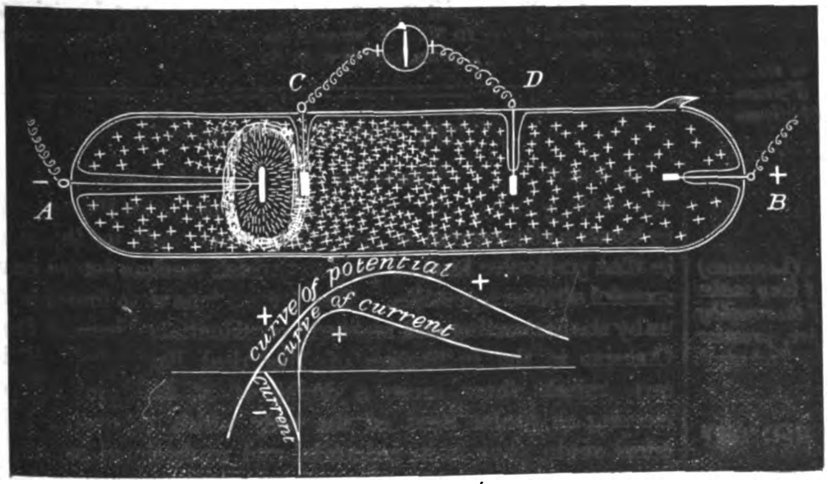



FIG. 8*c*.—P. = ·25 mm. = 330 M.

The dark space is next brought to such a position that the pole C is well within it (Fig. 8, *b*). A change has now come over the indications. The galvanometer shows a reverse current to that which was seen on the former occasion. C is now negative and D positive, but the gold leaves still tell us both poles are positively electrified.

At a certain position of the dark space, when its edge is on the pole C (Fig. 8, *c*), a neutral state is found at which the gold leaves still show strongly positive electrifications, and no current is seen on the galvanometer. The curves below (Fig. 8, *c*), roughly show the rise and fall of negative and positive current at different parts of the tube, whilst the potential curve keeps positive.

When a substance that will phosphoresce under electrical excitement is introduced into the tube, the position of greatest luminosity is found to be at the border of the dark space, just where the two opposing armies of negative and positive atoms meet in battle array and re-combine. Later on I shall refer to this phenomenon in connection with the phosphorescence of yttria.

*(To be continued.)*

## MEETINGS OF SCIENTIFIC SOCIETIES, &c.

**FRIDAY, January 16th.**

PHYSICAL SOCIETY.

*5.30 p.m.* Papers to be read: "Photo Electricity," by Prof. G. W. MINCHIN, M.A.; "A Lecture Room Method of Determining 'g,'" by Prof. BARRETT, B.A.; "On the Change in the Absorption Spectrum of Cobalt Glass produced by Heat," by Sir JOHN CONROY, Bart., M.A.

INSTITUTION OF CIVIL ENGINEERS.

*7.30 p.m.* Students' Meeting. Paper to be read: "On a Survey of the Bed of Sutton Pool, Plymouth," by R. G. HANSFORD WORTH, Stud. Inst. C.E.

**TUESDAY, January 20th.**

THE INSTITUTION OF CIVIL ENGINEERS.

*8 p.m.* Ordinary Meeting. Paper to be discussed: "Auxiliary Engines in connection with the Modern Marine-Engine," by W. H. ALLEN, A.M.I.C.E.

**WEDNESDAY, January 21st.**

ROYAL METEOROLOGICAL SOCIETY.

*7 p.m.* Ordinary Meeting. Papers to be read: "Note on a peculiar development of Cirrus Cloud observed in Southern Switzerland," by ROBERT H. SCOTT, M.A., F.R.S.; "Some Remarks on Dew," by Col. W. F. BADGLEY, F.R.Met.Soc. To be followed by the Annual General Meeting of the Society at 8.15 p.m., when the Report of the Council will be read, and the Election of Officers and Council for the ensuing year will take place.

SOCIETY OF ARTS.

*8 p.m.* Ordinary Meeting. Paper to be read: "Photography in Aniline Colours," by A. G. GREEN, C. F. CROSS, and E. J. BEVAN.

ROYAL MICROSCOPICAL SOCIETY.

*8 p.m.* Annual Meeting. President's Address. Election of Council and Officers.

**THURSDAY, January 22nd.**

INSTITUTION OF ELECTRICAL ENGINEERS.

*8 p.m.* Ordinary General Meeting. Paper to be read: "The Distribution of Electricity, with especial reference to the Chelsea system," by Major-Gen. C. E. Webber, R.E.

**FRIDAY, January 23rd.**

ROYAL INSTITUTION.

*9 p.m.* Evening Discourse: "Some Applications of Photography," by Lord RAYLEIGH, F.R.S.

Digitized by Google

# The Electrician.

**Published every Friday, Price Fourpence; Post Free, Fourpence Halfpenny**
**Editorial, Publishing, and Printing Offices:**
**SALISBURY COURT, FLEET ST., LONDON, E.C.**
*Telephone No. 2714. Telegrams:* "ELECTRICIAN NEWSPAPER, LONDON."

*All Letters relating to Subscriptions, Advertisements and other business matters should be addressed to the Publisher,* "THE ELECTRICIAN," *Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to* "THE ELECTRICIAN" *Printing and Publishing Company, Limited, and be crossed* "Coutts and Co." *All other letters to be addressed to the Editor.*

*All letters intended for insertion in* "THE ELECTRICIAN," *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

"THE ELECTRICIAN" *is published every Friday morning, in time for the morning mails. Subscribers should receive their copies by the first post on Friday morning.*

"THE ELECTRICIAN" *is on sale at the railway bookstalls throughout the Kingdom on Friday morning, and can be obtained of all Booksellers and Newsvendors; or direct from the Publishing Offices as above.*

*New Volumes of* "THE ELECTRICIAN" *commence in May and November.*

## SUBSCRIPTION RATES.

The rates for Subscriptions to "THE ELECTRICIAN" are as follows:—

| | 3 months. s. d. | 6 months. s. d. | 12 months. s. d. |
|---|---|---|---|
| For the United Kingdom | 5 0 | 10 0 | 19 6 |
| For Foreign Parts and Colonies:— Within Postal Union | 6 6 | 12 6 | 24 0 |
| Aden Borneo, Ceylon, China, India, Japan, Java, Labuan, Mozambique, New Caledonia, Persia, Philippine Islands, Siam, Transvaal, and Zanzibar | 7 6 | 14 6 | 28 0 |



## TO ADVERTISERS.

"THE ELECTRICIAN" *offers exceptional advantages to Advertisers.* **It has by far the largest circulation of any English Electrical paper, and circulates all over the World.**

*Particulars relating to Advertisements will be promptly forwarded on application to the Offices as above.*

TRADE ADVERTISEMENTS *intended for the current issue must reach the Offices not later than First Post on Thursday morning. Renewals of expiring advertisement orders and alterations to standing advertisements should be in the Publisher's hands by Wednesday at latest. No alteration can be made in Wrapper advertisements after Wednesday evening.*

SMALL PREPAID ADVERTISEMENTS *(for Rates see page xvii.) are accepted up to 4 p.m. on Thursday.*

## TECHNICAL PRINTING.

"THE ELECTRICIAN" PRINTING AND PUBLISHING COMPANY (LIMITED) *inform Electricians, Electric Light Engineers, &c., that they make a specialty of Technical Printing, and have a large Staff thoroughly acquainted with Electro-Technology. They can, therefore, promise Accuracy and Despatch in the Printing of Electro-Technical Literature, &c.*

## "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. (Royal 8vo.)

*Early in each year is issued* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. *The* DIRECTORY *was established in 1883; and the 1890 Edition consisted of about 850 pages of printed matter. The names and addresses of all persons engaged in the Electrical Industries at home and abroad may be relied upon as accurate. Useful Tables and Electrical Formulæ, and information specially compiled for this work are given, together with popularly-written Biographical Notices of the leading Electricians, Electrical Engineers, &c., accompanied in many cases by Portraits.*

*The 1891 Edition is now actively preparing, and Subscription and Advertisement Orders, New Names, Corrections, &c., can be received.*

## ELECTRICAL BOOKS AND PUBLICATIONS.

*All Books, Newspapers, and other publications, dealing with Electrical and kindred subjects, can be ordered direct of* "THE ELECTRICIAN" *Printing and Publishing Company, who are proprietors of the well-known* "ELECTRICIAN" *Series of Standard Electrical Works, and are agents for all the leading publishing houses at home and abroad.*


## CONTENTS OF THE CURRENT NUMBER.


NOTES .......... 317
William Crookes, F.R.S. ...... 322
Institution of Electrical Engineers—
Presidential Address of Prof. William Crookes, F.R.S.—"Electricity in Transitu: from Plenum to Vacuum. Illustrated .......... 323
Meetings of Scientific Societies. 327
IN THE VAN OF PROGRESS ...... 328
Electromagnetic Theory. II. By Oliver Heaviside. Continued .......... 330
The Oulton-Edmondson Meter. Illustrated .......... 332
The New Elihu Thomson Electric Meter, Illustrated ...... 332
Notes on the Economy of Electric Lighting .......... 333
Load Diagram of the St. James's and Pall Mall Company. Illustrated .......... 334
On the Measurement of Electro-Magnetic Radiation. By C. V. Boys, F.R.S., A. E. Briscoe, and W. Watson, B.Sc. Illus. Concluded .......... 335
Presentation Portrait of Sir John Pender .......... 338
The Electric Lighting of Dublin 338
American Notes .......... 339
CORRESPONDENCE—
The Bye-Laws of Urban Authorities — A. C. Curtis-Hayward .......... 339
The City and South London Railway—A. Willbond ... 340
The New Electric and Magnetic Theories — John T. Sprague .......... 340
LEGAL INTELLIGENCE—
The British Tanning Company v. Groth .......... 341
Trade Notes and Notices ...... 342
COMPANIES' MEETINGS, &c.—
Eastern Telegraph Company (Limited) .......... 343
Woodhouse and Rawson United (Limited) .......... 343
Elmore's French Patent Copper Depositing Company (Limited) .......... 345
The Direct United States Cable Company (Limited).. 347
City Notes, &c. .......... 347


## SPECIAL NOTICE.

**With this Number of "THE ELECTRICIAN" is issued a fine Steel-Plate Portrait of Prof. WILLIAM CROOKES, F.R.S.**

### STEEL-PLATE PORTRAITS

*Of W. H. Preece, F.R.S.; Michael Faraday; Sir John Pender, K.C.M.G.; Sir William Thomson, F.R.S. (Past-President of the Institution of Electrical Engineers); C. H. B. Patey, C.B. (Late Secretary of Telegraphs, G.P.O.); Dr. John Hopkinson, F.R.S. (Past-President of the Institution of Electrical Engineers); and Dr. Oliver J. Lodge, F.R.S., have been issued as Supplements to* "THE ELECTRICIAN." *A few Copies of these admirably-executed Steel Engravings can be supplied, price 1s. each, post free on roller, 1s. 2d. Or framed in neat Black Pillar or Brown Ornamental Frames, price, post free, 4s. 6d.*

## IN THE VAN OF PROGRESS.

Decidedly England leads the way. If our American cousins are more pushing in business, and surpass us in the capacity to boom a commercial novelty, they must yield us the palm in that particular kind of progress which renders future commercial advances possible. These reflections were forced upon us by the interesting and masterly presidential address of Prof. CROOKES to the Institution of Electrical Engineers. If in any minds there arose a doubt as to the propriety of electing as titular head of the body which represents electrical engineering in its industrial and professional aspects a chemist of world-wide distinction, it can only have been because the reputation of Prof. CROOKES as an electrician has been outshone by his fame as a chemist. But the presidential address which, by the courtesy of the President and officials of the Institution, we are able to present to our readers, affords ample justification of the choice made by the Council of that body in their selection for the current year. Not that the new President stood in need of any such justification; for his important works of earlier date can never be forgotten by the electrical fraternity. The improvements which from 1872 to 1876 he effected in the Sprengel vacuum-pump, when studying the repulsion due to radiation in exhausted tubes, not only led him to the invention of that fascinating toy, the radiometer, but enabled him to attain much higher degrees of exhaustion than had previously been

considered practicable, and, in this way, beyond all question paved the path of progress for the production five years later of the commercially successful glow-lamp. It is hardly too much to say that but for the researches of Prof. Crookes on high vacua at the date named very little would have been heard of the subsequent inventions of Swan, Edison, Lane-Fox, and others. Again, in continuation of these researches on high vacua, Prof. Crookes became the discoverer of that peculiar state which a highly attenuated gas assumes when subjected to an electric discharge, to which its discoverer has given the name of the "radiant matter" state; when, instead of pressing equally in all directions as ordinary gases do, it acts with greatly increased pressures, directed normally to the surface of the negative electrode. It was in pursuance of this line of discovery that Prof. Crookes was led to observe the strange phosphorescent lights with which certain substances, notably the rare earthy oxide yttria, the commoner oxide alumina, its rare crystalline variety the ruby, sundry other gems, and certain kinds of glass, exhibit when subjected to the discharge of the electrified molecules in a stream of radiant matter. In submitting the rays of these strange luminosities to the analysis of the spectroscope, Prof. Crookes was led on to institute a research into the group of curiously-allied metals of the earths alumina, glucina, yttria, erbia, samaria, and their congeners; with the result that to account for the singular properties so revealed, he was compelled to frame a hypothesis that the atoms of these elements or meta-elements are not all alike, but differ slightly *inter se*. According to this view the qualities hitherto attributed to any one of these metals are only a sort of average of the qualities possessed by its atoms; a view which, if substantiated, will contravene the *obiter dictum* of Maxwell, that the atoms of each distinct element were all similar, like well-manufactured articles. Considerations respecting the cause of these minute differences between the individual atoms of which any mass of an element is composed led Prof. Crookes on into an intricate speculation as to the possible genesis of the elements out of some simpler primordial stuff, which, under the influence of periodically recurring forces of an electric nature, took upon itself many complex groupings, of which some being unstable were but temporary, whilst others were of permanent type. In this way he sought to explain those remarkable recurrences of natural properties which are found to exist when the elements are considered in the order of their various atomic weights. The discovery of this "periodic" law, first by the English chemist Newlands, and later by the Russian Mendeljeff, was a great advance in theoretical chemistry; but it was reserved to Prof. Crookes to find in it a stepping-stone to still more advanced speculations upon the origin of the elements.

To the topics of extremely attenuated vacua, radiant matter, electric phosphorescence, and the genesis of elements and meta-elements thus closely connected in the development of Prof. Crookes's past researches, he has now returned in his presidential discourse. With a master's hand he has shown how the electric spark may become to the chemist a tool of the most precious and refined capabilities in unravelling phenomena of a degree of complexity and delicacy that would deter many a less-gifted experimenter and utterly baffle one possessing only the old chemical reagents and instruments of research. He has afresh examined the relations between the nature of the luminous discharge and the pressures of the residual gases in his highly exhausted bulbs and tubes, has triumphantly swept away sundry fictions, and has unravelled several of the problems which had hitherto escaped solution.

The vexed question of the origin of the parti-coloured stratifications, seen in a vacuum tube at a certain stage of exhaustion, has now entered on a new phase. And though it will doubtless be unsatisfactory to the ordinary chemist to learn that so simple a substance as hydrogen gas has never been obtained in a state of purity, it is some compensation to know what are the causes of the ever-present impurities. Again, when so notable a discovery as that of the radiant-matter state has been called in question by a skilled German experimenter, it is most gratifying to find that Prof. Crookes has been able to dispose of the points alleged in controversy by such a cogent and convincing series of experimental demonstrations as those which he has put forth. He seems, indeed, to have revelled in piling proof upon proof to establish his original proposition as to the nature of the molecular discharge set up by the electrical forces in his phosphorescent tubes.

The audience which cheered Prof. Crookes's brilliant succession of experiments, aroused as it was to no common pitch of enthusiasm, did not spend its cheers simply upon the glowing rubies and gleams of golden phosphorescence, nor yet upon the ingenious mechanical and experimental devices adopted in the investigations. Its applause was elicited by his successful quest into depths of the unknown. That, to adopt the President's own words, seed was being scattered for future discoveries and inventions, which must in due time bear its appropriate fruit. True, the mysteries of the electric discharge and of the electrical relations of vacuous space have not all been solved; they have indeed been added to by the discovery of new and puzzling facts. Why the presence of an outer tube of silver, or other good conductor, should act as an obstruction to the passage of an electric spark in the vacuous space within it, is a puzzle only equalled by the converse phenomenon that the presence of phosphorescent substances, all of which are non-conducting in themselves, should facilitate the passage of the discharge.

One thing we should like to see done. It is impossible to read Prof. Crookes's address without observing that he couches the description of his results in the ancient language of the two-fluid theory, and speaks of "positive electricity" and "negative electricity" as though they were two different things rather than two converse manifestations of one and the same entity. We are not saying that Prof. Crookes is wrong; it is very largely a question of language, and doubtless he has chosen those terms which best conveyed what he had in his mind. Nevertheless, we cannot but think that there would be some advantage if the same facts could be simply re-stated in more modern language. The older mode of speech is admittedly the simpler for describing a few of the phenomena of electricity, particularly those of electrolysis. But Prof. Crookes has himself shown us that the analogy between the gaseous conveyance of electricity and its conduction through an electrolytic liquid is less close than had previously been supposed. There is, therefore, all the less reason for following the language applied to electrolytic phenomena.

Prof. Crookes's presidential address, though it announces no new invention and propounds no new or startling theory, will, nevertheless, stand out in striking relief as a remarkable contribution to science; it will stamp the year 1891, even at this early date, as a year of progress in pure research. He has pushed investigation into the borderland between the known and the unknown one stage further, and this in a department of science where progress is only possible to one possessing the peculiar double qualification of electrician and chemist.

Digitized by Google

It is an honour to the Institution that such an address should emanate from its President, and we venture to predict that it will prove to be as fertile in stimulating research and invention as any of the presidential addresses of previous years have proved; for, in the eloquent words of the address, "pure research is the abundant source from which spring endless streams of practical application."

## ELECTRO-MAGNETIC THEORY.—II.

BY OLIVER HEAVISIDE.

(*Continued from p. 258.*)

§ 8. There are men of a certain type of mind who are never wearied with gibing at mathematics, at mathematicians, and at mathematical methods of inquiry. It goes almost without saying that these men have themselves little mathematical bent. I believe this to be a general fact; but, as a fact, it does not explain very well their attitude towards mathematicians. The reason seems to lie deeper. How does it come about, for instance, that whilst they are themselves so transparently ignorant of the real nature, meaning, and effects of mathematical investigation, they yet lay down the law in the most confident and self-satisfied manner, telling the mathematician what the nature of his work is (or rather is not), and of its erroneousness and inutility, and so forth? It is quite as if they knew all about it.

It reminds one of the professional paradoxers, the men who want to make you believe that the ratio of the circumference to the diameter of a circle is 3, or 3·125, or some other nice easy number (any but the right one); or that the earth is flat, or that the sun is a lump of ice; or that the distance of the moon is exactly 6 miles 500 yards, or that the speed of the current varies as the square of the length of the line. They, too, write as if they knew all about it! Plainly, then, the anti-mathematician must belong to the same class as the paradoxer, whose characteristic is to be wise in his ignorance, whereas the really wise man is ignorant in his wisdom. But this matter may be left for students of mind to settle. What is of greater importance is that the anti mathematicians sometimes do a deal of mischief. For there are many of a neutral frame of mind, little acquainted themselves with mathematical methods, who are sufficiently impressible to be easily taken in by the gibers and to be prejudiced thereby; and, should they possess some mathematical bent, they may be hindered by their prejudice from giving it fair development. We cannot all be Newtons or Laplaces, but that there is an immense amount of moderate mathematical talent lying latent in the average man I regard as a fact; and even the moderate development implied in a working knowledge of simple algebraical equations can, with common sense to assist, be not only the means of valuable mental discipline, but even be of commercial importance (which goes a long way with some people), should one's occupation be a branch of engineering for example.

§ 9. "Mathematics is gibberish." Little need be said about this statement. It is only worthy of the utterly illiterate.

"What is the use of it? It is all waste of time. Better be doing something useful. Why, you might be inventing a new dynamo in the time you waste over all that stuff." Now, similar remarks to these I have often heard from fairly intelligent and educated people. *They* don't see the use of it, that is plain. That is nothing; what is to the point is that they conclude that it is of no use. For it may be easily observed that the parrot-cry "What's the use of it?" does not emanate in a humble spirit of inquiry, but on the contrary, quite the reverse. You can see the nose turn up.

But what is the use of it, then? Well, it is quite certain that if a person has no mathematical talent whatever he had really better be doing something "useful," that is to say, something else than mathematics, (inventing a dynamo, for instance,) and not be wasting his time in (so to speak) trying to force a crop of wheat on the sands of the sea-shore. This is quite a personal question. Every mind should receive fair development (in good directions) for what it is capable of doing fairly well. People who do not cultivate their minds have no conception of what they lose. They become mere eating and drinking and money-grabbing machines. And yet they seem happy! There is some merciful dispensation at work, no doubt.

"Mathematics is a mere machine. You can't get anything out of it that you don't put in first. You put it in, and then just grind it out again. You can't discover anything by mathematics, or invent anything. You can't get more than a pint out of a pint pot." And so forth.

It is scarcely credible to the initiated that such statements could be made by any person who could be said to have an intellect. But I have heard similar remarks from really talented men, who might have fair mathematical aptitude themselves, though quite undeveloped. The fact is, the statements contain at once a profound truth, and a mischievous fallacy. That the fallacy is not self evident affords an excuse for its not being perceived even by those who may (perhaps imperfectly) recognise the element of truth. But as regards the truth mentioned, I doubt whether the caviller has generally any distinct idea of it either, or he would not express it so contemptuously along with the fallacy.

§ 10. By any process of reasoning whatever (not fancy) you cannot get any results that are not implicitly contained in the material with which you work, the fundamental data and their connections, which form the basis of your inquiry. You may make mistakes, and so arrive at erroneous results from the most correct data. Or the data may be faulty, and lead to erroneous conclusions by the most correct reasoning. And in general, if the data be imperfect, or be only true within certain limits hardly definable, the results can have but a limited application. Now all this obtains exactly in mathematical reasoning. It is in no way exempt from the perils of reasoning in general. But why the mathematical reasoning should be singled out for condemnation as mere machine work, dependent upon what the machine is made to do, with a given supply of material, is not very evident. The cause lies deep in the nature of the anti-mathematician; he has not recognised that all reasoning must be, in a sense, mechanical, else it is not sound reasoning at all, but vitiated by fancy.

Mathematical reasoning, is fundamentally, not different from reasoning in general. And as by the exercise of the reason discoveries can be made, why not by mathematical reasoning? Whatever were Newton and the long array of mathematical materialists who followed him doing all the time? Making discoveries, of course, largely assisted by their mathematics. I say nothing of the pure mathematicians. Their discoveries are extensions of the field of mathematics itself—a perfectly limitless field. I refer only to students of Nature on its material side, who have employed mathematics expressly for the purpose of making discoveries. Some of the unmathematical believe that the mathematician is merely engaged in counting or in doing long sums; this probably arises from reminiscences of their schooldays, when they were flogged over fractions. Now this is only a part of his work, a sometimes necessary and very disagreeable part, which he would willingly hand over to a properly trained computator. This part of the work only concerns the size of the effects, but it is the effects themselves to which I refer when I speak of discoveries.

§ 11. Mathematics is reasoning about quantities. Even if qualities are in question, it is their quantities that are subjected to the mathematics. If there be something which cannot be reduced to a quantity, or more generally to a definite function, no matter how complex and involved, of any number of other quantities which can be measured (either actually, or in imagination), then that something cannot be accurately reasoned about, because it is in part unknown. Not unknown in the sense in which a quantity is said to be unknown in algebra, when it is virtually known because virtually expressible in terms of known quantities, but literally unknown by the absence of sufficient quantitative connection with the known. Thus only the known can be accurately reasoned about. But this includes, it will be observed, everything that can be deduced from the known, without appeal to the unknown. The unknown is not necessarily unknowable; fresh knowns may make the former unknowns become also known. The distinction is

Digitized by Google

a very important one. The limits of human knowledge are ever shifting. But there must be an ultimate limit, because we are a part of Nature, and cannot go beyond it. Beyond this limit, the Unknown becomes the Unknowable, which it is of little service to discuss, though it will always be a favourite subject of speculation. But whatever is in this Universe can be (or might be) found out, and therefore does not belong to the unknowable. Thus the constitution of the middle of the sun, or of the ether, or the ultimate nature of magnetisation, or of universal gravitation, or of life, are not unknowable, and this statement is true, even though they should never be discovered. There are no inscrutables in Nature. By Faith only can we go beyond—as far and where we please.

Human nature, or say a man, is a highly complex quantity. We are compelled to take him in parts, and consider this or that quality, and imagine it measured and brought into proper connection with other qualities and external influences. Yet a man, if we only knew him intimately enough, could be formularised, and have his whole life-history developed. Even the universe itself, if every law in action were thoroughly known, could have its history, past, present, and to come, formularised down to the minutest particulars, provided no discontinuity or special act of creation occur. But even the special act of creation could be formularised, and its effects deduced, if we knew in what it consisted. And special acts of creation might be going on continuously, involving continuous changes in the laws of nature, and could be formularised, if the acts of creation were known, or the—so to speak—law of the discontinuities. The case is somewhat analogous to that of impressed forces acting upon a dynamical system. The behaviour of the system is perfectly definite and formularisable so long as no impressed forces act, and ceases to be definite if unknown impressed forces act. But if the forces be also known, then the course of events is again definitely formularisable. The assumption of a special act of creation, either now or at any time, is merely a confession of ignorance. We have no evidence of any such discontinuities. We cannot prove that there have never been any; nor can we prove that the sun will not rise to-morrow, or that the clock will not wind itself up again when the weight has run down.

§ 12. Nearly all the millions, or rather billions, of human beings who have peopled this earth have been content to go through life taking things as they found them, and without any desire to understand what is going on around them. It is exceedingly remarkable that the scientific spirit (asking how it is done), which is so active and widespread at the present day, should be of such recent origin. With a few exceptions, it hardly existed amongst the Ancients (who would be more appropriately termed the Youngsters). It is a very encouraging fact for evolutionists, leading them to believe that the evolution of man is not played out; but that man is capable, intellectually, of great development, and that the general standard will be far higher in the future than at present.

Now, in the development of our knowledge of the workings of Nature out of the tremendously complex assemblage of phenomena presented to the scientific inquirer, mathematics plays in some respects a very limited, in others a very important part. As regards the limitations, it is merely necessary to refer to the sciences connected with living matter, and to the ologies generally, to see that the facts and their connections are too indistinctly known to render mathematical analysis practicable, to say nothing of the complexity. Facts are of not much use, considered as facts. They bewilder by their number and their apparent incoherency. Let them be digested into theory, however, and brought into mutual harmony, and it is another matter. Theory is the essence of facts. Without theory scientific knowledge would be only worthy of the madhouse.

In some branches of knowledge, the facts have been so far refined into theory that mathematical reasoning becomes applicable on a most extensive scale. One of these branches is Electro-magnetism, that most extensive science which presents such a remarkable twosidedness, showing the electric and the magnetic aspects either separately or together, in stationary conditions, and a third condition when the electric and magnetic forces act suitably in dynamical combination, with equal development of the electric and magnetic energies, the state of electro magnetic waves.

It goes without saying that there are numerous phenomena connected with electricity and magnetism which are very imperfectly understood, and which have not been formularised, except perhaps in an empirical manner. Such is particularly the case where the sciences of Electricity and Chemistry meet. Chemistry is, so far, eminently unmathematical (and therefore a suitable study for men of large capacity, who may be nearly destitute of mathematical talent—but this by the way), and it appears to communicate a part of its complexity and vagueness to electrical science whenever electrical phenomena which we can study are accompanied by chemical changes. But generally speaking, excepting electrolytic phenomena and other complications, (*e.g.*, the transport of matter in rarefied media when electrical discharges occur) the phenomena of electro-magnetism are, in the main, remarkably well-known, and amenable to mathematical treatment.

§ 13. Ohm (a distinguished mathematician, be it noted) brought into order a host of puzzling facts connecting electromotive force and electric current in conductors, which all previous electricians had only succeeded in loosely binding together qualitatively under some rather vague statements. Even as late as 20 years ago, "quantity" and "tension" were much used by men who did not fully appreciate Ohm's law. (Is it not rather remarkable that some of Germany's best men of genius should have been, perhaps, unfairly treated? Ohm; Mayer; Reis; even von Helmholtz has mentioned the difficulty he had in getting recognised. But perhaps it is the same all the world over.) Ohm found that the results could be summed up in such a simple law that he who runs may read it, and a schoolboy now can predict what a Faraday then could only guess at roughly. By Ohm's discovery a large part of the domain of electricity became annexed to theory. Another large part became virtually annexed by Coulomb's discovery of the law of inverse squares, and completely annexed by Green's investigations. Poisson attacked the difficult problem of induced magnetisation, and his results, though differently expressed, are still the theory, as a most important first approximation. Ampère brought a multitude of phenomena into theory by his investigations of the mechanical forces between conductors supporting currents and magnets. Then there were the remarkable researches of Faraday, the prince of experimentalists, on electrostatics and electrodynamics and the induction of currents. These were rather long in being brought from the crude experimental state to a compact system, expressing the real essence. Unfortunately, in my opinion, Faraday was not a mathematician. It can scarcely be doubted that if he had been one, he would have been greatly assisted in his researches, have saved himself much useless speculation, and would have anticipated much later work. He would, for instance, knowing Ampère's theory, by his own results have readily been led to Neumann's theory, and the connected work of Helmholtz and Thomson. But it is perhaps too much to expect a man to be both the prince of experimentalists and a competent mathematician.

Passing over the other developments which were made in the theory of electricity and magnetism, without striking new departures, we come to about 1860. There was then a collection of detached theories, but loosely connected, and embedded in a heap of unnecessary hypotheses, scientifically valueless, and entirely opposed to the spirit of Faraday's ways of thinking, and, in fact, to the spirit of the time. All the useless hypotheses had to be discarded, for one thing; a complete and harmonious theory had to be made up out of the useful remainder, for another; and, in particular, the physics of the subject required to be rationalised, the supposed mutual attractions or repulsions of electricity, or of magnetism, or of elements of electric currents upon one another, abolished, and electromagnetic effects accounted for by continuous actions through a medium, propagated in time. All this, and much more, was done. The crowning achievement was reserved for the heaven-sent Maxwell, a man whose fame, great as it is now, has, comparatively speaking, yet to come.

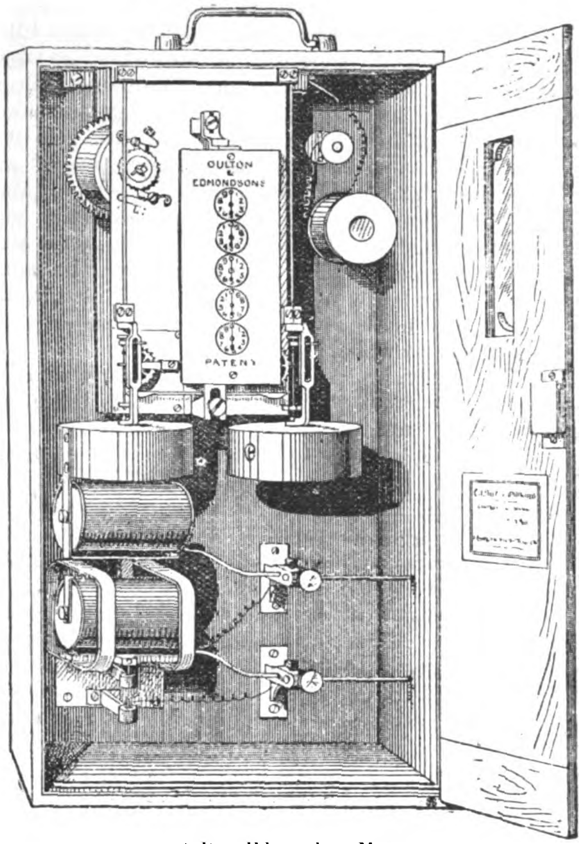
*(To be continued.)*

Digitized by Google

## THE OULTON-EDMONDSON METER.

This meter in its original form was fully described in *The Electrician*, Vol. XXIV., p. 111. The instrument has since then been subjected to prolonged tests, and has been modified in several respects. It now measures watts and is arranged for alternating or for continuous currents.

The meter consists of a clock train having two "torsion balances" which keep identical time, except when current is being consumed. When a current passes through the main conductor it quickens the speed of one of the balances, and the difference of speed (registered on the dials in B.T. units) is a measure of the current consumed. A difference of 10 beats per hour = 1 B.T. unit, and the measurement is proportional to the current throughout the whole range for which each instrument is constructed. Both balances are driven by one mainspring, the force of which is equally divided betwen them by a novel "differential gear."




Oulton-Edmondson Meter.

The electrical arrangements consist of two "compound-wound" solenoids, astatically attached to one of the balances, and swinging, the one *above* and the other *within*, the coils of the main conductor, and influenced by the current to be measured. The principal winding of the swinging solenoids consists of fine wire, connected with a fixed resistance coil (by which the instrument is calibrated), and coupled across the supply terminals. In a 100 ampere meter these high resistance or volt coils consume about ·007 ampere on a circuit of 100 volts. By themselves, however, they would not give proportional readings. For in pendulums and chronometric balances the force required to produce the vibrations is proportional to the square of the number of vibrations in a given time. If, therefore, $a$ = the normal number of vibrations, and $b$ = the number to be added by the current, the force required to produce $a$ will be $a^2$, and to produce $a + b$ will be $a^2 + 2\,a\,b + b^2$; the difference $(2\,a\,b + b^2)$ being the force to be exerted by the current under measurement. With the volt coils alone, the force actually exerted would be in the ratio $2\,a\,b + b$ only. Upon each volt coil, therefore, there is wound a "correcting coil," carrying a very small proportion of the current passing into consumption. If correctly calibrated, this small current brings the ratio up to $2\,a\,b + b^2$.

The right hand balance (*see* Figure) weighs about 4lb. It contains two "timing screws," which are really small weights, which, when screwed inwards will *quicken*, and when outwards will *retard*, the vibrations of the balance. The number of vibrations is about 15 per minute. The balance spring, instead of being coiled as in a watch, is quite straight, and forms the means of suspending the balance, which thus vibrates practically without friction. This spring acts by "torsion," a principle familiar to all who have seen the "400 day clock." The left hand balance and its solenoids are of about the same weight as the above, so as to vibrate in the same period of time.

Although driven by the same mainspring the two balances are free to move independently. The current for the volt and correcting coils is conveyed from the positive terminal to a mercury cup placed concentrically with the left hand balance, into which a wire upon, and concentric with, the balance projects. After traversing the volt coils it is conveyed up the "torsion spring" and through the fixed resistance coil to a terminal over the top of the case, and thence to the negative main. The current traversing the correcting coils returns through the upper mercury cup to the negative terminal of the instrument. This current is very small, as, for one ampere on 100 volt circuit, it has to furnish a magnetic force equal to only $\frac{1}{1800}$ of that furnished by the volt coils. As, however, the turns in the correcting coils are much fewer than those in the volt coils, the actual current in the former may be (for one ampere) somewhat greater than in the latter, and it increases in proportion to the current consumed. The denominator of the fraction $\frac{1}{1800}$ is the $2\,a\,b$ of the difference $2\,a\,b + b^2$ mentioned above, when the balances nominally vibrate 900 per hour.

## THE NEW ELIHU THOMSON ELECTRIC METER.

At the meeting of the Société Internationale des Electriciens on Thursday last week, M. Abdank Abakanowicz described a meter for use with alternating or continuous currents, which has been sent by Prof. Elihu Thomson to compete for the Paris Municipal prize. The remarkable simplicity of this meter, says our Paris correspondent, attracted unusual attention. The

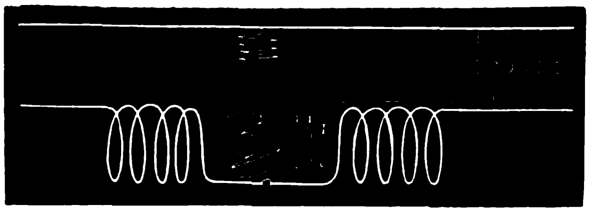


FIG. 1.—Diagram of Connections of the Elihu Thomson Meter.

instrument belongs to the group of continuously integrating motor meters, and consists essentially of a small electric motor, without iron and of a magnetic brake. The inducing coils are compound, and are wound on two rectangular frames. The thick wire is traversed by the total current. The fine wire, which is connected in series with the drum armature, and an additional non-inductive resistance, of 1,000 ohms, is arranged in shunt across the house terminals in the manner shown in the diagrammatic sketch (Fig. 1). The compounding serves to produce a couple equal to that caused by friction. The main couple tending to turn the armature is equal to E × C, that is to say, to the number of watts being consumed at any instant in the house circuit. The opposing couple is produced by Foucault currents developed in a copper disc, mounted on the same vertical axis as the armature. These currents are produced by three permanent horseshoe magnets arranged as shown in Fig 2.

The speed of rotation is very small, and is at maximum load, only one turn per second. The regulation of the apparatus is a very simple affair, since it is only necessary to have a constant difference of potential at the terminals of the shunt circuit to cause a constant current to go through the inducing coils, and to move one of the three permanent magnets until

Digitized by Google

the indications on the dials agree with the power consumed. The maximum power absorbed by the meter is 7·5 watts in the case of an instrument intended for a 50 volt 50 ampere circuit. The thin wire circuit absorbs 2·5 watts, and the thick wire circuit 5 watts. The instrument is said to register as soon as the power expended in the lamp circuit reaches 10 watts, and its inventor guarantees accuracy to within ½ per cent.

In the discussion which arose after the description of the meter, M. Sciama pointed out that the accuracy of its indications was likely to diminish in process of time since the constancy of the opposing couple depended on the permanency of the horseshoe magnets. He had noticed a diminution of 30 per cent. in one year in the strength of some permanent magnets attached to measuring instruments. On the other hand, M. R. V. Picou stated that makers had succeeded in securing such a degree of permanency with steel magnets that in three years their strength decreased by only 1 per cent. In support of this statement he instanced a Weston voltmeter brought

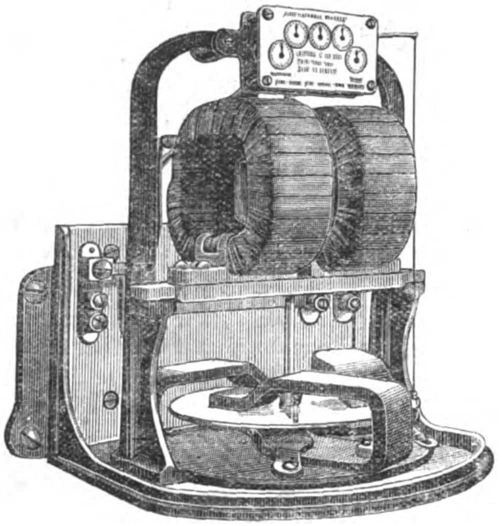


FIG. 2.—Elihu Thomson Motor Meter.

over three years ago from America by M. Abdank-Abakanowicz, and which still gave exactly the same indications. M. Picou did not know what process Weston employed to secure this remarkable permanency, but he himself obtained excellent results by the following *modus operandi*. Keep a magnetised steel bar at a temperature of 100° C. for several days. On cooling the bar will be found to have lost some of its magnetism. It must then be magnetised, and again heated to 100° C. Again its magnetism is diminished, but not to such an extent as before. It may then be magnetised a third time, and its magnetism will in reality be permanent. M. E. Sartiaux also testfied to the efficacy of this method of magnetisation.

A meter fulfilling the conditions of sensitiveness and accuracy to such a high degree as the above is certainly a remarkable one, but until the tests undertaken by the expert committee appointed by the Paris Municipal Council have been carried out, it is impossible to verify the claims put forward.

## NOTES ON THE ECONOMY OF ELECTRIC LIGHTING.

A practical paper on the cost of electric lighting compared with other illuminants is contributed to the *Electrical World* of New York by Dr. Louis Bell. As prices in the United States differ so much from those in this country, the paper as it stands would not be of direct interest to our readers. We, therefore, translate dollars and cents into shillings and pence, and interpolate where necessary comparisons with English experience, and thus contrast the economy of electric lighting in the two countries.

A few years ago, says Dr. Bell, there were very grave doubts in the minds of the majority of people concerning the possibility of really economical lighting by electricity; it was even said that while the quality and quantity of electric light would leave little to be desired, it could not be produced at a price to compete on favourable terms with gas. At this time such a statement would be immediately recognised as fallacious, for there are very many places where electric energy is sold at a price that puts gas quite in the background as an economical illuminant. A 16 candle-power electric incandescent light is the equivalent of a five-foot gas jet consuming the average quality of gas. In other words, we can in making a comparison between these two artificial lights reckon 200 electric lamp hours as the equivalent of 1,000 feet of gas. Consequently at the prevailing central station rate in America of one cent per lamp hour electric lighting costs an amount equivalent to 8s. 4d. a thousand feet for gas, while it possesses the great advantage of giving out relatively little heat and burning no oxygen out of the air. At the generally prevailing price for gas the two illuminants in the United States are so nearly on an equal footing that small accidents of situation are enough to control the question of relative economy.

The prevailing cost of electric energy in England may be put at 7¼d. per Board of Trade unit, since this is the average of the larger London companies, and the low prices in the North may be set against the few companies who charge 8d. One halfpenny per lamp hour, or one cent, as it stands in the original, for a 64 watt lamp, is equivalent to a Board of Trade unit at 7¾d. In this country, of course, there is no such equality of prices as that pointed out by Dr. Bell, since 200 lamp hours, at 64 watts per lamp, come to 12·8 units, and cost 7s. 8¾d., while gas costs from 2s. to 3s. This great discrepancy is alone sufficient to account to no small extent for the progress of electric lighting in the United States, and may be explained by the high price of gas coal as compared with steam coal in that country.

But it is not my purpose, continues Dr. Louis Bell, to discuss the somewhat worn question of electricity *versus* gas, but to call attention to what can be done in the way of domestic lighting by electricity, even when it has to compete with paraffin lamps. It may appear somewhat absurd to take the position that paraffin oil may in many cases cost as much as, or more than, electric lighting at the usual rates; nevertheless such is the fact. Of course where one is content with a comparatively small amount of light not at all equivalent to what would be secured by electricity or gas, the oil lamp owns no competitor, but if the problem in hand is to light a residence in a thoroughly satisfactory manner the conditions are very much changed. The author takes a concrete case drawn from his own observation, by way of illustration. The field of operations was a 10-room modern house in a suburban town, occupied by half-a-dozen adults. The lighting throughout was by oil lamps, 13 being in regular use, part of them having duplex burners, the others the simple flat wick. During a period covering the latter part of November and the first half of December 52 gallons of oil were consumed in 24 days. The price of oil being 6½d. per gallon, the daily cost of illumination was a small fraction over 1s. 2d. It may be added that the oil barrel had a locked faucet, so that unwarranted use of oil was prevented. While the price per gallon above given is about the same as the wholesale market price of common refined petroleum in this country, good oil free from smell costs about 10d· per gallon retail, in the small quantities generally purchased for domestic consumption. To render the comparison with electric lighting more easy, Dr. Bell reduces this figure to monthly consumption, and obtains £1. 15s. as the monthly lighting bill. Not all of the 13 lamps were lighted on every night, but they may be counted as being in regular use. This number of lamps appears to us to be high for so small a household, but the comparison is not affected thereby.

Now, what could be done under similar conditions with the incandescent lamp? On a liberal estimate, wiring the house for 15 lights would have given an illumination at least equivalent to that obtained by oil. It then appears that incandescent lamps at 2s. 8d. each per month, or £2 altogether, would have cost only one-third more than oil, with the additional great advantages of no care, no danger of fire, and no pollution of the air.

Digitized by Google

It may be replied, however, that the month taken as the basis of estimate was probably the one requiring most light, so that there would be a saving in oil during other parts of the year so great as to render the fixed charge for electricity anything but economical. This, of course, is in a measure true, but the number of incandescent lamps was deliberately taken larger than was necessary, to allow of fixed lamps in places where oil lamps are occasionally carried; and, further, 2s. 8d. per month is not a specially low rate for incandescent lamps in domestic service. In selling by contract the prices, of course, vary enormously from place to place. A few figures may, however, be of interest, particularly as they relate to small plants such as might be found in towns of very moderate size. In one small city in the United States the charge for domestic lighting is 2s. 6d. per lamp per month, the number of lights connected being less than a thousand, on the direct current system, coal being the fuel used at the station. Another direct current plant, having only 500 lights and burning coal obtained at a low rate on account of favourable situation, charges only 10d. per month for domestic service, provided at least six lights are wired. Still another, situated in a location where coal is about as expensive as in New York City, and furnishing 700 lights, charges for regular use 3s. 4d. per month, and for occasional lamps 2s. 1d. per month. As the latter class includes all lamps in sleeping apartments, and other rooms not constantly inhabited, the average price would fall to something like 2s. 6d. per month. In contract price, however, low-water mark is probably touched in a certain water-power plant where the charges for lamps in regular use average 1s. 3d. a month, and for those in occasional use, such as mentioned above, are furnished at 6¼d. per month.

It is difficult for purposes of comparison with English prices to express this 1s. 3d. per lamp-month in price per Board of Trade unit, as it is uncertain whether the lamps are turned off when not in use, and for how many hours they ought to be charged. However, taking it roughly at 100 hours per month throughout the year, and 64 watts per lamp, this would come to only a little over 2¼d. per unit, so that to make this tariff comparable with the *meter* charge of one cent per lamp hour referred to in the second paragraph, it must be supposed that the average number of lamps alight is never more than one-third of the total number wired.

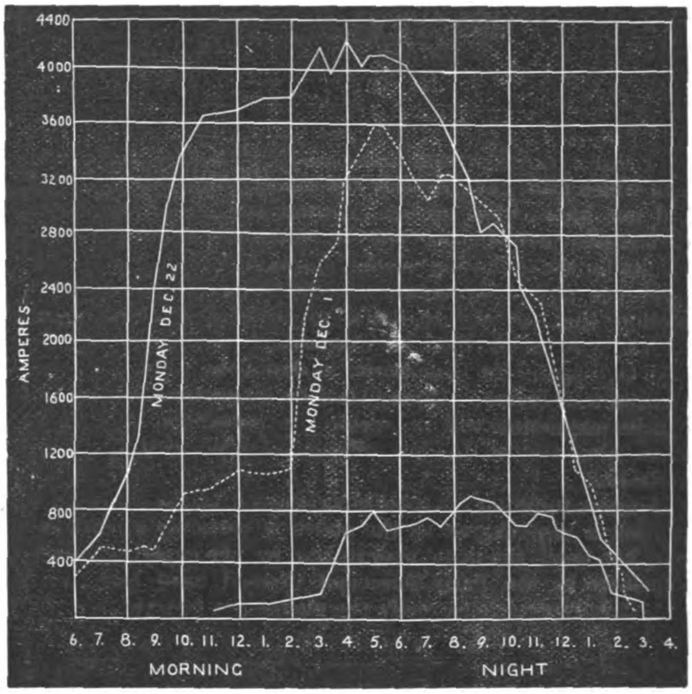
Where any considerable number of lamps, continues Dr. Bell, are used, as in large suburban towns, they can be furnished at a good profit at 2s. 1d. a month for domestic service; this, however, does not apply to commercial lighting or other cases where lamps are to be used regularly. But for the service we are discussing the price is such as very many companies would be only too glad to get. So much for lights supplied by contract. It is tolerably evident from what has been previously said that the difference in cost between oil and electricity for equal service in the United States is not very great, and may not infrequently be in favour of electricity.

Where incandescent lamps are supplied by meter the case is even more favourable. Assuming the standard central station charge of one cent per lamp hour the house above mentioned could unquestionably have been lighted as cheaply by electricity as by oil, for 32 lamp hours per night would be quite adequate for the service required; and here the comparison would be a fair one throughout the year, as only the electricity used is paid for. Unless in unfavourable situations one cent per lamp hour is a profitable selling price for incandescent lights, and this fact is attested by its being the charge made very frequently by City central stations, and even by small companies doing precisely the kind of work of which we are speaking. As a final contribution to the economy of this particular case, we are considering it should be mentioned that the price for gas in the town spoken of was 11s. 10½d. per thousand feet, which makes it distinctly more expensive than electric lighting at the rate last named. It is far from my purpose to contend that everywhere and under all circumstances electricity is the cheapest illuminant, but in many cases it could replace not only gas but oil lamps without increasing, and even in some places diminishing, the cost of illumination. Of course the weak point of the oil lamp, so far as economy is concerned, is the necessity for keeping it burning when the electric light, or even gas, would be extinguished. A lamp is not lighted without inconvenience, and therefore in rooms which will be occasionally visited during an evening oil is being constantly consumed where gas jets or incandescent lamps would be turned off. If one wished to go to the trouble of extinguishing and relighting these lamps a considerable saving might be effected; but for residences where plenty of light is desired and convenience somewhat consulted, the consumption of oil rises to an amount that gives gas and electricity an excellent chance for competition.

To sum up, where incandescent lamps can be obtained at one cent per lamp hour, or an equivalent contract price, they will compete in the United States on favourable terms not only with gas, but with oil, supposing equal illumination in each case. Aside from this the greater cleanliness and convenience of the incandescent lamp should commend it even where it is slightly at a disadvantage. It is a great pity that more suburban towns do not take advantage of electricity for house-to-house lighting, particularly since at the prices mentioned an electric light plant is in most situations a very good investment. This statement should not be understood as applying to localities where coal is very high, or where from an isolated situation or local circumstances the cost of operation rises to an amount considerably above the general average.

## LOAD DIAGRAMS OF THE ST. JAMES'S AND PALL MALL COMPANY.

The accompanying diagrams show a normal load curve (December 1, 1890) and one during a heavy fog (December 22, 1890). We are informed that this is probably the largest load curve that has been seen so far in England, if not in the world,




for a single supply station, and the efficiency of supply, owing to the machines working in parallel without any form of transformation, makes it all the more remarkable. The equivalent of 13,354 sixteen candle-power lamps are connected. We have reckoned the revenue earned on these two days, as this is a matter not without interest.

The load factor for the day of the normal curve is ·444, that is, the output was ·444 of that which would have been delivered if the maximum load had been carried for the whole 20 hours. The load factor for the foggy day is ·67. To show the increase in the normal supply made during the year we reproduce a load curve published in *The Electrician*, Vol. XXIV., p. 228, when about 2,000 lamps were connected.

Digitized by Google

## ON THE MEASUREMENT OF ELECTRO-MAGNETIC RADIATION.*

BY C. V. BOYS, F.R.S., A. E. BRISCOE, AND W. WATSON, B.SC.

*(Concluded from page 305.)*

### SECOND METHOD.

As the first method, carried out with all the delicacy which under the conditions we could make use of, gave no promise, we determined to find by some direct process whether the heat which Mr. Gregory had inferred from the expansion of the wire was real. For this purpose we made use of one of the most delicate heat-measuring instruments that exist, which is specially suitable for detecting very small quantities of heat diffused over a great length of wire, namely, the convection air-thermometer of the late Dr. Joule.† With this instrument he was able to detect the direct heating effect of the moon's rays unconcentrated by lens or mirror. His instrument consisted of a tube about 2ft. long and 4in. in diameter, divided longitudinally by a blackened pasteboard diaphragm, leaving spaces at the top and bottom. In the top space a piece of magnetised sewing-needle, furnished with a glass index, was suspended by a single silk fibre. Any excess of temperature on one side of the partition caused an air-current, which at the top passed from the hot to the cold side and deflected the needle.

We have made use of Joule's instrument, not exactly in the original form, but with two classes of index, and with an essential improvement which makes it extraordinarily sensitive without greatly affecting its simplicity. The first class of index depends for its working on the fact that when a small piece of phosphorous is placed in air it gradually oxidises, and the oxide formed slowly falls, if the air is still, in a well-defined column, appearing like smoke. If there is any very small motion of the surrounding air, this column of phosphorus oxide will be deflected. It thus forms an excessively delicate and light index for detecting movements in the air.

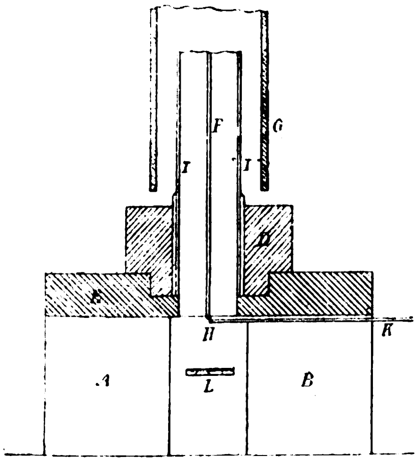



FIG. 5.

To overcome the difficulty of keeping the index at rest, owing to radiation from neighbouring bodies or to draughts of varying temperature, we have surrounded the divided tube by another, which was kept rotating continuously by clockwork. If any part of this guard-tube becomes slightly heated, it is carried round and made to heat the instrument equally all round, and so it produces no effect.

As the determination on theoretical grounds of the most suitable dimensions presents considerable difficulties, we decided to make a series of tubes of different sizes and compare their sensibility. The object of the instrument being to measure the heat developed by the electro-magnetic radiation in a wire within the instrument, it was necessary to make both the tube and guard-tube of some insulating material, such as glass.

The tube to be used was cleaned, and a roll of brown paper about 1in. long was pasted round one end. This fitted tightly into a mahogany ring, D (Fig. 5). The tube was divided longitudinally by a partition of cardboard (F), which was made to fit tightly into the tube. This partition extended from the bottom to within about an inch of the top, which end was closed by a cork.

The projecting end of the mahogany ring (D) fitted into a corresponding hole in a piece of wood (E), which was itself supported on two blocks (A and B). The tube (represented by the dotted circles in the plan, Fig. 6) came directly over this space between A and B, the partition being parallel to their adjacent faces.

Between A B, and immediately beneath the tube, two glass semi-cylinders were placed, with their convex surfaces facing each other. They are shown in plan in Fig. 6 (M N), and one is shown in perspective in Fig. 7. At 2 centim. from the top of one of these semi-cylinders a small paper scale (Fig. 5), divided in half-millimetres, was attached. When a current of air passes from one side of the tube to the other, it has to pass through the narrow space between these cylinders.

A hole was bored through the top of B, through which a capillary glass tube could be passed. This tube was filled with phosphorus, and the glass broken away for about one millimetre, so as to expose a clean piece of phosphorus whenever the stream of oxide had to be observed. The tube was then passed through the hole (K), so that the exposed piece of phosphorous came just beneath the partition and between the glass cylinders. It is shown in place at H in Fig. 5.

By this means the stream of phosphorous oxide was formed at the narrowest part of the air channel, and so was affected to the maximum extent by any passage of air from one side of the partition to the other. The resulting deflexion of the phosphorous-oxide stream could be read with an accuracy of about one-tenth millimetre. In this form, when the phosphorous index is deflected it is carried to a part where the channel is much wider, owing to the curvature of the glass half-cylinders. On this account the deflexion of the index is not any simple function of the rate at which the air is passing. With a view to do away with this want of proportionality, and also, if possible, to render the instrument more sensitive, the glass half-cylinders were replaced by a pair of narrow flat glass plates, near together, with a wide channel on each side communicating with the tube above. The instrument was, however, found to be less sensitive in this form than when the half-cylinders were used.

The sensitiveness of the instrument could, to a certain extent, be altered by moving M and N (Fig. 6) further apart, so that the phosphorus stream fell in a wider channel.

The divided tube was surrounded by another glass tube (G, Fig. 5), which was about 10 centimetres longer. This formed the guard-tube, and was suspended from one of the axles of a clock (K, Fig. 11), which made one revolution in about eight seconds.

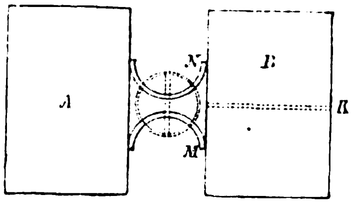



FIG. 6.

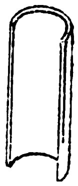


FIG. 7.

By means of three levelling-screws the guard-tube was made to hang free of the inside tube, so that it did not touch it at any part of its revolution. Thus no heat due to friction was developed near the divided tube.

The phosphorus could not be placed at the top of the tube, as the falling column of oxide was found to go on one side of the partition, and its weight was sufficient to keep up a down-current of air on this side and an up-current on the other side, and so make the instrument unstable.

Inside the divided tube, and on one side of the partition, two fine platinum wires were stretched, reaching from the top to the bottom. They were connected together at the top, and at the bottom were brought out and connected to two binding-screws fixed on the ring D (Fig. 5). By means of this wire, whose resistance was measured, a known amount of heat could be developed in the tube by passing a current of known intensity. The current was, in all the experiments, supplied by a single Daniell cell, which contained in its circuit, beside the wire of the instrument, a resistance-box and a key.

The clock was kept working for about half an hour before the commencement of an experiment, in order to equalise the temperature within the tube; and then a fresh piece of phosphorous was introduced. When the phosphorous index was quite steady, and approximately at the centre of the scale, the reading was taken (zero-reading), then resistance was unplugged in the box, and the current passed till the index had again come to rest. The current was then stopped and another zero-reading taken.

In testing the different tubes the largest resistance which would give a readable deflexion was in each case ascertained. The resistance of the cell and the connecting-wires could be neglected in comparison with the external resistance.

* From the *Phil. Mag.*, communicated by the Physical Society; read June 20, 1890.

† *Proc.* Manchester Phil. Soc., Vol. III., p. 73.

Digitized by Google

In the different tubes the total heat developed was not the same when the same current was passed, as the wires were of different lengths. This, however, was not taken into account in comparing the tubes together, as for the measurement of the electro-magnetic radiation it was necessary to get the greatest possible sensitiveness per centim. of the wire.

It is hardly necessary to give particulars of the different tubes experimented upon. It is sufficient to say that, while the length of the tube was of little consequence, it was found that a wide tube was much more sensitive than a narrow one. The results obtained in a particular case are given.

Tube No. 3:—Length 82, diameter 5 centimetres. Resistance of wire 29 ohms; outside resistance 500 ohms. Deflexion 1 millimetre.

To calculate the amount of heat corresponding to this deflexion, we have, taking the E.M.F. of a Daniell cell as 1 volt,

$$\text{Heat developed per sec.} = \frac{RC^2}{4\cdot 2}$$

$$= \frac{29}{529^2} \times \frac{1}{4\cdot 2} = \cdot 000{,}024 \text{ calorie}$$

over the whole length of the tube, or ·000,000,3 calorie per centimetre of the tube.

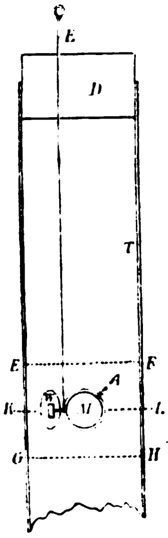



Fig. 8.

While this very small degree of heating was within the range of experimental certainty so long as the clockwork was going, it was impossible to keep any index visible at all when the clock had stopped, even though several concentric screens were placed round the tube.

The apparatus in this form was subject to the great fault that the phosphorous refused to form the oxide at a temperature below 15°C., which prevented the instrument being used on many days.

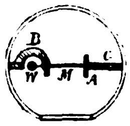



Fig. 9.

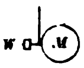


Fig. 10.

With the view of getting over this difficulty with the phosphorous index, and if possible of obtaining greater sensitiveness, a form of index was adopted which was a modification of Dr. Joule's arrangement.

The tube was closed at each end, the partition reaching right up to the cork at the top and leaving a space of about 15 centimetres at the bottom. Twelve centimetres below the top of the partition a hole was punched in the card. Into this hole a short cylinder of paper was glued. This is shown at A in Figs. 8 and 9. A plane mirror, M, fitted into this tube, allowing about one millimetre clearance all round. It was fastened to a cross bar, at the other end of which a counterpoise (W) was fixed.

The mirror and counterpoise were suspended by a fine quartz fibre from a pin (E, Fig. 8), which passed through the cork used to close the tube. When the mirror is at rest it almost completely fills up the hole in the partition, and forms a very delicate means of detecting any differences of pressure in the air at the two sides of the partition.

A small recess (B, Fig. 9) was made in the partition for the counterpoise, and covered in so that it was not exposed to the current of air. The arrangement is shown in elevation in Fig. 8, and in section through K L in Fig. 9. Fig. 10 shows the mirror and counterpoise separately. A hole was ground in the tube immediately in front of the mirror, into which a lens of a metre focal length was cemented.

In this form of the instrument the guard-tube, if continuous, would have prevented the formation of a clear image. It was therefore necessary to divide it into two portions. Rings of mahogany (N, Fig. 11) were cemented to the top of the lower portion and to the top and bottom of the upper. The two rings $N_1$ $N_2$ were connected together by three bolts, of such a length as to leave a space of about two centimetres between the rings. This break in the guard-tube came just on a level with the mirror, and thus allowed the beam of light to pass freely. The passage of the bolts before the mirror produced no inconvenient effect on the image

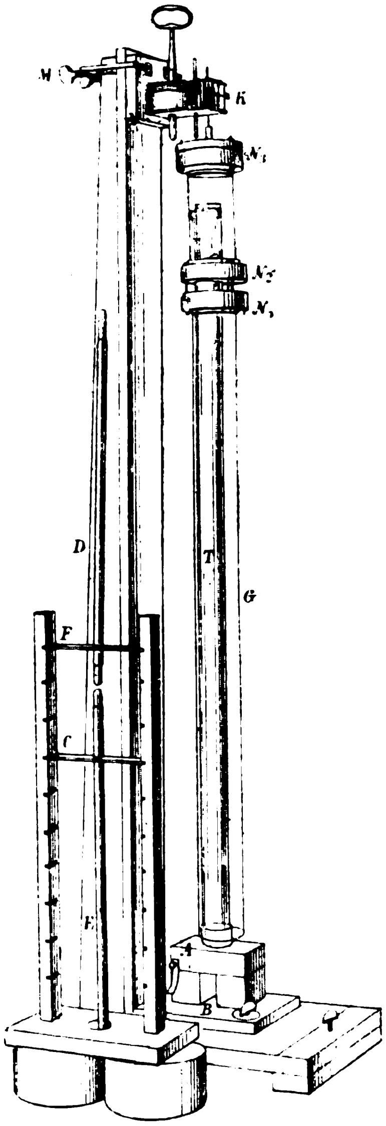



Fig. 11.

formed on the scale. The ends of the wire were brought out at the bottom of the tube, leaving about half an inch free. When using a continuous current, two brass clips (A, Fig. 11) were placed on these ends so as to connect them to a pair of binding-screws. When using the oscillator these clips were turned down (as in the figure), so that the wire should not be connected with any body having capacity.

The following are the dimensions of this tube (No. 4):—

Length 126 centimetres, diameter 4·7 centimetres.
Length of wire 2 × 103 centimetres.
Resistance of wire 38 ohms.
Diameter of guard-tube 7 centimetres.
Diameter of mirror 1·2 centimetre.
Length of fibre 9 centimetres.

As shaking interfered with the working of the instrument, the experiments were performed in a vault, which, however, was by no means steady.

Digitized by Google

The following are the results obtained when testing the sensibility of the instrument (scale at 100 centimetres from mirror):—

| Added Resistance. | Total Resistance. | Deflection. |
|---|---|---|
| ohms. | ohms. | centimetres. |
| 500 | 538 | 3·3 |
| 762 | 800 | 1·6 |

In the case of 800 ohms total resistance we have

$$\text{Heat developed in wire per sec.} = \frac{1}{\overline{800}^2} \times \frac{38}{4\cdot 2}$$

$$= \cdot 000{,}014 \text{ calorie.}$$

This is equivalent to one calorie developed in 19hrs. 42min. Or we may say that one calorie per day developed by the whole wire could certainly be detected; that is, one calorie in 103 days per centimetre of tube.

The oscillator used to set up the electro-magnetic radiation consisted of two hollow brass cylinders (D E, Fig. 11), fixed to ebonite cross pieces (F, C), which could be placed at different heights in a wooden stand. Short brass cylinders, with well-rounded ends, fitted into the ends of D and E, and allowed the length and sparking distance to be altered. These cylinders were connected by very fine wire with the terminals of the large Ruhmkorff's coil belonging to the Physical Laboratory. The length of the oscillator was the same as that of either of the wires in the tube, and it was placed so as to be in the plane of the partition of the tube, at a distance of about 30 centimetres (Fig. 11). The best length of spark was about half a centimetre.

At first, on separating the knobs of the oscillators, so that no spark passed, the instrument showed a large deflection in the direction of cold. This was due to electrostatic attraction between the oscillator and the mirror. To prevent this action a piece of tin-foil (E F G H, Fig. 8) was pasted round the tube at the level of the mirror, a hole being cut in it the size of the lens, which effectually put a stop to this action.

The instrument now indicated a considerable amount of heat developed in the wire whenever the coil was worked.

The effect of altering the capacity of the oscillator by adding pieces of tin-foil to the ends was tried, but with no beneficial result.

A wet duster was hung between the oscillator and the instrument for the purpose of seeing whether the radiation would pass through. The deflection produced was only slightly less than when no duster was interposed.

In order to measure the heat developed by the induced currents in the wire, the deflection produced when the coil was worked was noted; then a steady current was sent through the wire, and the resistance in the circuit altered till an equal deflection was obtained. The readings obtained with the oscillator were somewhat varied, owing to small changes in the character of the sparks. Another difficulty was caused by the coil often refusing to work continuously for the time necessary to get a reading (about 1½ minute), as the contact-breaker became burnt by the sparks.

The following are the deflections obtained in centimetres:—

45; 44; 37; 36; 35·6; 36·9; 44·8; 45·5; 40·2; 40·2; 39.

*Mean* 40·4 *centim.*

One Daniell cell working through a total external resistance of 115 ohms gave the following deflections:—

41·0; 40·0; 39·3; 40·0; 41·0.

*Mean* 40·3 *centim.*

We may therefore say that the heating effect due to the oscillations (oscillator at 30 centim.) is equal to that produced by one Daniell cell when the external resistance is 115 ohms, and the working resistance 38 ohms.

Therefore the heat produced per sec.

$$= \frac{38}{\overline{115}|^2} \times \frac{1}{4\cdot 2} \text{ calories,}$$

$$= \cdot 000{,}685 \text{ calorie;}$$

or it would take 24 minutes 20 sec. to produce one calorie.

The steady E.M.F. between the terminals of the wire which produces the same effect as the oscillations is ·33 volt. Mr. Gregory gives ·5 volt as the equivalent E.M.F. in his experiments. Though the conditions were not sufficiently similar to make the numerical results strictly comparable, nevertheless the fact that the figures obtained are of the same order goes to show that the expansion observed by Mr. Gregory was a true expansion due to heat, and that his results were real.

In calculating from the heat developed the mean square of the current produced in the wire by the electrical oscillations, it is necessary to take into account the fact that these rapidly alternating currents are not uniformly diffused throughout the cross section of the wire, but only pass through a thin stratum at the surface. On this account the resistance which the wire offers to these rapidly alternating currents is greater than that which it offers to steady currents.

Lord Rayleigh* gives a formula for calculating the effective resistance of a wire of round section to an alternating current of given frequency. It is

$$R' = \sqrt{(\tfrac{1}{2}pl\mu R)},$$

where R′ is the effective resistance; R the resistance to steady currents in C.G.S. units; $p2\pi$ times the number of oscillations in one second; $l$ the length of the wire; and $\mu$ the magnetic permeability of the substance of which the wire is composed.

In the following calculation one of the wires only is considered.

The length of the primary oscillator is 109 centimetres, and therefore the wave-length of the radiation given out is 218 centimetres. If $n$ = number of oscillations per sec., then

$$n = \frac{v}{\lambda} = 1\cdot 376 \times 10^8.$$

The length of the wire ($l$) is 103 centimetres, and its resistance 19 ohms = $19 \times 10^9$ C.G.S. units.

In the case of platinum $\mu$ may be taken as unity.

From this it follows that

$$R' = 29 \text{ ohms},$$

and since H (half the heat developed in the two wires) = ·000,342 calorie per second

$$C^2 = \frac{J\,H}{R'}$$

$$= \cdot 000{,}049.$$

Owing to the harmonic distribution of the current along the wire, in order to produce a given amount of heat in the whole wire, the strength of the current at the centre must be $\sqrt{2}$ times as great as that which would be necessary if the current were of uniform strength in all parts of the wire.

∴ the square root of the mean square of the current at the centre = ·01 ampere.

While it is impossible from the heat found to form any conclusion as to how fast heat was being generated during each spark, or what fraction of the whole time the oscillations lasted, yet here, as in the former case, the final result depends on the mean square of the current. We found by the first method that the square root of the mean square was certainly not ·003 ampere, if the theory was correct; while by the heat we find the square root of the mean square to be ·01 ampere. The arrangements in the two cases were not strictly comparable, for in the first the oscillator was only 30 centimetres long, while in the second it was 109 centimetres, and because the distance of the primary from the secondaries was relatively greater in the first than in the second case. We intended to have made a second set of measures in which the suspended cranked oscillator should itself be in the tube of the convection-thermometer together with the fixed cranked oscillator. In this way the force, if any, between them could be observed and measured at the same time that the deflection of the mirror due to the heat was read; then, by making contacts with the ends of the fixed cranked oscillator alone, and passing a current through it so as to produce the same deflection, all the data would be obtained to tell for certain whether the absence of force, or, if force was observed, if the actual force was that which the provisional theory set out at the beginning of this Paper indicated. The discrepancy of 3 : 10 in the present instance cannot be taken as proving that the theory is wrong, and that the forces ought not to be observed, but it does clearly show that they must be excessively minute, and that, if they exist, it is only by great refinement that they can be made evident. No doubt, as Prof. Fitzgerald suggested, the use of concentrating cylindrical mirrors of proper form would greatly increase the sensitiveness of the whole apparatus.

We have been prevented from completing this work because the elementary laboratory was required, and it is impossible to carry on any really delicate research requiring uniform conditions and steadiness in so unsuitable a building as the Science Schools. We have, therefore, published our results in their present imperfect condition, partly because we believe that the methods employed may be useful to others, but chiefly because we hope that some physicist who has the advantage of having a steady underground room may be induced to make the experiments under more perfect conditions, and so carry the matter to a successful issue.

* *Phil. Mag.*, May 1886, p. 388.

Digitized by Google

## PRESENTATION PORTRAIT OF SIR JOHN PENDER.

A luncheon was given by the Eastern and Associated Telegraph Companies at Winchester House, on Tuesday, the 13th inst., on the occasion of the presentation, on behalf of the late Lady Pender, of a portrait of Sir John Pender, K.C.M.G., by Prof. Herkomer, A.R.A., to be placed in the Board Room of the Companies.

The following gentlemen were present:—The Marquis of Tweeddale, Sir John Pender, K.C.M.G., Sir James Anderson, Admiral Sir G. Richards, K.C.B., Admiral Hon. Sir H. Keppel, G.C.B., Lord Sackville A. Cecil, Sir A. L. Cappel, K.C.I.E., Sir H. D. Gooch, Bart., Hon. St. John Brodrick, M.P., Sir Henry Mance, G. G. Nicol, Esq., John Denison Pender, Esq., W. Andrews, Esq., W. Shuter, Esq., T. Fuller, Esq., William Ford, Esq., James Pender, Esq., L. Floersheim, Esq., E. M. Underdown, Esq., Q.C., R. K. Gray, Esq., C. W. Earle, Esq., C. W. Stronge, Esq., K. Anderson, Esq., G. Draper, Esq., F. E. Hesse, Esq., W. Payton, Esq.

Sir JAMES ANDERSON read the following letter, which he had received from Sir John Pender:—

"The Eastern Telegraph Company (Limited),
Winchester House, 50, Old Broad-street,
London, E.C., December 17, 1890.

"MY DEAR SIR JAMES,—You were Chairman of the Committee which gave a banquet in my honour in 1889, and on that occasion, memorable to me, you and my friends gave a portrait of myself to Lady Pender, which she much valued.

"It was her strong desire then to give as a memento in return another portrait of myself, to be placed in the Board Room of the Companies with which, as first Chairman, I have been so long associated.

"I have now the pleasure to carry out her wish, and I beg the Boards' acceptance of the picture by Professor Herkomer, being a portrait of myself, which I believe has been generally acknowledged to be a good likeness.

"I hope it may continue to hang in the Board Room, and that those who may hereafter fill the position which I have so long occupied, and with so much pleasure still occupy, will recognise what the Boards have done by perfectly harmonious working in carrying to a successful issue a work which probably has played the most prominent part in bringing into closer communion the nations of the world, and in causing a more rapid development and progress of their political, social, and commercial life.—Believe me, yours faithfully, "(Signed) JOHN PENDER."

Sir JAMES ANDERSON then said: I do not think I ought to add many words, as Lord Tweeddale will accept the picture on behalf of the Companies; yet I cannot help recognising a certain sentiment about the occasion. All who had the pleasure of knowing the late Lady Pender must remember the interest she universally felt in the way those associated with these Companies had developed this new enterprise. It seems to me that we are erecting a kind of memorial upon the track of this great movement, and that this picture is the first historical portrait of the members of the cable combination. No one can say to what degree of importance this network of submarine cables may expand, and who knows that the younger members in this room may not yet see some great telegraph hall erected in which this may be the pioneer portrait and one of the best hung on its walls. At all events, I would say that whoever of you younger gentlemen may come forward and take up the reins which others will in the course of nature have to lay down, you will have to go straight ahead very much as we have done. Since ocean telegraphy was commenced, there has been no flagging. All this time your Chairman has followed the flag wherever commerce went, and I think if we had not followed the flag the flag must have followed us. When your time comes I can only wish you every success in your endeavour to do this, and I will now leave it to Lord Tweeddale to accept the picture in our name.

The MARQUIS OF TWEEDDALE: I have been entrusted with the agreeable duty of accepting on behalf of the Directors who occupy this Board Room the portrait which you see before you. The idea of presenting the portrait of our Chairman to these Companies originated with the late Lady Pender, who, as Sir James Anderson has told you, took from the very first to the very last the liveliest and most intelligent interest in the prospects and prosperity of submarine telegraphy. I deeply deplore her loss, because I know the gratification with which she would have received your thanks for her generous gift. I am happy to think that so many of us have been permitted to meet here to express our acknowledgments for the splendid portrait which hangs on the wall. We have to thank Sir John Pender for the manner in which he has carried out Lady Pender's wish, and to tell him that we appreciate the gift, not only for its intrinsic merit as a work of art of the highest order, but as an excellent and faithful likeness of himself and as recalling the features of the man who has guided our counsels for nearly 22 years with rare courage, energy, and success. In such a company as this it is not necessary for me to dilate upon the importance of the enterprise with which Sir John Pender's name will be long and honourably associated. It is not, however, exaggeration to say that every department of life throughout the world has been thereby profoundly affected, whether it be socially or commercially, or whether we regard it from a national or international point of view, and I venture to think that when the history of the latter part of this century comes to be written no enterprise will occupy so prominent a position as that of the development of submarine telegraphy, and that no other name will be so closely associated with it as that of Sir John Pender; because without for a moment wishing to undervalue the services of others who have worked in the same field, I think you will agree with me that to no other single individual is due in so large a degree the successful development of that enterprise. Therefore, gentlemen, I will now ask you to join in the expression of a warm and hearty hope that he may live long to occupy that position which he fills with such conspicuous ability, with so much advantage to the interests entrusted to him, and with so many benefits, not only to this country, but to the world at large.

Sir JOHN PENDER: My Lord, Sir James Anderson, and gentlemen, speaking, as I do, before men who have played alongside of myself an important part in the great ocean system of telegraphy, you can well understand that I speak under a feeling of considerable diffidence. Looking back upon the period that we have been associated together, there are points which strike me as remarkable, and as fore-shadowing the success of that great enterprise, although, when I remember our earlier public meetings, I feel that they were very much like ordinary meetings of that kind. There were some who were not quite conspicuous for their conduct as gentlemen, who pretty roundly accused us of doing everything but that which was straightforward. I think, gentlemen, we have lived all that down. We have shown to the world the great success of the enterprise. I believe I may say that no undertaking was ever carried out more successfully, more honestly, or with a more earnest desire to benefit the community at large than that of the Companies over which I have the honour to preside. I am, and always have been, anxious that those who are behind us in years and experience may, in the future, carry the standard as high as we have carried it, and if they continue that course they will find their reward will be very much the same as ours—not only a reward conferred by crowned heads, but a reward bestowed by the approbation of the keenest intellects of the day. There is no Prime Minister either in this country or in any part of Europe who has not acknowledged the great importance of what we have done. It seems like praising ourselves; but there is still, as Sir James Anderson has said, work to be done, and that work will have to be accomplished by harmonious and united action. During the twenty years that I have presided over these Boards I do not remember a single division in the voting. We always managed to make matters go in the right course before we attempted to vote on them. We have thrashed out everything to the satisfaction of every Director, and the result has been united action in carrying matters through. Now, gentlemen, I think I have said enough, but I cannot conclude without saying that I am very proud of the Companies over which I preside, very proud of the great amount of support which I have received from gentlemen sitting at this table, as well as from those who preside over other cable companies, and who are as devoted to the service of those companies as we are to those with which we are connected. I have had a vast amount of support all round from everyone connected with the submarine system, both from those engaged in working the cables and from those engaged in manufacturing them, with which I had something to do in my earlier days. I now come to a point which is to me most touching. My wife was greatly interested in and proud of the growth of this system and of her husband's connection with it. She expressed a wish that when I had passed away I might be still represented in the Board Room in which I had so long presided. She said she should very much like to present my portrait to the Companies. That brings me to-day to thank you all for so gracefully accepting it as from her. Once more I thank you, gentlemen.

Sir JAMES ANDERSON said that letters had been received from Lord Monck, Sir Thomas Fairbairn, Sir George Elliott, and Sir Leopold Heath regretting their inability to be present on account of the state of their health.

After some remarks from Lord SACKVILLE CECIL in acknowledgment of the kind remarks made in reference to the younger Directors, Sir JOHN PENDER proposed a vote of thanks to the Chairman and the proceedings terminated.

## THE ELECTRIC LIGHTING OF DUBLIN.

A meeting of the Dublin Corporation was announced for Monday last to consider the tenders of various English and Irish firms for the electric lighting of the city, but owing to the death of a member of the Corporation the meeting was adjourned without any business being done.

The tenders, 18 in number, were opened on November 1st last. The specifications were on two schemes—one on the assumption that a central station was put down with sufficient plant to provide current for 80 arc lamps of about 1,000 candle-power each; and 3,000 incandescent lamps of 16 candle-power each; the other on the assumption that power was provided for the same number of arc lamps for the public lighting, but with sufficient power and enlarged mains for the supply of current to 5,000 lamps of 16 candle-power each for the private lighting.

These tenders were referred by the Special Committee having the electric lighting in charge, to the Borough Surveyor (Mr. Spencer Harty), and to Mr. Manville, electrical engineer, for analysis and report. In the course of their report these gentlemen state that "the complete tender of the Electrical Engineering Company of Ireland, inclusive of the dearest engines of the three types named by them, and amounting to £28,907, without buildings, is, perhaps, the most complete total tender, at a moderate price; but in the event of your deciding to accept this tender for all sections, we recommend that they be asked to reconsider their system of main laying."

The Special Committee recommend for acceptance the tender of the Electrical Engineering Company of Ireland, based on the

Digitized by Google

original specification, inclusive of buildings, but with the alterations as to main laying recommended by the engineers, viz., that cast-iron pipes and vulcanised rubber cables shall be used, and also lamps of the Brockie-Pell pattern for the lighting of the streets.

With these alterations the Company are willing to execute the works for £30,714. The Company also offer to undertake to run the entire station and the 80 arc lamps for a year for £4,000, plus 7½ per cent. on the gross revenue derived from the private lighting, and the Committee state that consideration of the estimates indicated that the acceptance of this offer would be of advantage to the Corporation.

| | | |
|---|---|---|
| Hornsby and Sons ........ .............. | £29.904 | — |
| Sharp and Kent .......................... | — | Partial only. |
| Johnson and Phillips ............... ..... | 30.639 | — |
| Edmundson and Co........................ | 39.117 | — |
| Laing, Wharton, and Down ........... | 27.090 | — |
| Electrical Engineering Co. of Ireland.. | 29.338 | Alternative, £29.825. |
| Irish House-to-House Electrical Co. ... | 37.000 | — |
| Woodhouse and Rawson ................. | 38.103 | — |
| Crompton and Co.......................... | 31.354 | Alternative, £28,971. |
| Electric Construction Co.................. | -- | Partial only. |
| Ryan and Purcell ......................... | 23,448 | With extras would be £24.472, exclusive of buildings. |
| J. E. H. Gordon and Co.................. | 38.500 | — |
| Babcock and Wilcox....................... | 5.003 | Boilers only. |
| W. T. Goolden and Co.................... | — | Partial only. |
| Siemens Bros. and Co..................... | -- | Partial only. |
| Westinghouse Electric Co. .............. | 52,000 | £55.350, reducible to £51.000. |
| Latimer, Clarke, Muirhead, and Co. ... | 21.283 | Exclusive of buildings. |
| Drake and Gorham ........................ | — | Partial only. |

## AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *January* 2, 1891.

**The Position of the Westinghouse Company.**—The Westinghouse Electric Company seems to have been in great need of ready cash recently, inasmuch as extraordinary efforts were made by Mr. Westinghouse to negotiate a loan of half a million dollars to tide over present embarrassments. These efforts were successful, although the makers of the loan required Mr. Westinghouse's personal security in the way of mortgages and collateral. There is no reason for believing that the Company is in any way insolvent, or in danger of becoming so. The simple truth being that it has extended its business so much that its capital has been tied up, and unavailable for immediate needs. The introduction of the electric railway system has been a source of very large expense to the Westinghouse Company, and other new departures have called for a very large amount of capital. The railway department will doubtless prove a good and paying investment, but it caused a severe strain on the resources of the Company.

**The Municipal Rapid Transit Question in New York.**—The rapid transit question in New York is again being vigorously agitated by the daily press. The recent successful inauguration of the City and South London Railway has been a decided stimulus to American engineers in attacking the same problem here; but the difficulties to be met are so great that a happy solution of the present difficulties may be very far off. Unfortunately, the cable-railway scheme, which will shortly be put into execution on Broadway, will, if carried out as contemplated, interfere with any subway work on that street, unless it is carried far below the level which might otherwise be necessary. The most practicable plan as yet suggested for rapid transit is one that contemplates the construction of a four-track substructure, reaching from near the battery to the extreme northern end of Manhattan Island, but passing considerably to the east of Broadway, and through a portion of the city where the injury to property and consequently expense of construction would be very much less than if the same enterprise were to be conducted on more important streets. The particular part of the city selected for the execution of such a plan is, however, of very little importance, for provided the subway should extend the whole length of the island it would do its work effectively enough, as the width at no point is so great as to make branch lines necessary. As the case stands at present, something of this description must be done, and done in a very few years if the city is to continue its present rate of growth. Standing on the Palisades opposite the north end of Manhattan Island, hardly a trace of the existence of a great city can be distinguished within easy view. Far to the southward lies the smoke and haze that surrounds the metropolis, but the upper end of the island is to all appearance deserted, and simply for the reason that it is quite inaccessible for residences. As a result a large part of the increase in population at present overflows into Brooklyn and the towns and cities that lie conveniently near in New Jersey.

**The American Telegraph System in a Fog.**—An unwonted difficulty with telegraph lines through a large part of the country has marked the bad weather of the last week. The severe and widespread snowstorm of Christmas week interfered considerably with telegraphic service, but its effect was as nothing compared with the demoralisation produced by a fog over a large portion of the Middle and Western States a few days later. For a single night telegraphic communication was very seriously interrupted; hardly a line was in working order, and the few over which signals could be obtained at all were working badly. The Associated Press lines from this city as far west as St. Paul, Minn., were, for the time being, crippled. The length of our Trunk lines is so great that when wet weather is general throughout their extent leakage makes a successful working almost impossible. The unpleasant phenomena observed may be more frequent with you in England, but they are almost unique here.

**A New Submarine Boat.**—A submarine boat is reported as being in process of construction in Detroit, Mich. It is a comparatively small affair, not by any means so large as the La Gymnote, of Continental fame, but like it, is to be operated by storage batteries. A peculiarity, however, is that its normal position is just at the surface, and it is held submerged only by the action of a screw, so that in case of any accident, instead of remaining at the bottom, the boat will promptly rise to the surface.

## CORRESPONDENCE.

### THE BYE-LAWS OF URBAN AUTHORITIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The power granted to Urban Authorities by the Public Health Act, 1890, of making bye-laws with respect to wires placed above ground, which was referred to in your Editorial Notes last week, does not threaten any serious obstruction to electric lighting interests. Any such bye-laws, if made, can have but a very limited operation, since the wires of "undertakers," under the Electric Lighting Acts, are expressly exempted from their operation.

The progress of legislative interference with overhead wires has been somewhat spasmodic, so that it is not surprising if some misapprehension on the subject exists. The Electric Lighting Act of 1882 forbade "undertakers" to lay their wires above ground without the consent of the Local Authority, but left untouched those erected by persons who had not obtained Parliamentary powers to supply electricity. The Electric Lighting Act of 1888 for the first time brought the wires of these outsiders under the control of the Board of Trade. The regulations framed by the Board under that Act apply to the wires of such persons only, and although these have since been almost entirely incorporated in the more extensive regulations issued last year to "undertakers," yet it must not be assumed that the former have become merged in the latter for all purposes, since the two sets of regulations are issued under different Acts and apply to different classes of persons, and must, therefore, maintain independent existences.

The Act of 1888 did not extend the power of vetoing overhead wires, nor the power to make bye-laws for securing public safety, both of which were given to Local Authorities by the Act of 1882 in respect of Parliamentary undertakings, so as to make either of these powers applicable to the wires of outsiders. Thus, while the principle had been admitted of allow-

Digitized by Google

ing Local Authorities a control in such matters, there was an apparent anomaly in applying it only to those cases in which it is probably least likely to be required, namely, those of "undertakers" who are already very strictly tied up by Parliament.

This inconsistency has been now removed by the clauses on the subject inserted in the Public Health Act of last year, to the extent of allowing bye-laws to be made in respect of un-Parliamentary wires, though the Act does not give power to absolutely prohibit these being carried overhead. The reason for this omission, no doubt, is that these clauses are, as you surmise, principally directed against telephone wires, and we are not yet ready for a general decree that these must be buried.

Under the Acts both of 1882 and 1890 confirmation by the Board of Trade is necessary to give validity to any bye-laws which may be framed. No such confirmation has hitherto been granted in any case; and so far as I am aware the only application ever made for such confirmation was that of the Bradford Corporation, which did not receive the desired sanction.—Yours truly, A. C. CURTIS-HAYWARD.

27, Chancery-lane.

## THE CITY AND SOUTH LONDON RAILWAY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the last issue of your journal you state:—"During the first fourteen days ended on Saturday last the receipts amounted to £1,947, showing that 233,640 passengers had been carried during that period, or on an average 16,688 per day; that is to say, nearly 40 per cent. more than was estimated by the pessimistic Mr. A. Willbond." This is all very well in its way, and might have passed muster amongst your readers were it not for the extraordinary fact—which seems to have escaped your attention in making up—that you have yourself discounted your own figures by stating that it must "be borne in mind that novelty is only a temporary attraction, and that comfort and regularity will alone secure permanent patronage."

The figures given by me in the *Electrical Review* were based upon permanent traffic, and I have found when travelling on the railway in question that the actual number of passengers carried was on several occasions only a *very small* percentage higher than given in my estimate. "It is, moreover, to be borne in mind that novelty," which "is only a temporary attraction," was at that time still temporarily attracting.

I hope that your readers who have read the two leaderettes in question will find my letter at least a "temporary attraction."

When about to post this letter, I find that the official returns for last week's traffic give the total receipts as £748. Thus, notwithstanding the "temporary attraction," the average number of passengers carried per day was only 12,823, or about 7½ per cent. more than the number given in my estimate.—Yours truly, A. WILLBOND.

London, January 13, 1891.

## THE NEW ELECTRIC AND MAGNETIC THEORIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As Mr. O. Heaviside proposes to give us an explanation of electro-magnetic theory in language that may be understanded of the people, may I make a request in the name of that, I believe, large class called by Prof. Silvanus Thompson "half educated electricians," called so, not because they have not acquired a complete knowledge of the subject (in that sense we are all very fractionally educated), but because they have not surrendered the teachings of experiment, the belief that Ohm's law represents actual facts of nature, and the faith that electric currents are conveyed by the "so-called conductor."

What I would ask for is the evidence, proof that electric and magnetic propagation are effected by "ether" and not by common matter. I have never yet seen any better answer to the sceptic on this matter than that which Prof. Poynting said some time ago was the only answer he could give, that the said sceptic was a very disagreeable person. Mr. Heaviside now begins by making the assertion (p. 258) that the etherial theory is proved; but, as far as I can find, it is simply asserted, or taken as proved. As far as I can see the Hertz experiments prove nothing. They only have given experimental proof of what is self-evident, viz., that periodic impulses of any sort which rise and fall in intensity must develop a wave motion; that they show such a motion in the ether is only an assertion, which people who do not believe it do not trouble themselves to dispute.

The argument is that these motions are of an order of which ordinary matter is incapable. I propose to show that if there is anything which we can be said to know, when it is beyond our direct observation and examination, it is that *ordinary matter does constantly maintain these very motions*, viz., vibrations analogous to those of light.

The origin and basis of the ether theories is, after all, the fact of transmission of light across space, where ordinary matter cannot exist. The hypothesis was therefore framed that space contained a something, which, while not possessing any of the properties of ordinary matter, and, as to these, being indistinguishable from pure "nothing," yet transmits light (we may extend this to energy) in the form of undulations communicable to matter. But how do these undulations in ether originate? Undulations in air transmit sound; but these undulations are produced by just the same vibrations first set up in solid matter, wires, &c. It is the same with light: the ether undulations are produced by motions of exactly the same order in the ordinary matter of the luminous bodies. The spectroscope tells us that the ultimate atoms of matter are all executing motions which are imparted to the surrounding agent of transmission. The real truth which light teaches us is, not the undulation of the ether, of which we know nothing at all, but the specific infinitesimal motions of matter, about which we know a great deal.

Who, then, has the right to assert that magnetic and electric wave propagation must be transmitted by ether because the ordinary matter is not capable of such motions? We know that it is capable, and we have no evidence of any sort that the ether is capable of transmitting either magnetism or electricity. We know that light crosses space, and it is very certain that neither electricity nor magnetism do.

As to this point, which is of much importance, because it is often supposed that these forces do traverse space, and produce magnetisations in the earth simultaneously with visible solar disturbances, I must refer to the principles first set forth, p. 444, of the 2nd edition of my "Electricity: its Theory, Sources, and Applications." I there pointed out that electric charges could not exist on the cosmical bodies, or lines of electric force in space, because the consequent attractions and repulsions would produce variations in the apparent action of gravitation which do not exist. The same applies to magnetic force; if it existed in space the planetary axes would most certainly sway about. Besides, it is most probable that no magnetism exists in the sun on account of its high temperature; and even if it did, it would be in the form of closed lines, forming a shell round the sun, and only extending a little way into space.

In the face of these essential facts, and the absolute difference between light, as a straight line, radiant form of energy, and electricity and magnetism as purely dual and forming closed curves, it needs a very highly-developed education to see that they are identical in nature and propagation.

The fact is, that it is only since alternating currents became of practical importance, and the effects at make and break had to be explained and formulated, that these new imaginations became serious; the professors found it easier to invent theoretical explanations than to study natural facts, so they converted our old enemy—retardation—into conduction by the ether. In another letter I will try to show that there is a better way. JOHN T. SPRAGUE.

[Mr. Sprague need hardly trouble so high an authority as Mr. Heaviside with such questions as the above. He will find ample reasons for the ether theory in well-known books. We would refer him to Dr. Oliver Lodge's "Modern Views," p 339, where he will find a clear account of the differences between ether and ordinary matter. It is obvious that matter can vibrate fast enough to produce light, but it is not rigid enough to transmit vibrations at the well-known speed of light. For

Digitized by Google

this purpose it must be about a thousand million times more rigid than steel. Maxwell predicted, and Hertz has proved, that magnetic and electric wave propagations are transmitted at the same speed as light; no known form of matter would suffice. We can only know of things by their appearances, and certain appearances are called the properties of a certain something, and that something we call ether. Mr. Sprague has done considerable service in the production of his well-known book, which, while we cannot endorse it as altogether orthodox, contains much useful information; but he would do well to study the recent advances in electrical science before he begins to treat in so categorical a manner of subjects with which he does not appear to be very familiar.—Ed. *E.*]

## LEGAL INTELLIGENCE.

### The British Tanning Company v. Groth.

This action came on for hearing on Wednesday in the Chancery Division of the High Court of Justice, before Mr. Justice Romer. The Attorney-General (Sir R. Webster, Q.C.), with whom was Mr. Farwell, appeared for the plaintiff company, and Mr. Moulton, Q.C., and Mr. Oswald appeared for the defendant; Mr. Ashton Cross watched the case for parties interested.

The ATTORNEY-GENERAL, in opening the case, said the action was brought by the British Tanning Company (Limited), who were the owners of letters patent granted to French people of the name of Eugène Worms and Jean Balé, the date of the patent being the 5th July, 1887. A point that would arise he ought to mention, viz., that there was a prior publication—which he should not deny would be sufficient to invalidate the patent under ordinary circumstances—of their invention made in England by sending over to the Patent Office an abstract of an American specification a few weeks before their own application; that would be fatal but for the fact that the patent was applied for by a French patentee, and the 103rd Section of the Patent Act provided that a patent should not be invalidated if it were made within seven months of the date of the foreign patent. The patent, as he had said, was dated July 5, 1887, and was for an improved process of and an improved apparatus for the tanning of hides. It had been known for many years that the oscillations or shaking about of hides in the tanning greatly accelerated the process of tanning; that by shaking or rolling about the liquor got more rapidly and thoroughly in contact with the various parts of the hides and permeated the pores of the skins more quickly, therefore tanning proceeded quicker when there was motion, oscillation, or shaking about of the liquor and hides. This had been known for a great many years, and it was also known that a current of electricity had a useful effect in the operation of tanning, though he did not know that anyone could say why that was so; but prior to the plaintiffs' patent there had been no effective method discovered of applying electricity to the operation of tanning. There had been numerous attempts, but they had all failed. The action was peculiar in this respect, that the defendant did not set up or allege any anticipation by prior publication, except the prior publication of the plaintiffs' own invention. This was important when considering that the invention was one of very practical utility and undoubted novelty. Put shortly, the invention was this, that, for the first time, the two necessary elements in the process of tanning, viz., motion of the hides in the tanning liquor and electricity, were brought into combination. As he had said, it was well know that motion, or shaking about of the hides, was good, it was imagined that electricity was good, but there had never been any practical means of bringing into play the force of electricity in the operation of tanning; the two things had never been combined. A French patent was taken out in the month of December, 1886, and Worms and Balé, who were the French patentees, came over to England and engaged the defendant, Mr. Groth, as their agent to push their invention. The defendant had nothing whatever to do with tanning, and had never been engaged in a tanning business, in fact, he was a gentleman of commercial skill and ability, and for a period of five or six months was engaged in endeavouring to push through or to bring out a company for the working of Worms and Balé's invention. In October, 1887, two gentlemen were sent over to France by the defendant in order to see the invention in operation, and from their inspection it was seen that the invention was going to be a successful one. From a practical point of view the result of the invention was most remarkable. It would be proved by expert witnesses that whereas tanning under the best process prior to the invention used to take from six to eight months, under Worms and Balé's patented process it could be done in something like from 48 to 72 hours. This remarkable shortening of time was the result of the combination of motion and electricity. That being the case, it was evident the invention was one that was likely to attract attention, and one which those in the business would be glad to avail themselves either as licencees or by means of an infringement. In the invention the hides were put into a revolving cylinder or barrel, being hung upon hooks or pegs. The tanning liquor was then put in, and fresh tanning liquor could be put in through the axle of the revolving barrel. Around the outside of the barrel were two bands of copper, and from a dynamo a current of electricity was brought to the two terminals on the barrel connected with the copper strips. The current passed from one copper strip to the other, and into the barrel, where there were other copper strips, and in this way the current was passed through the fluid, which was revolving all the time. The consequence was that the hides were constantly shaken about, and the electric current passed through the liquor from one electrical to the other. He would ask his lordship to look at the specification of Worms and Balé's patent, as an anticipation of it had been set up by the defendant, the anticipation being an abstract of plaintiffs' own invention. The learned counsel then read the specification of Worms and Balé, and stated that under it they claimed two things, the process of tanning rapidly by subjecting the hides to oscillation by a drumming motion, and the passing of an electric current through them at the same time. With reference to the invalidity, he thought that matter could easily be disposed of. The particulars of objection which were filed on January 6th stated that an abstract of the patent had been published in this country prior to the date of the patent. With regard to the publication, he did not think his learned friend could prove anything as to the publication of a complete specification; and as to the abstract, it should be borne in mind that that was an abstract of the plaintiffs' own patent and had been sent over by someone in the United States. It was a most useful and completely successful invention, and it was impossible for the defendant Groth to point to any anticipation by prior publication, or anything else that would invalidate it, except this publication, which was an abstract of his own invention. Mr. Groth, the defendant, was an agent of Messrs. Worms and Balé, but difficulties arising between them the agency was revoked, and thereupon Mr. Groth set to work to avail himself of the knowledge he had obtained from the plaintiffs' invention to infringe the patent or, as Lord Justice James said of infringers, looked round to see how he could get the real merit of the invention without imitating it. The defendant's apparatus had been seen at work at the Grange Works, Bermondsey, by witnesses that he (the Attorney-General) should call, and they would state that there was practically no difference between the working of the two. Upon the whole case he should ask the Court to come to the conclusion that an infringement of a most useful apparatus had been made by the defendant. He admitted that in April, 1887, prior to the date of plaintiffs' patent, there was a publication of the invention by an abstract sent over from the United States; but he submitted that as the plaintiffs were foreigners they came within Section 103 of the Patent Act of 1883. There was not the slightest doubt that the patent was vested in his clients, and without taking up further time he would call his witnesses.

Mr. JUSTICE ROMER: Is that the only point?

Mr. MOULTON: The two points really are the question of the prior publication and the infringement, and my learned friend the Attorney-General has admitted that the question of prior publication turns upon Section 103.

The ATTORNEY-GENERAL then put in a copy of the French patent dated 14th December, 1886, and taken out by Eugène Worms and Jean Balé.

Prof. WILLIAM CROOKS, scientific chemist, was then called, and said that he had considered the plaintiffs' specification from a scientific point of view, and found that it was really an important invention, as under its operation oxhides could be tanned in a space of 80 hours, as against from 5, 6, and even to 14 months as was formerly the case. The application of the current of electricity while the hides were being moved about in the liquid gave a fresh surface of liquor to the hide, and thus prevented their remaining in a liquor (as in pits) which practically got used up. The construction of the drum was well known, and he did not see that anything was gained by the rotary motion of the drum.

In cross-examination by Mr. MOULTON witness said he had not seen the alleged infringement prior to the action, and he had never been connected with tanning, though the process of tanning had been brought to his attention during his scientific pursuits. He believed that one invention as applied to the process of tanning was a rotatory drum, and that it was well known. He was not a practical tanner, and therefore could not say that it was claimed for it that the rotatory motion had a salutary effect. When electricity was not applied to the operation of tanning it was not important to move the hides more than once a week, or once a month; but when electricity was applied it was necessary to keep them constantly in motion. Passing electricity through a stationary vat would have the same effect as in the plaintiffs' invention. There was nothing in the defendant's specification to show an intention to claim the force of electricity with any other method than that of a horizontal drum. In the French specification it was admitted that the application of electricity to the process of tanning was useful, and generally so acknowledged, and that the use of rotatory drums was economically advantageous. In the plantiffs' process the hides in the drum were rolled over and over by the means of pegs sticking radially inwards, and thus the tanning liquor was generally diffused amongst them. In the defendant's process the hides were stretched on pegs or bars, and kept in that position as they revolved in the liquor. He did not see the difference between the defendant's apparatus and a vertical drum with some of the staves left out put in a pit. There were plenty of other processes which an electrician could devise in which the barrel principle need not be used. He could not mention one on the spur of the moment that would be outside Worms and Balé's invention. The motion might be up and down. He could not say whether that would be within Worms and Balé. In plaintiffs' process the electricity would go through the hides in the same way generally, unless the hides were thrown upside down by the pegs inside. There was no provision for that in the invention, but it might be that the very higgledy-piggledyness of the process increased its effect.

At this stage the further cross-examination was adjourned until Thursday.

Thursday, January 15th.

On the further hearing of this action being resumed,

Mr. MOULTON, Q.C., said he did not desire to cross-examine Prof. Crookes further, as he understood there would be other witnesses who would speak to the electrical part of the invention.

Digitized by Google

In re-examination by Mr. Farwell, Prof. CROOKES said he considered it made no difference in the process whether the hides were turned in a horizontal or vertical barrel.

Prof. SILVANUS THOMPSON stated that he had considered the specification of Messrs. Worms and Balé from a scientific point of view. He was acquainted with the length of time occupied in tanning before Messrs. Worms and Balé's process. Roughly, the reduction in the time the operation took now and formerly varied from four to 14 months under the old process down to from two to five days in the new process. The new process was a complete departure. Drums for the purpose of rotating skins in the tanning liquor were perfectly well known things, and he had seen vats in the pits in tan yards moved round in the tanning liquor. He had seen the defendant's apparatus at work, and the model produced was substantially correct. There was practically no difference between the motion of the axes in Messrs. Worms and Balé's barrel and that in the infringement. He did not know of any difference between the two as to the effect of the tanning liquor on the hides, and there was also no difference between the electrical operation in the one case and the other. He had experimented upon the electrical part of the invention. There was no difference in the electrical action of the defendants' as compared with the plaintiffs' process. He did not find anything in plaintiffs' specification for producing rapid tanning except electricity and motion.

In cross-examination by Mr. MOULTON, Q.C., witness said that in a general way he knew a good deal about tanning. For many years in tanning it had been known to be important to keep up the circulation of the tanning liquor. This was not only well known, but plant had been designed to facilitate it. A process was used in America known as the rocking process, in which hides were rocked in the liquor upon frames. He had never heard of skins being placed on a frame which was run upon wheels from end to end of a trough of tanning liquor: it was ingenious, but he never heard of it before. As each new plant was introduced, of course special advantages were claimed for it. The one essential effect of using the rotatory drum was to produce suppleness in the hides. According to the French specifications, electricity was well known as aiding the rapidity of tanning. He only knew in a general way that the application of electricity increased the speed of tanning. In 1884 he was shown by Mr. Goulard skins that he had tanned in pits by the aid of electricity, and that the process of tanning, he was told, occupied a period of two months. So far as he knew, it might take a month for the defendant's apparatus to produce sole leather. Assuming it took that period, there was a difference between the defendant's and plaintiffs' apparatus, the advantage being with the plaintiffs. He could not indicate the cause, not being acquainted with all the circumstances and details of the operation. He could not say whether it arose from not having the advantage of the rotating drum or not, but it was certainly not entirely a question of plant. The strongest part of the current was at that point immediately under the axle. He had been to see the defendant's apparatus at work at the Grange Works, Bermondsey. The apparatus was rotating, but there were no hides in the vats, and no electricity was being used. He saw, however, how the electricity was applied. He saw two apparatus—one being a round drum and the other a square tank, and in the latter the process was to move the hides to and fro on a frame, and to apply electricity to the tank. There was nothing special about the way in which electricity was sent through the liquor. The similarity between the defendant's and plaintiffs' process was that the motion was rotatory in each case.

In re-examination by Mr. FARWELL, witness said he never heard of an apparatus like the defendant's square model being used, and knew of no results produced by it. The strength and quantity of tanning liquor had a great deal to do in producing suppleness in hides.

Questioned by his LORDSHIP, witness said that he could not say whether the defendant's model would come within the term rotary drum, but for the purpose of producing motion, he should certainly call it a rotating drum. As to the square model there was no rotating motion whatever of a relative kind.

Prof. GEO. FORBES: He agreed thoroughly with all that gentleman's statements on the electrical and mechanical parts of the question, but he had not the same experience of tanning operations.

Cross-examined by Mr. MOULTON, witness said that his remark applied to the cross-examination as well as the examination-in-chief. The mechanical and electrical effect in tanning of the old rotating drum and the effect of rotation in a cage like the one produced was identical. He heard Prof. Thompson say that the rotating drum produced a suppling effect, but there was not much, if anything, like that in the rotation in the vat. That being an important matter, the effect produced by the two methods was not identical.

Mr. JAMES SWINBURNE likewise agreed with the evidence of Prof. Thompson. He understood that when it was wanted to make the skins supple on a rotating drum, a large number of skins was used, and a comparatively small quantity of liquor, so that the skins were turned about a good deal. For the tanning of heavy skins, few skins were used in comparison with the liquor, so that the mechanical action of the skins was less. He did not think the strength of the liquor was as important as the relative quantity of skins and liquor; the more punching there was, the more suppleness was produced. Electricity helped the liquor to penetrate the skins, and when the liquor penetrated a fresh supply of it was taken in.

Re-examined by Mr. FARWELL: The simultaneity of the mechanical motion and electricity was the whole gist of the invention; without this the efficacy of the process would be less, because the liquid in the immediate neighbourhood of the skins would be used up. This simultaneity was found in the defendant's process as well as in the plaintiffs' process. He considered this to be a mechanical equivalent of the plaintiffs' motion, but an inferior one.

In cross-examination by Mr. MOULTON, Q.C., witness said he was not sure how far rotation was important, and he did not think their knowledge was sufficient to enable electricians to say how far it was important to reverse the current of electricity. In order that hides should not remain in the tanks stationary for too long a period it was formerly the custom to have them taken out and put back again. This was done for the express purpose of freshening the liquid in contact with the hides. It was well known that the application of electricity increased the rapidity of absorption. The freshening of the liquid was more important the more rapidly there was absorption, and that was where the importance of the invention came in. He had never been to a tan-yard before he was employed in this case. A rotating drum did more than freshen up the liquid, it acted upon the hides in producing suppleness. The drum being enclosed would produce heat, but he could not say what effect that would have on the tanning, though most chemical actions went on better at a slightly higher temperature. The defendant's process did not bind the skins together and churn them up as in the case of the revolving drum. The defendant's process by the square model was on the broad question of electricity and motion a practical equivalent of the plaintiffs', but there were differences in the results that might be important.

Mr. JOHN THOMAS BLACKMORE, a practical tanner of 30 years' experience, said that at one time he was a Director of the plaintiff Company, but he was no longer so.

Mr. MOULTON: Resigned for purposes of the trial, we know. (Laughter.)

Proceeding, Mr. BLACKMORE said that he had used the plaintiffs' process some months before the Company was brought out, and found that it was an advantageous system, as it enabled the operation of tanning to be completed so rapidly. He had not tried the defendant's process, but had seen the models at defendant's premises when he acted as agent to Messrs. Worms and Balé. Apart from the application of electricity, he did not consider the defendant's process of any use, as it took too long to complete the operation of tanning.

In cross-examination, witness said that defendant's process would take a period of thirty days to complete the operation of tanning, and that being so, the cost of steam-power and labour would be ruinous. He considered the reason for that was that the apparatus in each of defendant's processes was open at the top. Without the application of electricity the plaintiffs' process, being enclosed, would tan more rapidly than the defendant's.

This closed the evidence in support of the plaintiffs' case, and

Mr. FARWELL, on behalf of the plaintiffs, summed up the evidence, and submitted that the patent of the plaintiffs was novel, important, and useful, and that the plaintiff Company was entitled to the injunction sought for, to restrain the defendant from infringing the invention, the patent rights of which belonged to the plaintiff Company.

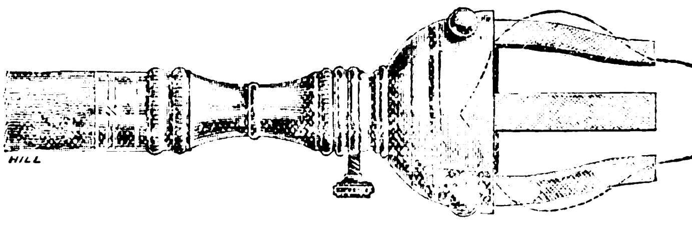
The Court then adjourned for lunch.

## TRADE NOTES AND NOTICES.

*[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.]*

FIRE.—A disastrous fire broke out on Friday afternoon at the show-rooms of Messrs. Richard Evered and Co. (Limited), electrolier manufacturers, at 49 and 50, Holborn-viaduct, E.C., the upper floors being badly damaged by fire and water, and the rest of the premises by water. Messrs. Evered and Co. state that, notwithstanding the fire, they are still able to meet any demands that may be made upon them for the exhibition of their specialities.

INCANDESCENT LAMP CHANGER.—Messrs. Edmundsons, of 19, Great George-street, Westminster, are introducing a very useful device for removing incandescent lamps which are placed far out of reach upon ceilings, &c. By means of the lamp changer this can be effected in a few moments, and without the use of long steps, which are usually necessary to reach the lamps. The apparatus consists of a spring socket, as illustrated, mounted on a ten-foot rod, which




for convenience is made in three joints. The socket grips the lamp firmly, and enables it to be easily removed from or replaced into the usual bayonet joint or screw-holders.

THE GENERAL ELECTRIC COMPANY.—The eighth edition of this Company's electric bells and accessories catalogue is just issued, and consists of 76 well arranged and fully illustrated pages; descriptions and prices are given of various classes of electric bells, bell sets, watch and clock alarms, indicators, bell show boards, pushes, pulleys, &c., bell switches, fire alarms, heat indicators, exploders, and fusers, batteries, insulators, &c., &c. In addition

Digitized by Google

to a number of useful electrical accessories at the end of the catalogue, some notes of the application of electricity, and instructions for fixing bells, &c., by diagrams are given. The General Electric Company's new catalogue of telephone accessories is promised shortly.

THE MANCHESTER EDISON-SWAN COMPANY.—This Company has experienced considerable increase in its business during 1890, some 33,469 incandescent lamps having been supplied by them for the Lancashire district. At the commencement of the year they found it necessary to take additional premises in Little John-street, Manchester, on account of the increase in the manufacturing branch of their business. This, however, now proves to be inadequate, and it has been decided to move their works further out of the city, where a well appointed and commodious factory will shortly be built.

THE WOODHOUSE ELECTRIC SUPPLY COMPANY OF GREAT BRITAIN (LIMITED).—We are notified that Messrs. Woodhouse and Rawson United (Limited) have taken over the business of this Company, excepting so far as the supply of incandescent lamps made under licence from the Brush Electric Light Company is concerned. This part of the business will continue to be carried on by the Supply Company as before.

MESSRS. COX AND CO.—This firm of manufacturing electricians have opened new premises at Fetter-lane, opposite the Record Office, where they will keep a large stock of apparatus and materials for all scientific work. They have also issued illustrated lists of each department, and that dealing with electrical apparatus, which gives details of telephone facts, &c., should be specially useful.

MESSRS. RICHARD FRÈRES.—This firm is about to open, at 43, London Wall, E.C., a branch office and show-room for the exhibition of their specialities in self-recording scientific instruments. Mr. J. A. Berly will be entrusted with the management.

REMOVAL NOTICE. — The Empire Telephone Company has changed its offices from 60, to 171, Queen Victoria-street, E.C.

VOLTA ELECTRICAL COMPANY (LIMITED) (IN LIQUIDATION).—We understand that this Company has been finally wound up, and that a dividend will shortly be paid to the shareholders.

PORTSMOUTH AND SOUTH HANTS ELECTRICITY SUPPLY COMPANY (LIMITED) (IN LIQUIDATION).—Claims are to be sent in to the liquidator, Mr. W. Edmonds, C.A., Portsea, by February 14th.

COMMERCIAL CABLES COMPANY.—We have received a handsomely got-up calendar issued by this Company, which is certainly equal to any previously issued by the Company, and will be found very useful.

## COMPANIES' MEETINGS & REPORTS.

### The Eastern Telegraph Company (Limited).

The thirty-seventh half-yearly ordinary general meeting of the Eastern Telegraph Company (Limited) was held yesterday, at Winchester House, 50, Old Broad-street, E.C.; Sir John Pender, K.C.M.G., presiding.

The SECRETARY (Mr. Geo. Draper) read the notice convening the meeting, and the minutes of the previous meeting, which were confirmed by the present meeting, and signed by the Chairman as correctly entered.

The report of the Directors and statement of accounts were taken as read.

The CHAIRMAN said that before entering upon the business of the day he might fairly congratulate them on the year that was passed, and express a hope that the one they had just entered upon would be as prosperous for the Company. Their revenue from all sources for the half-year ended September, 1890, amounted to £352,873, as against £351,014 in the corresponding period of the previous year, showing an increase of £1,859. Analysing this revenue, they would find a falling off in their receipts from telegrams exchanged with South Africa of over £5,000. In addition to this, the dividend that they had had on their investment in the South African Company was £5,900 less than in the corresponding six months, so that they ought to put down a loss of £11,000, as attributable to the collapse of speculation in gold mining and diamond shares in South Africa. Their Egyptian, Greek, and Turkish traffic also showed a decline of some £1,500, but this decrease was made up by a growth of over £12,000 in their Indian, trans-Indian, and Spanish traffic, and by increased dividends on their other investments of £2,000. For the six months they showed a gross increase of £1,859. The total working expenses for the half year to September, 1890, amounted to £91,723, as against £87,730, or an increase of £3,993. The general expenses in London were £8,502, against £8,410, or an increase of £92. The working expenses at stations amounted to £68,435, against £64,712, or an increase of £3,723, the principal item being £2,657 in the salaries of their foreign staff. A number of their more advanced probationers were transferred to the staff at Porthcurno, Gibraltar, Malta, and Zante in connection with the full working of the triplicate cable, and in the increase in the number of messages carried. There was also an increase of £639 in repairs to stations, buildings, &c., the most important being at Alexandria, where rather extensive alterations and improvements were being carried out. The amount written off for depreciation of cable stock was £802 more than in the corresponding period, owing to their having a larger stock of spare cable. The amount carried to the Maintenance Ships' Reserved Fund was only £2,500, as against £5,000 in the previous half-year, the other portion having been contributed by those telegraph companies who had hired their ships during the half-year. The expenses in connection with the Paris Telegraph Conference, which appeared in the revenue account this time, amounting to £981, was an exceptional item, but a very necessary one, and he thought he might safely say that full value had been received for this expenditure. Expences attending repairs and renewals of cables amounted to £31,477, against £49,634, or a decrease of £18,157. Full details of the expenses of the ships, &c., and value of cable used would be found on reference to abstract "C" of the accounts. The amount of cable used in repairs during the half-year was exceptionally small, and their ships had been several times employed in cable laying and repairing work for other companies, the credits derived from this source having been applied in reduction of the ship's expenses, &c. The summary of the half-year's revenue account was as follows:—The increase in gross revenue and amount brought forward from last half-year was £3,369, while the decrease in the total expenses was £18,678. They were, therefore, after providing for all expenses and interest charges against revenue, able to pay the usual interim dividend at the rate of 5 per cent. per annum, and to carry forward to next half-year's account £78,195, against £61,151, or £17,044 more than in the corresponding period of 1889. He thought that this condensed statement of their affairs must be a very satisfactory one to them all. They had not increased their capital to any extent, but still they had laid down cables that amounted to nearly a million sterling, which they had taken from their reserves; and although they did not receive a very large dividend, the shareholders had got behind them in consequence a great deal of strength, as was apparent from the value of the shares in the Market. They had doubled, trebled, and quadrupled many of the cables in their system, and had been carrying out the policy, which they had always adopted, of being ahead of the requirements of the public. He had, on previous occasions, indicated that in this lay their strength, and when they found that a new departure was going to take place in the Australian Colonies, by way of an endeavour on their part—which was very strongly supported by the Company—to reduce the rate from 8s. to 4s. a word, they felt that if that was to be successful, they must practically double the volume of traffic over their system. That traffic had to come largely over the Eastern Company's system, and consequently it would never have done for them to be behind in their arrangements to meet it. Consequently they were now about to complete the laying of a third cable in the Red Sea which would enable them effectively to deal with that large increase of traffic from Australia. He concluded by moving the adoption of the report and accounts.

The Marquis of TWEEDDALE seconded the motion, which was unanimously agreed to without discussion.

The retiring Directors, Sir John Pender and the Marquis of Tweeddale, were afterwards unanimously re-elected to their seats at the Board.

The auditors, Messrs. Henry Dever and Welton, Jones and Co. were also reappointed, and a vote of thanks to the Chairman and directors having been passed, the proceedings terminated.

[*A full report of this meeting will appear in our next week's issue.*]

### Woodhouse and Rawson United (Limited).

Sir Rawson W. Rawson presided, on the 9th inst., at Winchester House, Old Broad-street, over an extraordinary general meeting of the shareholders in this Company, convened to consider two resolutions: 1, for authorising the Directors to enter into an arrangement with the liquidators of Woodhouse and Rawson (Limited) for repaying the sum of £75,000 deposited by them with the Company until July 1, 1892; and 2, for increasing the capital of the Company by the issue of 40,000 new shares of £5 each.

The SECRETARY (Mr. G. Worrall) having read the advertisement convening the meeting,

The CHAIRMAN said:—Gentlemen, about a year ago I had the honour of occupying this chair at our statutory meeting, and of expressing to you my confidence that the Company would realise fully the expectations of its promoters, the promises of its prospectus, and the hopes of its shareholders, and I am happy on this occasion to have the opportunity of repeating the confidence of the Board that the success which has hitherto attended the Company will continue to be maintained. It will be in your recollection that Lord Aberdare, our late Chairman, whose retirement from the Board we greatly regret, stated his opinion very confidently that the capital of the Company was insufficient for the opportunities it had of realising large profits from excellent and sound undertakings. His colleagues were of the same opinion, and were prepared at an earlier period than the present to address the shareholders upon that subject, if it had not been for the financial crisis which has stopped anything of the kind for some weeks past, and we have taken the earliest opportunity that we consider advisable to present our views to you, and ask your sanction to what we propose to carry out. There are two objects in the resolutions that have been circulated, and which you have had the opportunity of examining. The first is to enter into such arrangements as we may think advisable in the interests of this Company with the liquidators of Woodhouse and Rawson (Limited) for repaying the sum of £75,000, which was deposited by them with us as a guarantee that for three years the shareholders of this Company should be secured 8 per cent. on their Preference shares, and 15 per cent. on their ordinary shares. You will have seen in our balance-sheet for the first year that the profits of that year, after paying those rates of dividend to our shareholders, left a surplus of £41,000—equal to about a year and a-half of our annual payment at those rates to our shareholders. Now a year and a-half has already

Digitized by Google

elapsed of the three years for which the guarantee fund was left in our hands, and it is time that we should consider how that sum is to be repaid. Therefore, we consider that it is convenient when we are asking you to increase our capital for general working purposes to propose to you at the same time an arrangement for repaying the limited company this loan. I had hoped that we might have been able to inform you to-day that the terms were settled, but they have not been arranged up to the present moment. We feel confident that the security of our shareholders is perfect for the three guaranteed years. Already one year has elapsed, and we have paid our shareholders at the rates that we undertook—namely, 8 and 15 per cent.; another half-year has elapsed, and our profits have been, I may venture to say, not less than last year. Our expectations of the coming six months are no less favourable. We shall, therefore, at the end of the second year have another surplus to add to the £41,000 wherewith to pay our shareholders at the end of the third year. We are not pledged beyond the third year, but our hopes certainly extend beyond that period, and we trust that at the end of three years we shall not be in a worse position than we are now to satisfy our shareholders with large and abundant profits. The second point is that the capital of the Company be increased from the present amount to £550,000 by the creation of additional shares. When this Company was brought out the working capital for which we asked was decidedly moderate. We were satisfied that we should be able to show such a rate of profit as would justify us in coming before the shareholders, and saying, "You see what we are capable of earning. If we have a larger capital we shall be able not only to continue this rate, but to improve upon it, and we believe that our shareholders will then find sufficient reason for confidence in the Board to meet their appeal, and to furnish them with further capital." Well, since that time, which is now about 18 months ago, things have considerably changed. Experience has shown us that our capital is insufficient, as our business has largely increased. I yesterday had put into my hands the earnings of our supply department. The second six months were 50 per cent. over the first six months; the third six months were 30 per cent. over the second six months; and this in the supply business alone, where we must hold in our hands a large and very valuable stock of electrical goods to meet the demands of our customers, and moreover must have large outstanding accounts, with several thousand customers, swallowing up our available working capital. In the same way we have already stated to you that we have increased our business by the purchase of one very important and very extensive business to enable us to hold, as we believe, our prominent position amongst the electrical companies of England. We should be sorry to drop back instead of progressing in our position, and in order to secure it, and to be independent of other people, we find it necessary that we should manufacture a number of the more important articles required by our customers so as to be ready to meet their wants without delay, and without the difficulty of procuring the articles from other people. As regards the Debentures, our Articles of Association empower us to increase the issue to the extent of £250,000. Inasmuch as the value of money, independently of the recent financial crisis, has decidedly lowered, and the action of the Chancellor of the Exchequer with regard to the conversion of Consols last year has given us an indication of the probable future value of money, we consider that the 6 per cent. interest payable to our Debenture holders is excessive, and it is therefore our intention to recal those Debentures, giving the holders of them the profit that we promised them at the time of their issue, and issuing a larger sum at 5 per cent., probably to the extent of £200,000 instead of £100,000. That will be a profitable arrangement for the Company and for the ordinary shareholders, for there will remain a larger sum available for distribution to them. As regards the Debenture holders, they have a largely-increased security, having the advantage of all the purchases of real property and factories that we have made; and in other respects their position will be improved. As regards the question of the issue of new shares, you are aware that the shares already issued have recently fallen in value. Your directors have not been at all frightened by that, inasmuch as 15 per cent., safely earned and likely to be continuously earned, ought to place the shares considerably above par. We have had several difficulties to contend against. We have had the difficulty of the delay in the settlement of the affairs of Woodhouse and Rawson (Limited), for which we are in no way responsible, and for which the liquidators, as far as we know, have not been responsible. The public do not understand the difference between Woodhouse and Rawson (Limited), and Woodhouse and Rawson United (Limited). That difficulty, happily, is at an end. Another difficulty we have had is in connection with getting a quotation for our shares. The Committee of the Stock Exchange is exceedingly particular. One difficulty that we had was in consequence of our issuing 100 shares in payment to a patentee from whom we had bought a patent. That happened not to be included in the list. They noticed it, and said these were vendors' shares. That caused weeks of delay; and so in the same way from time to time it has been delayed. I am happy to say, however, that there remains only one affidavit now to be completed in order to obtain our settlement. That affidavit we count upon receiving next week. The Managing Director reminds me that one of our difficulties has been in taking over so many companies and businesses. There has been a remarkable and unusual complication in clearing the whole of the transactions to the satisfaction of the Stock Exchange. These circumstances have combined to lower the value of our shares beyond their proper value, but we feel confident that when our shareholders and the public find that the profits we made last year are not accidental, and not casual, but will be maintained this year, and have every apparent prospect of continuing during the third year—we cannot look further than that—that the public will have restored confidence in our shares, and that the shares will reach their proper value. There are three good reasons for our not calling up our uncalled capital. The first is, that our ordinary shareholders, some of them at all events, were led to expect that it was not our intention to do so unless it was absolutely necessary. Another cause has been that we thought it right to keep this capital in reserve, for the purpose of meeting the repayment of the loan to the limited company. The third reason is that it is exceedingly desirable in a company carrying on a business of this kind to have a reserve fund upon which, when opportunities of useful extension present themselves, they should be able to borrow for temporary purposes, instead of keeping a large balance at the bankers yielding the small rate of interest that money now fetches. I have the satisfaction of drawing your attention to the success which has attended the Company, both in the matter of the Elmore shares, and of the International Okonite shares. Every day confirms the truth of the original statements made with regard to the value of the Elmore process and the two companies that have been issued for foreign countries, which are only a prelude to the arrangements for the sale of the patent in other countries. The French Company will hold their meeting this afternoon, and I have reason to know that statements will be laid before the shareholders of that company, which will contain the most satisfactory assurances of the confidence that the French members of the Board have that the process will be even more profitable than has been held out hitherto to the shareholders of the company. With regard to the other company, the International Okonite Company, the certificate of the accountants, Messrs. Price, Waterhouse and Company, shows that our expectations of the earnings for the six months of last year, from January to July, have been exceeded. The Directors of that company have announced their intention of paying an interim dividend at the rate of 10 per cent. upon the working of the last six months; and this, it must be borne in mind, has been before the Manchester branch has been able to erect their works and commence operations under the Okonite patent in England. Consequently the success of the International Okonite Company, as far as profits are concerned, is substantiated to the fullest. These are companies in which we have been interested, and they will give you an indication of the class of enterprise that we desire to promote—not untried companies, or chance patents, but patents and processes that we have the opportunity of testing with our numerous staff, scientific and financial, and with our variety of factories. We can therefore see that in taking up these things we do not take up anything haphazard. The method of our taking them up secures us from any risks beyond that of the expense of launching the companies, so that our shareholders need not be afraid that the Directors are likely to embark in any rash undertakings that are calculated at all to risk the property and the capital of the shareholders. With regard to our own factory, you are aware that we have leased one of our buildings at Kensington to the Kensington Stores, and we have therefore built a new block for ourselves nearly double the size of the original one. We hope, by the end of February, that this will be at work, and we have a number of new machines ready to manufacture as soon as we are able to get into the new premises. Our profit from that branch of the business is likely for the future to be very much larger than it has hitherto been. I think I need not detain you longer except to say that, as far as we can judge, our future prospects are very bright, and as our promises have been realised during the past year, we hope that you will give us your confidence, and believe that we would not make a promise for the coming year if we were not satisfied that it would be substantiated. We expect that the interim dividend for the past six months will be declared in a very short time. He concluded by moving the first resolution as follows:—

*"That the Directors be authorised to enter into such arrangement as they shall think advisable with the Liquidators of Woodhouse and Rawson (Limited) for the immediate or early repayment to such Liquidators of the sum of £75,000, or any part thereof, deposited with the Company on the terms that it should be retained till the 1st of July, 1892, as a Dividend Guarantee Fund."*

The Right Hon. Sir E. THORNTON, G.C.B., seconded the motion.

In the course of the discussion which followed several speakers addressed the meeting. Objection was taken to the proposal to repay the loan of £75,000, it being contended that much of the profits that had hitherto been made had been in connection with the promotion of companies, and not from legitimate trading. It was further pointed out that interest would have to be paid on the money, which was obtained to repay the loan, whereas on the latter the Company paid no interest. Disappointment was also expressed at the delay in the Company's securing a quotation for the shares on the Stock Exchange. Some of the speakers thought that the repayment of the loan might be a judicious financial operation for the benefit of the Company. The general feeling of the speakers was that the present would be an inopportune time for issuing new shares, the existing shares being at a discount.

The MANAGING DIRECTOR (Mr. F. L. Rawson) at the close of the discussion said: The Chairman has asked me to answer the various questions that have been asked, and also to amplify anything in his speech that I might consider advisable to mention to the shareholders. I should like to call attention to the fact that the proposed new capital is an additional security for the Debenture holders justifying the increase of the Debentures to £200,000, and the reduction to 5 per cent.; secondly, that the depreciation that has taken place in the market value of our shares is very largely due, not only to the financial position of the country—for if you take almost any of the industrial securities you will find that they have fallen from 10 to 20 per cent.—but also to the fact that during the last two months we have been distributing the shares of the companies whose properties we purchased under the agreements made. We gave the shares to the liquidators of those companies some time ago, but they were not able to distribute them until quite recently, and hence during the past fortnight or month there has been about £80,000 of capital put upon the market, and large numbers of shares have been obliged to be put upon the market at the

Digitized by Google

same time. During the past few days, however, the shares have steadily risen. I bought some myself yesterday, and had to pay a good deal more than I expected. The name of Mr. Baker, our works manager, has been mentioned as having sold shares. I was rather surprised when I heard Mr. Baker was selling, and I took an opportunity of speaking to him on the subject. The explanation is this: It seems that Mr. Baker was paid altogether in preference shares when we purchased his interest, and he had to realise a large number of them in order to settle his own arrangements. I may mention, however, that Mr. Baker has ever since, from time to time, been steadily buying ordinary shares. The same remarks apply to myself. I have taken up some £28,000 of shares in the last six months, and paid 5s. premium on them, and I do not think you could have any better proof than that of my belief in the future of this undertaking. The prospects of the Company are decidedly good. We may have been thought speculative in purchasing so many as four new businesses in so short a time as 18 months, but we wanted to put ourselves in the position of being able to manufacture, creditably to ourselves and profitably to our clients, every class of electrical goods; and this we are now able to do—with the exception of cables and wires which are a special manufacture by themselves—and I may add that the businesses we have taken over have turned out very well. In one of them, about which we were a little doubtful, we have received an important commission from the Government, and I hope it will result very profitably to our Company. As regards new companies, we have been quite different from ordinary company promoters. We have been connected with very few companies; indeed, during the 18 months of our existence we have only been connected with three, counting the Elmore as one. As a rule, we are associated with any new enterprise we take up for some 18 months or two years before they come out as companies. We gradually work at them, and help to build them up, so that we have a long experience of them, and know what they are capable of. At the meeting last year it was mentioned that we had three new inventions in hand. I am glad to say that all of them have turned out very satisfactorily. One is completed, and we are now commencing manufacturing on a large scale ourselves. If it outgrows our capacity we shall turn it into a separate company. We have another new electrical invention, which we have now commenced to carefully test. The demand for electricity, both for lighting and motive power, has increased so much that the position is now very different to what it was 18 months ago. The electric light, as the Americans say, has now come to stay. With regard to the remarks made by one speaker, I would like to draw attention to the fact that we have the power of paying the liquidators this £75,000 in cash or debentures, and naturally we shall pay them in what is most advantageous to the Company. If we give them Five per Cent. Debentures it only adds a sum of £3,750 per annum to our annual expenses, which is very small out of a margin of profit of £41,000. Suppose we get a discount of 10 per cent., in that case we should have a profit there of about £5,000, or about a year and a-half's interest. Then, with regard to the issue of the new shares, the Directors have only asked for the power to issue them, and they will do so when a favourable opportunity presents itself. If the ordinary shares are only half paid up we shall have £150,000 of share capital, whereas we shall have the benefit of £100,000 of Debentures, besides reducing the rate of interest to 5 per cent. The uncalled capital is a valuable security for those Debenture holders; and we must have a proper proportion of ordinary and Preference shares and Debentures. The Chairman has told you that we are about to pay the interim dividend; we have made in six months more than enough to pay the whole year's dividend at 15 per cent. The first thing I look to in our business is to have it safe, because our profits are so large now, and the electrical business has increased to so great an extent that we need not go into speculative things. I do not think there is a single business that we have gone into during the last year and a-half that has practically involved us in a liability of even £10,000. We consider it right to set a portion of our profits aside for the repayment of the guarantee fund. At the date of the last balance-sheet we had lent Woodhouse and Rawson (Limited) £39,000, and we also put certain shares aside as security; but since the balance-sheet those shares have been sold, and they fetched more than the price we put them down at. We have re-invested part of that money, and that is set aside for the repayment of the amount. We do not care to invest sums of that kind in Consols; we take the class of security that does us good and helps our business. With regard to the notice of meeting being rather short, Mr. Horsfield is quite correct in that view, living as he does in Manchester; but it must be remembered that changes of a financial character may occur so quickly, thus affecting the market, that no time can be lost in a matter like this. I am, however, sure the Directors will not object to our giving longer notice in future when possible. With regard to the time of issue of the new shares, it is ridiculous to imagine our shares being so low when such large profits are being made, and where the surplus profits are so good. The price, therefore, must rise, more especially after a meeting such as this, when you have heard what a satisfactory position the Company is in. I think the manufacturing profits will be considerably larger this year than last—£10,000 or £12,000 larger. With regard to our new Company work, you will be glad to hear that now a very different class of business is being offered us. We have a tremendous amount of work offered in connection with new companies, with which there is practically no risk to us at all, but which we do not accept. In the late Elmore companies, for instance, we did not involve ourselves in one penny risk; we had not even to pay any preliminary expenses or anything of the kind. We made arrangements whereby all others did this.

The CHAIRMAN then put the resolution, and it was carried *nem. con.* Continuing, he proposed the second resolution, as follows:—

"*That the capital of the Company be increased to* £550,000 *by the creation of* 40,000 *new shares of* £5 *each, of which* 20,000 *shares shall be Preference shares, which shall be entitled to the same preferential dividend and rights, other than the benefit of the dividend guarantee fund, and shall be subject to the same conditions as and rank for all purposes* pari passu *with the existing issue of* 30,000 *Preference shares of* £5 *each of the Company, the remaining* 20,000 *shares shall be ordinary shares, and shall be entitled to the same dividends and rights, other than the benefit of the dividend guarantee fund, and shall be subject to the same conditions as, and rank for all purposes* pari passu *with, the existing* 40,000 *ordinary shares of the Company.*"

He reminded the shareholders that the Directors were as much interested in this matter as the shareholders were—indeed personally more interested, as their credit was engaged. They would, therefore, certainly not take any action that was likely to injure the welfare of the Company. All that they asked for was permission to issue the new share capital when the time presented itself for their doing so. They believed and hoped that there would be, perhaps, a sudden revulsion of feeling, when they might go to their shareholders and to the public with great success.

Mr. PHILIP RAWSON seconded the motion, which was also adopted.

Mr. CHAPMAN then proposed a vote of thanks to the Chairman and Directors.

Mr. HOSTER seconded the resolution, which was carried unanimously, and the meeting then separated.

## Elmore's French Patent Copper Depositing Company (Limited).

The first general meeting of this Company (being the statutory meeting required to be held within four months after the registration of the Company) was held at Cannon-street Hotel, on the 9th inst., under the presidency of Sir Richard Meade, K.C.S.I.

The SECRETARY (Mr. J. Shurmer) having read the advertisement convening the meeting,

The CHAIRMAN said: Gentlemen, all present are doubtless aware that this is only a statutory meeting of the Company, and not for the transaction of business. We propose, however, to ask the meeting to sanction certain alterations in the Articles of Association, of which due intimation is given in the notice convening the meeting, which are required by the Committee of the Stock Exchange. I have stated that we are not here to-day for the transaction of business, but we are glad to have the opportunity of meeting our fellow-shareholders, and of informing them of what has been done since its formation to carry out the objects of the Company. I have first to state that the 66,750 shares offered to the public were applied for about four times over, and that a full allotment was made among some 2,000 applicants. The sums due on allotment have, with a small exception, been all paid up, and those still outstanding on the first and final calls are in course of adjustment. The Stock Exchange Committee has granted a settlement for our shares, and provided this meeting passes the alterations in the Articles of Association, of which notice has been given, there will be an official quotation of our shares on the London Stock Exchange at a very early date. Steps are also being taken to introduce our shares upon the Paris Bourse, which will, no doubt, be successful, and thus lead to an important extension in the dealings in our shares.

The first question your Directors had to deal with was that of the general management of the Company's manufactories and business in France, and they congratulate the shareholders on their having been able to secure the very valuable services of M. Eugène Secrétan as the Company's General Manager there. M. Secrétan was formerly manager of the largest copper manufacturing industry in the world, and your Directors are confident, from all they have learned and know of him, that in placing him at the head of the Company's affairs in France they have taken the most important step that was possible towards securing the complete and early success of the business of the Company in that country. M. Secrétan was, it is understood, convinced of the merits of the Elmore process when it was exhibited in Paris in 1889, and before entering the service of the Company he visited the works of the English Company at Leeds, accompanied by several colleagues, and his assurances to your Board, after making that visit, of his entire confidence in the future success of our Company were most emphatic and satisfactory. As stated in the prospectus, your Directors had secured for the Company land at Bellegarde, near the Swiss frontier, suitable for a site for the works, with water available as a motive power, but M. Secrétan was so satisfied of the vast importance of establishing a manufactory, and commencing business at first in the north of France, that, after much anxious consideration, we accepted his recommendation on this point, and decided to concentrate our attention and efforts on the establishment of works there, in the first instance, on a sufficiently large scale to admit of a more considerable out-turn of manufactured goods than was originally contemplated. M. Secrétan gave us the strongest assurances that he would be able to dispose of all the goods that would be thus turned out, and he was accordingly authorised to take the necessary steps for securing a convenient and suitable site, for the preparation of plans and estimates of the buildings that would be required, and for ordering the engines, machinery, and plant needed to stock the works. These arrangements he has carried out with characteristic energy, and we are able to inform this meeting that an excellent and convenient site, of ample extent, has been obtained by him on very advantageous terms, at Dives, near Havre; that the plans and estimates for the buildings to be erected thereon have been approved and sanctioned by the Board, and that the engines, machinery, and plant have been ordered from the best manufacturers of such articles in France. The winter season will, of course, delay the progress of the buildings, but M. Secrétan states that the works will be in operation by July 1st next. M. Secrétan, who is present here to-day, will address the meeting, and as he does not speak English, an English version of his remarks will be afterwards read. I may mention

Digitized by Google

that he has secured the assistance of a committee of experts in Paris, whose aid will be most valuable in the work that lays before him.

I will now refer to the financial aspect of the more extended operations your Directors have authorised. The prospectus provided for a working capital of £50,000, which, it was thought, would be quite sufficient for starting the works successfully on a moderate scale. But it was at once apparent that the adoption of M. Secrétan's proposals would necessitate a large increase to this amount, and, after much consideration, we decided to avail ourselves of an offer from the parent Company (Elmore's Foreign and Colonial Company, Limited) to lend to us for this purpose £50,000, at 6 per cent. per annum, for three years. The shareholders were informed of the circumstances of this arrangement by a circular issued to them on October 29th last. I have only to add that we are satisfied that the course we have thus taken was the best that it was in our power to adopt in the interests of the Company. The measures now laid before the meeting will enable the Company to retain in its own hands—instead of disposing of the same to a sub-company, as was intended—the exclusive licence to make copper wire in France by the Elmore process. The value of our shares should be largely increased by such retention, as the profits from the manufacture of wire will by-and-by be very considerable. The patents which we have purchased have been duly transferred to us, and we have every assurance that the same are perfectly good and valid. The Company obtains, free of charge, all improvements worked out from time to time by the Elmore English Company in this country, and I may mention, in this connection, that one additional patent on this account has already been taken out by us in France. It only remains for me to say that the Board has the fullest confidence in the future success and prosperity of the Company. I or my colleagues will be happy to answer any questions that may be put to us before I propose the resolution for the alterations in our Articles of Association. I have the pleasure, before sitting down, to introduce M. Secretan to the meeting.

Dr. HETLEY inquired whether the extra £50,000 capital, to which the Chairman had referred as having been raised, was in debentures or preference capital.

The CHAIRMAN: I venture to suggest that any remarks may be deferred until after M. Secretan's address.

Dr. HETLEY: Certainly.

M. SECRETAN then addressed the meeting in French, his remarks being subsequently read to the meeting in English by the Secretary, as follows:—I am very sorry I cannot express myself in English, and I trust some member of the Board will kindly translate the few words I ask permission to address to you.

Gentlemen, the Board of your Company has expressed a wish that I should be present at this meeting. It is with great satisfaction that I have complied with that request; because, on the one hand, it permits me to thank your Directors publicly for the honour they have conferred upon me by appointing me general manager of your Company in France; and, on the other hand, I thought you would be glad to hear a few words from me on the present and future position of your Company. The extended and careful investigations and trials that have been made up to the present time have convinced me and my most trustworthy and competent advisers that the Elmore process has definitely reached a practical manufacturing stage. You have the exclusive right to manufacture under this process in France, and the articles produced are of extraordinarily good quality, and the cost of production is extremely low, more so, indeed, than is stated in the prospectus. These facts being now incontestable, the time for hesitation has passed, and that for work has arrived. I have submitted to your Board plans for the erection of the first factory, and I had the good fortune to see them fully approved. Immediately after this approval I entered into arrangements with excellent contractors for the erection of the buildings, and with the most competent manufacturers for the machinery and plant. There will be no hitch in the completion of your factory, as too often happens. To avoid this I have only dealt with firms of the highest standing and the greatest experience, who are renowned for the scrupulous carrying out of their engagements. With these I have entered into definite contracts at prices which are absolutely binding, and cannot be exceeded. Under these contracts the buildings will be handed over complete at the end of next April. Engines, boilers, dynamos and plant generally will be erected, in working order, by the end of June, and on July 1st next your first works in France, constructed to produce 370 tons of copper articles per month, will commence work, and will at the end of another three months have reached their full production. I need not tell you that the sale of these articles is absolutely assured. Supported by the confidence of your board, seconded by my French Committee of Direction, and aided by a staff, of whose industry and goodwill I cannot speak too highly, I undertake, as far as I am personally concerned, to work with untiring energy, and with entire devotion to your interests. In conclusion, I can assure you, gentlemen, that you can regard the future with absolute confidence and faith in the prosperity of your Company.

The CHAIRMAN then called upon Dr. Hetley.

Dr. HETLEY said he desired to know whether the additional £50.000 of capital was in Debentures or in Preference shares. In the event of its being Debentures, he thought that it might have been offered to the shareholders.

M. LAWES asked what the profits of the Metal Company had been to which the Chairman had alluded as having been formerly managed by M. Secretan, whose address, it had appeared to him, had not contained any practical facts.

The CHAIRMAN: You cannot expect a reply to a question like that. We all know that M. Secrétan's experience has been very great in the particular business in connection with which he has now taken service with us.

Mr. LAWES, continuing, observed that in the first prospectus a point was made about the water-power by which the Elmore process was to be carried on at a very low price. It seemed to him that all this had been thrown to the winds by the change in the *locale* of the Company. It also appeared to him that before the shareholders would derive any benefit from their works every penny of the profits was hypothecated to another company. Six per cent. interest and 5 per cent. premium seemed to him to be a high price to have paid for the additional money they had required.

Mr. F. L. RAWSON stated that it was with M. Secrétan that his (the speaker's) firm, Woodhouse and Rawson, originally negotiated the sale of the Elmore patents for £750,000. The opinion of his brother, who was in France for many months, of M. Secrétan was of the highest description M. Secrétan did not pretend to be a financier, but as a metallurgist and as a manufacturer of copper, he stood *facile princeps*. When he saw that there was a chance of M. Secretan coming to the French Elmore Company, his own remark was that the future of that Company was assured.

The CHAIRMAN, in reply, said: I understood Dr. Hetley's meaning to be that the debentures ought to have been offered to the shareholders of this Company?

Dr. HETLEY said he thought they might have been; he would not say ought to have been.

The CHAIRMAN: I am informed that Elmore's Foreign and Colonial Company, who lent the £50,000 on Debentures, would be very glad to issue them to any of the shareholders of this Company who are willing to take them up. We could not enter into any "part and parcel" arrangement in this matter. The great object we had in view was to secure promptly the possession of a sufficient sum of money to enable us to start what M. Secrétan assured us was necessary for the success of the Company. We could only do that by accepting this arrangement which was offered by the parent Company to lend us the sum of £50,000 on these terms, which we consider to be fair. We came to that conclusion after very great consideration, and are perfectly confident that it was the best thing we

PATENT

# SILICIUM BRONZE AND SILICIUM COPPER WIRE.

The best for overhead Telephone and Telegraph Lines,

AND ALL ELECTRICAL PURPOSES.

Hard Drawn High Conductivity Copper Wire.

ROLLED AND DRAWN PHOSPHOR BRONZE.

PHOSPHOR BRONZE VULCAN PHOSPHOR DURO METAL

PHOSPHOR BRONZE BEARINGS, BUSHES, AND OTHER PARTS OF ELECTRICAL MACHINERY

*SOLE PROPRIETORS of the British, Indian and Colonial Patents,*

THE PHOSPHOR BRONZE COMPANY (Limited),

*87, Sumner Street, Southwark, London, S.E.*

WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

Digitized by Google

could have done for our Company. We had secured a site at Bellegarde with water-power, but we could not commence two manufactories at once; and the weight of evidence in favour of starting first in the North of France was so conclusive that we were compelled for the present to put Bellegarde aside. We still, however, retain our interest at Bellegarde, and when the proper time comes, and we have money sufficient to start a second factory, we propose to establish one there.

Mr. RAWSON observed that the profits of the Société des Metaux, of which M. Secrétan was formerly the manager, were last year £240,000.

The CHAIRMAN: Are there any other questions? Then I will propose the first of the resolutions for altering the Articles of Association. They are merely formal, in accordance with the requirements of the Committee of the Stock Exchange. The first resolution is as follows:—

*"That the following words be added to Article 15, at the end thereof:—'Provided that twenty-one days' notice at least shall be given of each call, and that no call shall exceed one-fourth of the nominal amount of a share, or be made payable within two months after the last preceding call was payable.'"*

Major CHARLES JONES seconded the resolution, which was carried.

On the motion of the CHAIRMAN, seconded by Mr. C. G. PHILIPS, the following resolution was also agreed to:—

*"That the following words be added to Article 44, at the end thereof:—'Provided that the Directors shall not, without the sanction of a general meeting of the Company, raise or borrow any sum of money which will make the amount raised or borrowed by the Company and then outstanding exceed one half of the subscribed capital of the Company, and so that every Debenture, Debenture Stock Certificate, Mortgage, or other charge shall be under the common seal of the Company.'"*

The CHAIRMAN afterwards proposed, and Major JONES seconded, the following resolution, which was carried unanimously:—

*"That the following words be added to Article 116, at the end thereof:—'A printed copy of such balance-sheet shall seven days previously to the meeting be sent to the members in the manner in which notices are hereinafter directed to be served.'"*

Sir RAWSON W. RAWSON then proposed, and Dr. HETLEY seconded, a vote of thanks to the Chairman, which was agreed to, and a similar compliment was paid to M. Secrétan on the motion of Mr. CALLANDER, seconded by Mr. CHIROL.

The CHAIRMAN: On the part of my colleagues and myself, I have much pleasure in thanking you for your kindness in proposing the vote of thanks, and I can only assure the shareholders that they will have the very best efforts of myself and all associated with me on this Board in making the Company a success.

The meeting then separated.

## The Direct United States Cable Company (Limited).

The following is the report of the Diectors of this Company for the six months ended December 31, 1890, to be presented at the twenty-seventh ordinary general meeting of the Company, to be held at Winchester House, Old Broad-street, E.C., this day (Friday) at 2 p.m.:—

The half-year's revenue (subject to revision on decision of the case mentioned below), after deducting out-payments, amounted to £43,346 13s. 7d. against £42,356 12s. 1d. for the corresponding period of 1889, being a difference of £990 1s. 6d. in favour of the half-year under review.

The working and other expenses for the half-year with income tax, and including the expenses of the New York Office entirely borne by this Company (*vide* paragraph 6 of the report to June 30 last), but exclusive of cost of repairs of cable, amounted to £17,555 12s. 7d., leaving a balance of £25,791 1s. as the net profit, making, with £968 0s. 3d. brought forward from the previous half-year, a total of £26,759 1s. 3d. For the corresponding period of 1889, the working expenses and other payments amounted to £15,509 5s. 8d.

Interim dividends of 3s. 6d. per share for the quarter ended September 30, 1890 (paid October 24, 1890), and of 3s. 6d. per share for the quarter ended December 31, 1890 (payable January 24, 1891), together amounting to £21,248 10s., have been declared, and the balance of £5,510 11s. 3d. on the revenue account has been carried forward.

An interruption of the main cable, occasioned by a vessel's anchor, occurred on September 1st last, near the Green Bank, and was repaired on September 8th. The repairing operations have cost £1,629 12s. 5d., which has been charged to the reserve fund account as heretofore.

In the case of the Anglo-American Telegraph Company *v.* Cie Française du Télégraphe de Paris à New York, the appeal to the Council of State, mentioned in the report to June 30, 1889, is still pending.

[*A full report will appear in our next issue.*]

## CITY NOTES, &c.

**BRAZILIAN SUBMARINE TELEGRAPH COMPANY.**—The receipts of this Company for the week ended January 9th amounted to £5,487.

**CITY AND SOUTH LONDON RAILWAY.**—The receipts of this Company for the week ended January 10th amounted to £748.

**EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY (LIMITED)**.—Our advertisement columns contain notices that the whole of the Company's £320,000 Six per Cent. Debentures falling due February 1st next, together with the last half-yearly coupon on these Debentures for the accrued interest to February 1st, will be paid by the Consolidated Bank (Limited), 52, Threadneedle-street, E.C., on and after February 2nd. The Debentures will be paid off at par, and both the Debentures and coupons must be left three clear days previously for examination at the bank, where forms for specifying the same may be had on application.

**ELECTRIC CONSTRUCTION CORPORATION (LIMITED).**—The International Trustee, Assets, and Debenture Corporation (Limited) is authorised by the Corporation to receive applications at par for £100,000 Six per Cent. First Mortgage Debentures. The prospectus (which will be found on page xiv.) states that this issue is made in consequence of the growth of the business of the Corporation, and for the purpose of extending its operations and repaying a bankers' advance of £30,000 (secured by temporary debentures) which has enabled the Corporation to complete and equip its new works at Bushbury, Wolverhampton. The profit and loss account from June, 1889, to September, 1890, shows a profit balance of £52,639. The annual sum required to pay the interest on this debenture issue is £6,000. The security for the debentures will be the freehold and leasehold properties, plant, machinery, stock, book debts, patent rights, shares in other companies, goodwill, and other assets of the Corporation, the whole of which stood in the balance-sheet of the Corporation at September 30, 1890, at £586,648. 16s. 11d. The freehold and leasehold properties, plant, machinery, stock, &c., have been valued at £146,833 by Messrs. Farebrother, Ellis, Clark, and Co., who, speaking from some experience of electrical works and machinery, add that "the buildings at Bushbury are perhaps the finest and best constructed as electrical factories in the United Kingdom, and the plant and machinery are all of the newest and best possible workmanship, and capable of dealing with the growing demand for electrical appliances for various objects to a vast extent." The book debts of the Corporation on September 30, 1890, stood at £104,882. 5s. 5d. Prospectuses may be obtained from the bankers of the Corporation, at the offices, and from the International Trustee, Assets, and Debenture Corporation (Limited), 13, George-street, Mansion House, London, E.C. The subscription list closes on Wednesday next, the 21st inst.

**GLOBE TELEGRAPH AND TRUST COMPANY.**—The Directors of this Company have declared an interim dividend of 1s. 9d. per share.

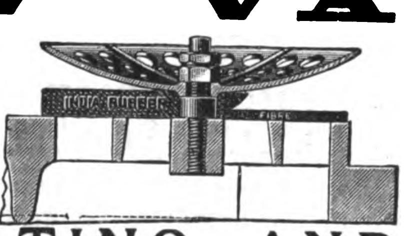
**ST. JAMES'S AND PALL MALL ELECTRIC LIGHT COMPANY (LIMITED).**—Mr. Egerton H. Clarke has joined the Board of this Company.

**VENEZUELA TELEPHONE AND ELECTRICAL APPLIANCES COMPANY (LIMITED).**—Warrants for an interim dividend at the rate of 3 per cent. per annum have been posted to the shareholders. The Stock Exchange Committee have appointed Friday, January 16th, a special settling day in this Company's shares Nos. 1 to 13,144, and debentures Nos. 1 to 572.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY.**—The traffic receipts of this Company for the week ending January 9, 1891, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £4,434.

NEW VALVE

No Rubber, Percha, or Leather.



One-half the price of Rubber or Metal.

FOR CIRCULATING AND AIR PUMPS.

Unaffected by any Lubricating Oils. Does not Expand in diameter. Feed Water may be worked at any temperature Suitable for any shaped guards. Only one quality manufactured.

"12, John-street, Sunderland, 26th Sept. 1885.

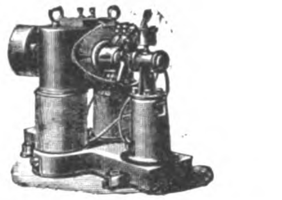
"DEAR SIRS,—In reply to your letter of the 25th inst., the Valves I got from you have done their work well, and ARE AN UNQUALIFIED SUCCESS. I will continue to get them from you as required.—Yours faithfully, JAMES WESTOLL."

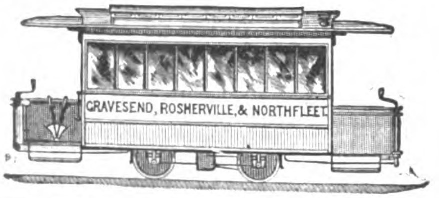
For further Testimony and Prices, apply to MOSSES & MITCHELL, 68-71, Chiswell Street, London.

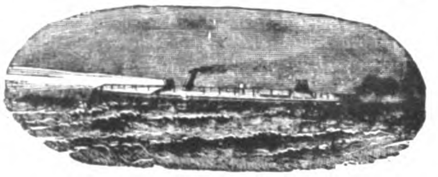
Digitized by Google

# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name. | Previous Week's Price, Jan. 7. | | Price Wednesday, Jan. 14. | | Rate per Cent. Yielded. | Dividend Due. | Business Done During Week Ending Jan. 6. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **TELEGRAPHS.** | | | | | £ s. d. | | | |
| £1,381,380 | Stock | 15/0 | Anglo-American | 48½ | 49½ | 49 | 50 | 5 15 0 | Jan., Apr., July, Oct. | 49 | .. |
| £2,809,310 | Stock | 30/0 | Do. Preferred | 85 | 86 | 85½ | 86½ | 6 12 11 | ,, ,, | 86½ | 85¼ |
| £2,809,310 | Stock | .. | Do. Deferred | 13¼ | 13¾ | 13¼ | 13¾ | .. | .. | 13⅜ | 13⅜ |
| £250,000 | £100 | 4% | African Direct, 4 per Cent. Debentures | 97 | 100 | 98 | 101 | 3 19 3 | January and July .. | 99¼ | 99 |
| £130,000 | 10 | 6/0 | Brazilian Submarine | 11 | 11½ | 11¼ | 11¾ | 6 7 6 | Mar., June, Oct., Dec. | 11½ | 11¼ |
| £84,500 | 100 | 5% | Do. 5 per Cent. Bonds | 102 | 104 | 102 | 104 | 4 16 2 | January and July .. | .. | .. |
| £75,000 | 100 | 5% | Do. 5 per Cent. Bonds (2nd Series, 1906) | 102 | 106 | 102 | 106 | 4 14 4 | June and December | .. | .. |
| $7,216,000 | $100 | $1½ | Commercial Cables | 102 | 104 | 104 | 105 | 6 3 10 | April and October .. | .. | .. |
| £16,000 | £10 | 8/0 | Cuba Submarine | 11½ | 12 | 11 | 12 | 7 1 8 | February and August | .. | .. |
| £6,000 | 10 | 10% | Do. Preference 10% | 16½ | 17½ | 16½ | 17½ | 5 14 3 | ,, ,, | .. | .. |
| £12,931 | 5 | 2/4¾ | Direct Spanish (£4 paid) | 3¾ | 4¼ | 3¾ | 4¼ | 5 12 11 | April and October.. | 3 15/16 | .. |
| £6,000 | 5 | 10% | Do. Preference 10% | 9 | 10 | 9 | 10 | 5 0 0 | ,, ,, | .. | .. |
| £60,710 | 20 | 3/6 | Direct United States xd | 10⅛ | 10⅜ | 10¼ | 10⅜ | 6 15 0 | Jan., Apr., July, Oct. | 10⅜ | 10 5/16 |
| £400,000 | 10 | 2/6 | Eastern xd | 14 | 14¼ | 13¾ | 14¼ | 4 11 3 | ,, ,, | 14¼ | 14⅛ |
| £70,000 | 10 | 6% | Do. 6 per Cent. Preference xd | 14¾ | 15¼ | 14¾ | 15¼ | 3 18 8 | ,, ,, | 15½ | .. |
| £1,200,000 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock | 104 | 107 | 104 | 107 | 3 14 5 | May and November | 106¾ | 105½ |
| £200,000 | £100 | 5% | Do. 5 per Cent Debentures, 1899 | 107 | 110 | 108 | 111 | 4 10 1 | February & August | 109 | .. |
| £250,000 | 10 | 2/6 | Eastern Extension xd | 14⅛ | 14⅜ | 14⅛ | 14⅜ | 4 17 5 | Jan., Apr., July, Oct. | 14⅜ | 14 5/16 |
| £320,000 | 100 | 6% | Do. 6 per Cent. Debentures, 1891 | 101 | 103 | 101 | 103 | 5 16 6 | February & August | .. | .. |
| £320,000 | 100 | .. | Do. 4 per Cent. Debentures Stock | 102 | 104 | .. | | .. | .. | .. | .. |
| £91,800 | 100 | 5% | Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900 | 102 | 105 | 102 | 105 | 4 15 3 | January and July .. | .. | .. |
| £145,300 | 100 | 5% | Eastern & S. African 5 per Cent. Mor. Deb., 1900 | 101 | 104 | 101 | 104 | 4 16 2 | ,, ,, | 102⅜ | .. |
| £180,227 | 10 | 1/9 | Globe Telegraph and Trust | 8¾ | 9 | 8⅞ | 9⅛ | 5 6 10 | Jan., Apr., July, Oct. | 9 1/16 | 8¾ |
| £180,042 | 10 | 6% | Do. 6 per Cent. Preference | 14⅝ | 14⅞ | 14¾ | 15 | 4 0 0 | ,, ,, | 14 11/16 | 14⅝ |
| £150,000 | 10 | 5/0 | Great Northern | 15¾ | 16¼ | 16¼ | 16¾ | 4 9 7 | Jan., April, and July | 16¼ | 16 |
| £230,000 | 100 | 5% | Do. 5 per Cent. Debentures, 1883 | 104 | 107 | 105 | 108 | 4 12 7 | March & September | .. | .. |
| £17,000 | 25 | 12/6 | Indo-European | 35 | 37 | 35 | 37 | 6 15 2 | May and November | .. | .. |
| £38,348 | 10 | 4/0 | London Platino-Brazilian | 6 | 7 | 6 | 7 | 5 14 4 | ,, ,, | .. | .. |
| £100,000 | 100 | 6% | Do. 6 per Cent. Debentures | 107 | 110 | 107 | 110 | 5 9 1 | March & September | .. | .. |
| £9,000 | 8 | 4/0 | Reuter's | 8½ | 9 | 8½ | 9 | 5 11 1 | April and October.. | 8¾ | .. |
| £3,381 | £100 Cert. | 6% | Submarine Cables Trust | 110 | 114 | 110 | 114 | 5 5 3 | ,, ,, | 112¾ | .. |
| £15,609 | £10 | 6/6 | West African | 8 | 9 | 8 | 9 | 5 11 1 | January and July .. | .. | .. |
| £290,900 | 100 | 5% | Do. 5 per Cent. Debentures | 98 | 101 | 98 | 101 | 4 19 0 | March & September | 100½ | 98¼ |
| £30,000 | 10 | 3/0 | West Coast of America | 2 | 4 | 2 | 4 | .. | January and July .. | 3½ | .. |
| £150,000 | 100 | 8% | Do. Debentures 8% | 97 | 102 | 97 | 102 | .. | June and December | .. | .. |
| £38,321 | 10 | Nil. | West India and Panama | 2¾ | 3 | 2¾ | 3 | .. | .. | 2 15/16 | .. |
| £34,563 | 10 | 6/0 | Do. 1st Preference 6% | 11¼ | 11¾ | 11¼ | 11¾ | 5 2 2 | May and November | 11 9/16 | 11½ |
| £4,669 | 10 | £3 | Do. 6 p. c. 2nd Pref. | 11 | 12 | 11 | 12 | 5 0 0 | ,, ,, | .. | .. |
| £64,174 | 15 | 6/0 | Western and Brazilian | 10¾ | 11¼ | 10¾ | 11¼ | 5 6 8 | ,, ,, | 10¾ | .. |
| £27,873 | 7½ | 6/0 | Do. 5 per Cent. Cumulative Preferred | 6¼ | 6¾ | 6¼ | 6¾ | .. | .. | 6¾ | 6 9/16 |
| £27,873 | 7½ | 4/6 | Do. 5 per Cent. Deferred | 4½ | 5 | 4¼ | 4¾ | .. | .. | 4⅝ | .. |
| £200,000 | 100 | 6% | Do. 6 per Cent. Debs., Series "A" | 103 | 106 | 103 | 106 | 5 13 2 | February & August | .. | .. |
| £250,000 | 100 | 6% | Do. 6 per Cent. Mort. Debs., Series "B" | 103 | 106 | 103 | 106 | 5 13 2 | ,, ,, | .. | .. |
| $1,336,000 | $1,000 | 7% | Western Union 7 per Cent. 1st Mortgage | 120 | 125 | 120 | 125 | 5 12 0 | May and November | .. | .. |
| £175,100 | £100 | 6% | Do. 6 per Cent. Sterling Bonds | 99 | 103 | 99 | 103 | 5 16 0 | March & September | 103 | .. |
| | | | **TELEPHONES.** | | | | | | | | |
| £224,850 | 14/0 | 0/4½ | Consolidated Telephone Const. & Maintenance. | 7/16 | 9/16 | 7/16 | 9/16 | .. | May and November | .. | .. |
| £220,000 | £1 | 3% | Oriental (11s. paid) | ½ | ⅝ | ½ | ⅝ | 4 8 3 | Yearly | .. | .. |
| £138,984 | 5 | 3/0 | National | 4⅜ | 4⅝ | 4⅜ | 4⅝ | 5 18 11 | June and December | 4⅝ | 4 9/16 |
| £15,000 | 10 | 6/0 | Do. 6 per Cent. Cumulative 1st Pref. | 12 | 12½ | 12¼ | 12¾ | 4 14 1 | ,, ,, | 12 11/16 | 12¼ |
| £15,000 | 10 | 4/9⅗ | Do. 6 per Cent. Cumulative 2nd Pref. (£8 pd) | 10 | 10½ | 10 | 10½ | 4 11 5 | ,, ,, | .. | .. |
| £209,750 | 1 | ½% | South of England, Ordinary | ⅛ | ⅜ | ⅛ | ⅜ | .. | .. | .. | .. |
| £20,000 | 5 | 2/1 | Do. 6 per Cent. Cumulative Pf. (£3 10s. pd) | 2½ | 3 | 2¾ | 3¼ | .. | .. | .. | .. |
| £58,000 | 5 | 1/0 | United River Plate | 3 | 4 | 3 | 4 | .. | January and July .. | .. | .. |
| £146,128 | Stock | 5% | Do. 5 per Cent. Debenture Stock | 90 | 95 | 90 | 95 | 5 5 3 | .. | .. | .. |
| £3,200 | 100 | 7% | Do. 7 per Cent. Debentures | .. | | .. | | .. | .. | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | | | |
| £200,000 | £5 | .. | London Electric Supply | 1¾ | 2 | 2 | 2¼ | .. | .. | .. | .. |
| £43,900 | 10 | .. | Metropolitan Electric Supply (£8 paid) | 7¾ | 8¼ | 7¾ | 8¼ | .. | .. | 8⅛ | 7⅞ |
| £12,853 | 5 | .. | Westminster Electric Supply (£3 paid) | 2½ | 3 | 2½ | 3 | .. | .. | .. | .. |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | | | |
| £53,416 | 3 | .. | Brush Electrical Engineering | 1¾ | 2 | 2¼ | 2½ | .. | .. | 2½ | 2 |
| £63,416 | 2 | 0/10 | Do. 6 per Cent. Preference | 1½ | 2 | 1½ | 2 | 6 0 0 | June and December | 1 13/16 | 1¾ |
| £20,000 | 5 | 7% | Crompton and Co., 7 per Cent. Pref. Shares | 5 | 5½ | 5 | 5½ | 6 7 3 | January and July .. | .. | .. |
| £17,139 | 5 | .. | Edison and Swan United | .. | | .. | | .. | .. | .. | .. |
| £45,000 | 10 | 6% | Electric Construction | 7 | 7½ | 7 | 7½ | 8 0 0 | .. | 7½ | 7⅛ |
| £70,000 | 2 | 10/0 | Elmore's Patent Copper Depositing | 4 | 4½ | 4 | 4½ | .. | .. | 4¼ | 3 13/16 |
| £20,000 | 5 | .. | Fowler-Waring Cables (£4 paid) | 2½ | 3½ | 2½ | 3½ | .. | .. | .. | .. |
| £41,600 | 10 | 10/0 | India Rubber, Gutta Percha & Telegraph Works | 18½ | 19½ | 18½ | 19½ | 5 2 7 | February & August | 19 | .. |
| £200,000 | 100 | 4½% | Do. 4½ per Cent. Debentures, 1896 | 100 | 102 | 102 | 104 | 4 6 7 | March & September | .. | .. |
| £11,334 | £10 | .. | International Okonite, Ordinary xd | 8½ | 10 | 9¼ | 9¾ | .. | .. | .. | .. |
| £11,334 | £10 | .. | Do. Preference xd | 9½ | 10 | 9¼ | 9¾ | .. | .. | .. | .. |
| £78,949 | 5 | 10% | Swan United (£3. 10s. paid) ..10% for year | 4½ | 5 | 4½ | 5 | 6 19 10 | May and November | 4⅞ | 4⅝ |
| £37,350 | 12 | 12/0 | Telegraph Construction and Maintenance | 43 | 45 | 44 | 46 | 5 4 9 | March and July | .. | .. |
| £150,000 | 100 | 5% | Do. 5 per Cent. Bonds, red. 1894 | 100 | 102 | 101 | 103 | 4 17 1 | January and July . | .. | .. |



# BEFORE ORDERING!

## ELECTRICAL PLANT & ACCESSORIES

(Statter's) WRITE FOR THE FOLLOWING PAMPHLETS TO THE (United)

## ELECTRICAL ENGINEERING CORPORATION, Ld.

PLANT WORKS: WEST DRAYTON, near LONDON.
FITTINGS WORKS: ALBERT WORKS, 36, ALBERT EMBANKMENT, S.E.
LONDON OFFICES: 3, PRINCES MANSIONS, VICTORIA STREET, WESTMINSTER.

"ELECTRICAL DISTRIBUTION."—Commercially considered, with Estimates.

"MACHINE DRIVING BY ELECTRICITY."—The Uses of Electro-Motors for Traction and Stationary Purposes.

"THE TELPHER SYSTEM OF CHEAP TRANSPORT," for Minerals, Goods and Passengers.

"ELECTRICAL SUPPLIES."—Prices and Particulars of the most approved Electrical Appliances.

**ELECTRICAL PLANT ON VIEW.**

# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 662.—Vol. XXVI. FRIDAY, JANUARY 23, 1891. Price Fourpence.

## NOTES.

Although the process of hastening tanning by electricity is as yet in its infancy, the case of Worms and Balé v. Groth, which was decided last week, presented two points of interest. It was of the nature of a test case of the provisions of the Patent and Designs Act of 1883, with regard to the International Convention. Owing to want of space we have not given the arguments by the counsel in full, since the matter is thoroughly dealt with in the judgment. The invention was originally patented in France, and was afterwards patented in America, the drawings being identical, and the specification practically the same An abstract of this latter patent, in the United States Patent Office Journal, was received in England before the date of the English patent. It was pleaded that under the International Convention this would not be a "prior publication," but it was decided that the English patent was thereby invalidated. Attempts have been made to show that such official publications should not be treated as actual publications, but since they are reproduced in many technical journals they are undoubtedly a most efficient form of publication. The second point is one of more general interest, and concerns one of the most common kinds of infringement of a patent. To all of our readers who are inventors, and, indeed, to those who own or are interested in patents, we commend the careful perusal of Mr. Moulton's speech.

Of electrical tanning it is at present too early to say much. The terminology of the art has been enriched by two expressions put forward with some modesty by Mr. Justice Romer—"statical tanning," and "dynamical tanning." We shall soon hear of "electro-kinetic dermatization." It is true that a scientific explanation of the process was not called for during the recent action, but we doubt whether a clear theory could have been put forward among the three professors, headed by the President of the Institution of Electrical Engineers, to say nothing of the other experts. In the present state of knowledge it is sufficient to speak of the electrical action as being a hastening of the combination of tannin with the gelatin. Whether it be due to the acceleration of osmosis or to electrolysis, whether the current acts on the liquor or on the hides, or on neither, but merely facilitates the diffusion of the former through the latter, must be left to future experiments. That leather can be produced by this process with a most important saving of time is undeniable, and that the result may be either good leather or bad leather is worthy of a passing remark.

Mr. Swinburne has recently discussed in *Industries* the theories which have been advanced to explain the curious rise of pressure which occurs on the Ferranti mains. His contention that the effect is due to armature reactions in the dynamo was first explained in his Paper on condensers read before the Physical Society on December 12th, and has given rise to an interesting controversy. Our readers are already familiar, from articles we have published recently by Messrs. Glazebrook, Kapp, and Fleming, with what may be called the orthodox theory of the phenomenon, that of electric resonance, first clearly explained by Dr. Hopkinson in 1884. Mr. Swinburne's objection to this theory appears merely to refer to its name, his argument being that, as true resonance can only occur at one particular frequency, it is inaccurate to use the term to describe an effect which takes place more or less at all frequencies. This may be true, but is of minor importance. The point is, will Dr. Hopkinson's equation for the rise of volts, which Mr. Swinburne accepts and quotes, give an approximately correct result when the actual values are substituted for the self-induction of the armature, the frequency of the current, and the resistance and capacity of the cable. The advocates of the resonance theory do not assume that the condition for perfect resonance is fulfilled. When this is so, it is true, as Mr. Swinburne says, that a slight variation in the frequency of the current will produce a great fall in the voltage; but under ordinary circumstances this sensitiveness will not be exhibited, so that the absence of any such effect in the Deptford case is no argument against the theory.

The critical value of the inductance to give the greatest effect is far too large to occur in the transformers or in the armature of the dynamo, and the enormous potential of over ten million volts which this induction would cause has evidently nothing to do with the case, and is only instructive in showing the need, in alternate current work, of guarding against combinations in which the true resonance condition is approximately satisfied. Mr. Swinburne, however, shows that it is only necessary to have a self-induction of ·4 henrys somewhere in circuit to produce the rise of volts actually observed, and this does not appear to be too great for a large transformer whose secondary is working at very much below its full load. We cannot

Digitized by Google

agree with Mr. Swinburne that the self-induction of a converter, whose ratio is unit T, is the same as if the primary and secondary coils were joined in series in opposite directions. The two currents, although of equal amount, and in very nearly opposite phase, are sufficiently different to have an important magnetising effect, irrespective of any magnetic leakage which may take place in the converter, and although no measurements have been published, we believe that the difference in phase between the amperes and volts given out by the Deptford transformers is quite sufficient to account for the rise in volts observed on the mains.

It must not be supposed that we object to Mr. Swinburne's armature reaction theory. On the contrary, we think it exhibits his well known originality of thought and boldness of style, and is worthy of most careful consideration. It is quite independent of the theory of resonance, and may still be the explanation of part of the Ferranti effect. The Westinghouse constant current alternator, described in *The Electrician* for April 5th and June 13th of last year, is an instance of the possibility of altering the strength of field by merely shifting the phase of the armature current. In that dynamo the re-action of the armature on the field is so great that the voltage rises with the resistance of the external circuit so as to keep the current the same. It is this effect in a smaller degree which Mr. Swinburne assumes to take place in the Ferranti dynamo, the necessary shifting of phase being brought about by the condenser current whose phase is necessarily different from that of the other currents. The reaction of the armature current on the field as its phase is varied is an important subject which has yet to be studied in connection with the design of alternators. We agree with Mr. Swinburne that the idea of self-induction in connection with the armatures of alternators is misleading, and we would add that it is equally so in connection with the coils of transformers. A more simple and practical view is to consider merely the lines of force enclosed, and the reactive influence of the currents on them.

M. Branly has recently found that the spark of a Holtz machine or induction coil has a remarkable effect in temporarily decreasing the resistance of certain badly-conducting mixtures, such as powdered or oxidised metals, or pastes formed by immersing filings of iron, copper, or other metals in a non-conducting fluid. The effect is generally increased by connecting one or both of the sparking terminals with the substance under test, although the spark alone may be sufficient. In one case the resistance of a junction of two pieces of oxidised copper, as measured by a Wheatstone's Bridge, was reduced from 80,000 ohms to 7 ohms in this way. The diminution of resistance of such conductors may last for as long as 24 hours, unless the substance is disturbed by vibrations, in which case the high resistance is restored. The effect would appear to be the result of the high potential momentarily applied to the substance when the sparking takes place, and is probably only an exaggerated instance of the general tendency of high voltages to lower the resistance of bad conductors or dielectrics. The power of such voltages to prepare adjacent surfaces for conduction is often shown in overcoming the obstruction presented by a dirty joint between two copper wires. Such a connection, although appearing of infinite resistance when measured by a Wheatstone's Bridge, gives no trouble when high voltages are used, and if its resistance is measured by the Bridge after the current has passed its resistance is found to be inappreciable.

The impulsion effects of the photo-electric cells, described in Professor Minchin's paper on Photo-electricity, of which an abstract is given in another column, are very remarkable, and the explanation of them when found may very probably throw light on some of the obscure problems of molecular physics. The suggested application of the seleno-aluminium cell to the construction of a photometer capable of accurately comparing the light from different coloured sources, appears to be as hopeful as any of the chemical methods which have been suggested, and such an instrument is greatly needed. We direct our readers' attention to the announcement that the Paper will be discussed at the annual general meeting of the Physical Society on February 13th, and that the author, in compliance with a suggestion made by the President, will then repeat some of the experiments.

The revival of public interest has given rise to much inflated talk in the non-technical Press on the subject of electricity, but it remained for our weekly contemporary, the *World*, to outshine all previous performances in this direction. A few weeks ago that journal treated its readers to an amusing lucubration on the lighting of London, and in its last issue it outdoes itself in an article called "Lightning in Harness." A somewhat infelicitous title, since it is not, as we at first suspected, an advertisement of a certain eminent gentleman, disguised after the manner which now obtains with the *St. James'* and *Pall Mall Gazettes.* As a sample of the whole we quote the first paragraph:—"The electrician is your modern miracle-worker. In the sixteenth century he would have been convicted of collusion with the Devil, and the town would have turned out to see him fried. He has bottled Jove's lightning, and he retails it by the ampere. He sits by his dynamo like Zeus on Olympus, and he shakes the earth with his volts of pressure. At the wag of his forefinger, a hundred full moons dispel darkness from the habitations of men. His voice traverses the ocean depths and the haunts of leviathan, whom he could hook an he would! He can hold in the hollow of his hand the lightning equivalent of the force of five thousand horses—unconscious of its presence, and proof against sudden death. He is a walking paradox: he is two characters in one, for he is a lord because he is a thrall; he soars into the empyrean because he plods on the earth, plantigrade; he is Baconian philosophy incarnated, for more than any of the sons of men does he master Nature by obeying her. We stand uncovered before this astonishing thaumaturgist; for if he goes on at his present rate he will so transform industry and social conditions that the world will hardly know itself in fifty years." This may be English, though we doubt it. It is certainly nonsense.

Digitized by Google

**Lowestoft.**—The Town Council has decided to apply for an electric lighting order.

**Dublin.**—The discussion on the electric lighting tenders, to which we referred in our last issue, still continues.

**Stockholm.**—The electric lighting of Stockholm has, we learn, been entrusted to Messrs. Siemens and Halske, of Berlin. The installation will comprise 15,000 glow lamps.

**Woking.**—The Electric Light Committee of the Dorking Local Board paid a visit to Woking last week to inspect the electric light.

**Berlin.**—All theatres and places of amusement in Berlin capable of accommodating more than 800 persons have been ordered to be lighted by electricity by January next.

**Derby.**—At the last meeting of the Town Council, the report of the Electric Lighting Committee, recommending the obtaining of a report from Sir Frederick Bramwell, was adopted after some discussion.

**Cable Extensions.**—The s.s. "Silvertown" completed, on the 15th inst., the Chorillos-Yquique section of the new Central and South American Company's cables between Chorillos, Yquique, and Valparaiso.

**The East African Company's Land Lines.**—The Imperial East African Company have opened a telegraph station at Malindi, on the land line they are constructing towards the Lakes. The line is now open to the public for traffic.

**Cambridge.**—Prof. Ewing delivered his inaugural lecture on Tuesday. A grace will be brought forward at the next congregation to confer the degree of Master of Arts (Honoris Causa) upon the new professor.

**Tunis.**—A telephone exchange will be opened at Tunis about the middle of February, and already about 100 subscribers have been obtained. The suburbs of La Goulette and of La Mersa will be included in the system.

**Royal Society.**—At the last meeting of the Royal Society the following papers were down for reading:—H. Wilde, F.R.S., "On the Unsymmetrical Distribution of Terrestrial Magnetism." T. Andrews, F.R.S., "The Passive State of Iron and Steel.—Part II."

**Utilisation of the Water-power of the Reuss.**—A Zürich Company is endeavouring to obtain a concession from the authorities of Aargau for building a canal on the left bank of the Reuss. The power obtained is to be used for industrial purposes.

**The Consumption of Electricity in Paris.**—The gross receipts of the central stations of the Compagnie Continentale Edison for December last amounted to £7,879. Taking the price per 1,000 watt-hours at 1fr. this denotes an output for the month of about 197,000 units.

**Electric Lighting and Transmission of Power at Spandau.**—The Berliner Maschinenban Actien-Gesellchaft has just completed an installation consisting of 3,000 glow lamps and 80 arcs at the Spandau Small Arms Factory. A 29 horse-power electric motor is also used to drive boring machines, lathes, &c.

**The Mayer Electric Motor.**—The American technical journals describe a motor designed by a Mr. Mayer, of New York. The motor is of the single-magnet, two-pole, iron-clad type. The whole of the magnetic circuit is stamped out of one sheet of Swedish iron, the sheets being bolted together to form the magnet frame.

**A New Insulator.**—Mr. F. N. Gisborne, the superintendent of Canadian Telegraphs, has recently tested the insulating properties of samples of the petroleum-saturated sand, which is found in large quantities in the Athabasca district in North-West Canada, and speaks of it most highly. This sand lies exposed all along the Athabasca River, and has a saturation of 12 per cent. of petroleum.

**Eastbourne.**—The Eastbourne Electric Lighting Company contemplate considerable additions to their plant. An order has been given by the Marquis of Hartington for an installation at Compton-place, and the electric light is also to be introduced into the Clifton Hotel. There are now between 3,000 and 4,000 lamps connected to the alternate current mains, exclusive of those which are run off the arc light mains.

**Glasgow.**—There does not seem to be much disposition on the part of the special committee on electric lighting to promptly carry out the Provisional Order of last Session. Mr. Crompton's report has been in type several months, and within the past few weeks Prof. Jamieson has been called in to advise the committee. Meanwhile the Board of Trade has inquired as to what system of lighting has been resolved upon.

**Village Lighting in Germany.**—The Allgemeine Elektricitats Gesellschaft of Berlin have concluded arrangements for lighting the villages around Nuremberg. A central station is to be established in a factory at Schnigling, and sub-stations will be erected as required. The price for current has been fixed at what is equivalent to 9½d. per Board of Trade unit, with a rebate up to 5 per cent. according to the consumption.

**Private Telephone Lines.**—In the country the telephone is beginning to make its way in the direction of private lines and local exchanges. The Directors of the Hebden Bridge Co-operative Industrial Society have just decided to adopt a system of telephonic communications between the Central Stores and their several country branches, and the work has been entrusted to Mr. R. S. Blackburn, of that town.

**London Electric Supply Corporation.**—This Company was sued on Monday by Mr. Samuel for £72 for damage done to his stable and its contents. The stable is in Brad-street, close to the bridge of the South-Eastern Railway Company at Waterloo Bridge. According to the plaintiff the servants of the Company trespassed on to his roof at the stable while cutting the electric cable which runs to Deptford to test it. A verdict was given for the plaintiff for £65.

**The Hanover-square School of Electrical Engineering.**—We are informed that Mr. Léon Drugman, the manager of this school, has obtained the consent of Sir Samuel Canning, Dr. P. Herbert Carpenter, F.R.S., Mr. Gisbert Kapp, and Prof. Alex. B. W. Kennedy, F.R.S., to form a permanent "Consulting Committee," who will have the control of the teaching of the school. We congratulate the school upon having secured such valuable co-operation.

**Electric Light along a Railway.**—Not content with adopting electric head-lights for their locomotives, the Americans now propose to actually light a railway line. The line of the Pennsylvania Company from Frankford Creek to Povuessing Creek, at Torresdale, a distance of nearly seven miles, is to be lighted by electric lights placed at intervals along the side of the track. The line to be lighted runs through a populous district, and has long been noted for the frequency of accidents on it.

**The Woodward Storage Battery.**—Dr. Woodward, of the Woodward Electrical Company of Detroit, has arrived in this country with a view of establishing electric works in England for the manufacture of the Woodward Battery. One special advantage claimed by Dr. Woodward for his new type cylindrical battery, which is made in various sizes, from 100 ampere-hours capacity up to 2,000 ampere-hours, is that it will stand a much higher rate of charge and discharge than the grid form of plate, and buckling of the cylinders is impossible.

**The French Telegraph Service.**—According to *La Lumière Electrique*, the telegraphic work in connection with some recent trials at Draguignan, near Toulon, proved too much for the French telegraphic service, the leading Paris papers complaining that their despatches took seven hours to traverse the 500 miles separating Draguignan from the capital. As Draguignan is only a town of some 10,000 inhabitants, it is perhaps surprising that the messages arrived as soon as they did, if no additional apparatus and staff were available.

**Load Diagrams of the St. James's and Pall Mall Company.**—The following footnotes should have been printed under the load curves of this Company's station, which appeared on page 334 of our last issue.

| | | | |
|---|---|---|---|
| Monday, December 1st, | Units generated, | 3,915 | |
| | " on station, | 105 | |
| | " metered, | 3,715 | at 7d.=£108 7s. 1d. |
| Monday, December 22nd, | Units generated, | 6,177 | |
| | " on station, | 112 | |
| | " metered, | 5,913 | at 7d.=£172 9s. 3d. |

Digitized by Google

**Contracts by Telephone.**—On Thursday, last week, in the Westminster County Court, the case of Mitchell *v.* Isaacs came before Judge Bayley. The plaintiff sought to recover 13s. 6d. for a stall ticket for Drury Lane Theatre. The case for the plaintiff was, that in December they got a message through the telephone to send a stall ticket to 2, Tavistock-square, for Mr. A. Isaacs. The ticket was sent and handed to a servant. Defendant denied ordering the ticket, and said it must have been a joke of someone's. He had never had the ticket. Judgment was given for the defendant.

**City and South London Railway.**—The traffic receipts of this Company for the week ended January 17th amounted to £758, against £748 for the week preceding. The line has now been open to the public for a month, the regular service of trains having commenced on December 18th. The total receipts for this period amount to £3,453, showing that over 414,000 passengers have passed the turnstiles, the daily average, if we exclude Sundays (when the trains do not run) amounts, therefore, to 15,347. If the monthly receipts are maintained throughout the year at this figure they will amount to £41,436.

**Relative Consumptions of Gas and Electricity in the Metropolis.**—Taking the figures quoted in Mr. Bailey's recent Paper before the Society of Arts, Mr. John T. Sheard, in a letter to the *Journal of Gas Lighting*, works out that if all the incandescent lamps at present in use in the Metropolis were replaced by gas-burners giving the same amount of light an additional annual consumption of nearly 500,000,000 cubic feet might be anticipated. He hastens, however, to point out that this is only $1\frac{2}{3}$ per cent. of the present total gas consumption of the Metropolis, which attained in 1890 the gigantic total of 30,707,000,000 cubic feet.

**The St. Luke's Vestry and Electric Traction.**—On Monday last the St. Luke's Vestry, accompanied by their surveyor and the engineer of the North Metropolitan Tramways Company, visited the General Electric Power and Traction Company's electric cars and installation on the Barking-road section of the North Metropolitan Tramways Company's system. Having made a minute inspection of the working of the cars, the members of the Vestry expressed themselves as greatly pleased at all they had seen. As the Tramway Company has signified its intention to run electric cars from Stamford-hill to Moorgate-street, and as this Vestry controls a portion of the route, their inspection was on that account most exhaustive.

**Brighton.**—At the last meeting of the Town Council, the General Purposes Committee submitted draft objections to the application of the Brighton and Hove Electric Light Company for a Provisional Order. The adoption of the Report met with some opposition, one member asking why, if the Corporation were not going to supply a certain part of the town, they should prevent a company from doing so? Alderman Ewart denied that the Corporation policy was a dog-in-the-manger policy. He denied that they were spending the ratepayers' money. They were making an investment which would turn out, if they only supported it as they should do, one of the grandest investments ever made in any town of the kingdom. The report and the draft objections were finally adopted.

**London Chamber of Commerce.**—The following are the agenda for the meeting of the Electrical and Allied Trades' Section Committee to be held on Monday next. (1) Board of Trade Provisional Orders in regard to telephones, suggested modifications in; (2) Board of Trade rules and regulations, re overhead wires; report of Sub-Committee; (3) Board of Trade forms of accounts, report of Sub-Committee; (4) Board of Trade Electrical Standards Committee, correspondence in connection with; (5) Proposed exhibition in London of electrical appliances, letter from Mr. Seymour Wade; (6) St. Pancras Electrical Exhibition, letter from Messrs. W. T. Goolden and Co.; (7) Automatic Electric Railway signalling, letter from Mr. Martin Perls proposing address on "Is railway travelling safe as managed at present?" (8) Other matters.

**St. Pancras.**—Mr. Alderman T. E. Gibb, clerk of the Vestry, presented a report to the Electricity Committee last week on the subject of the holding of an exhibition of electrical appliances at the Vestry Hall, with a view of informing those who are to be served by the Stanhope-street Station and the parishioners generally on questions concerning the uses of electricity for lighting purposes and motive power. By June next, he stated, the Stanhope-street Station will be completed, and already many of the inhabitants of the district were asking for information about terms, mode of supply, and the most economical mode of fitting up their houses and shops. This information the proposed exhibition would supply. The Committee have approved the proposal conditionally upon no part of the cost being charged to the rates.

**Photographic Registration of the Movements of the Seismo-Microphone.**—According to the *Rivista Scientifico-Industriale*, Signor Baratta, finding some defects in the method of mechanical registration of the motions of the seismo-microphone, has substituted a photographic system with advantage. The device is briefly this:—The telephone wire is connected with a subterranean microphone. Before the telephone-diaphragm, and connected with its centre by a fine aluminium wire, is a short slip of the same metal, fixed below, and having a curved piece at the top, which rests against a small mirror, movable about a horizontal axis. This mirror reflects the light from a lamp and lens to photographic paper on a rotated drum. The light is momentarily shut off every quarter of an hour, by a shutter arrangement, worked electro-magnetically by the clockwork which moves the drum.

**Matlock.**—At the meeting of the Local Board last week some reports were presented upon the question of electric lighting. Mr. Etheridge said he had no desire to bore the Board with a lot of correspondence, but his object was to ask for a committee to be appointed, empowered with authority to go into the subject of electric lighting. He had a letter from the Chairman of the Lynton Local Board, showing that they were highly pleased with the electric light there. Mr. George Fletcher, electrician to the Midland Railway Company, wrote that Mr. Cameron, whose opinion could be relied upon, was convinced, after visiting the district, that there would be no difficulty in getting at least 100 horse-power from the river without interfering with the works already using water-power. Mr. Etheridge, in conclusion, suggested that they should accept the offer of Mr. Geen, of Okehampton, to come and report, and that a committee should be formed to meet the engineers. The resolution was carried *nem. con.*

**Henderson Multiple Carbon Arc Lamp.**—The cost of trimming arc lamps was very early recognised to involve a not inconsiderable part of the total operating expense in arc lighting, and to this fact, says the *Electrical Engineer* of New York, the creation of the double carbon lamp is due. Still another method which has lately been brought out consists in providing a number of sets of carbons, each of which is successively brought into action as its predecessor is consumed. A lamp based upon this principle has recently been devised by Mr. W. B. Henderson, of Crafton, Pa. Six pairs of carbons are employed, mounted on two hubs which are controlled by the lamp mechanism. Each pair of carbons starts into operation at an angular position, and as they burn away the hubs are revolved so as to bring the points towards each other; so that when fully consumed the carbons are exactly in a horizontal position. When this point is reached, the mechanism automatically brings the succeeding pair of carbons into circuit, and this operation is continued until all the carbons are consumed.

**The Perrier-Lloyd Generator.**—Two actions in connection with this primary battery were heard last week at the Sheriffs' Court. Mr. Joseph Mitchell, of Bolton Hall, Yorkshire, a colliery proprietor, was the plaintiff; and the defendant, Mr. De Vesey, was the proprietor of the patent known as the "Perrier-Lloyd" for generating electricity by chemicals. Plaintiff stated that in July, 1889, the defendant called upon him and showed him two pamphlets, which went to prove that this patent could produce electricity free of cost, and was to be applied to the lighting of the streets of London under the direction of Sir Henry Roscoe. He persuaded him to advance him £2,800 to float the scheme. Mr. Scudder, principal assistant to Sir Henry Roscoe, gave evidence to the effect that the system was tried in London, and found to be an utter absurdity. The jury awarded the plaintiff the sum of £2,800 damages. In the second action, Mr. William Cox, of Fairfield Hall, Harrogate,

Digitized by Google

Yorkshire, sued for the return of £2,200 advanced to the defendant under similar circumstances. The jury assessed the damages at that amount.

**Sophia.**—In our issue of December 5, 1890, we referred to the discontent which had been aroused by the perfunctory manner in which the Committee entrusted with the examination of the electric lightings tenders, invited by the municipal authorities of Sophia, had performed its duties. The following are some further particulars connected with this scheme. The plant was to be installed at the Government printing-office, and current was to be supplied to the Palace about half-a-mile away, and to the Sobranje, 286 yards distant. The total light required was estimated at 12,500 candles by arcs, and 25,000 candles by incandescents. A storage battery was to be employed as a reserve. The following tenders were received:—Egger and Co. (Vienna), £9,328; Ganz and Co., £9,535; Schuckert (Nuremberg), £9,768; Siemens and Halske, £11,158; Sautter-Harlé, £11,600; Société Gramme, £13,440; Kremenezky, £13,500; Compagnie Continentale Edison, £15,120 and £15,881; Crompton and Co., £11,120 and £15,290; Allgemeine Elektricitäts Gesellschaft, £15,940; Southgate Engineering Company, £16,896; Société d'Appareillage Électrique (Paris), £48,000. The contract was given, as we announced previously, to Egger and Co., of Vienna.

**Lightning in a Cable Station.**—The following extract from a letter of Mr. Bonnard, by the West African Telegraph Company, may be of interest:—

"Kotonou, November 30, 1890.

"I have also the honour of confirming my service telegram of the 27th instant, in which I informed you that the lightning struck our house, happily without causing any harm beyond damaging some furniture. The weather was fine, the sun was shining, and only a dry storm-cloud was threatening on the Porto Novo side. All at once a tremendous explosion resounded, and a light, taking the form of a ball of fire, ran along the air passage of the ventilator to the verandah. At that moment we were receiving a despatch from Accra. Nobody was injured, but Mr. Orsini was hurled about two yards from the door without, however, sustaining any serious bruises; and Mr. Thomas and myself received a violent shock. Several wires of the lightning guard were fused. This is the first time such an accident has happened to us, and I think I can explain it in this way:—During the late hostilities, the wood which used to lie about 200 yards on the west of our station was cut down. The trees in it were very high, and, as these trees and thick damp bushes no longer exist around us, the result is that our metal roof, which has an area of about 150 square yards, attracts the atmospheric discharges more readily. I think that to fix a lightning protector would be a useful precaution for the future. The damage done to our furniture is as follows:—The large beams of the ventilator were split from one end to the other, the partitions of the office were much shaken, the roof has been badly damaged, and two legs of the bedstead in Mr. Lefebore's room twisted. The station clock has either kept very bad time or not gone at all since this accident.

**The German Telegraph Tariff.**—On the advice of Herr von Stephan, the German Government has reduced the tariff for inland telegrams from six to five pfennigs a word, with a minimum charge of fifty pfennigs, or sixpence. Herr von Stephan has, however, resisted all demands for a tariff for press telegrams similar to that existing in England. Speaking last week before the Budget Committee of the Reichstag, Herr von Stephan, in the name of the Federal Government, declared that he saw no good and sufficient reason to yield to the demand of the 234 newspapers which had petitioned for a reduced tariff for press telegrams. These newspapers, he said, had already enjoyed advantages enough in the lowness of the rates for their postal transmission, as well as in the comparative cheapness of the wires of which they might have the special use at night. Of over 14 million telegrams that were last year sent and delivered within the Empire only 1·29 per cent. were press messages, representing a revenue to the State of about 153,000 marks, or £7,600. If the press were granted a special price for telegrams, charitable societies, universities, &c., would be sure to follow suit with similar requests for exceptional treatment which could never be accorded. The present tariff was not too high, as witness the many unnecessary telegrams which the newspapers printed.

**The Central London Railway.**—The following are the principal differences between the Central London Railway Bill of last year and that which will come before Parliament during the present Session. The line as now proposed runs from Shepherd's Bush to Cornhill, and the western terminus will be on land adjoining the Shepherd's Bush sidings of the London and North-Western Railway. This makes the entire length of the line six miles, instead of four and a-half miles, and, besides accommodating a wider district, enables the Company to purchase the land for its western terminus at a much lower figure than would be required to acquire expensive house property like that at Kensington. The Post Office station has been moved to the north side of Newgate-street, presumably in deference to the views of the authorities of St. Paul's Cathedral. A station is to be made at Chancery-lane. A new station is to be constructed between the Marble Arch and Oxford-circus, at the corner of Davies-street, near Bond-street. A new station is also proposed at Notting-hill Gate, in close proximity to the existing underground railway, which will enable passengers to change there from one line to the other; and the extension to Shepherd's Bush also involves a new station at Lansdowne-road (opposite Holland Park) and the terminal station at Shepherd's Bush. An examination of the plan shows that the line generally is placed at a somewhat deeper level than last year.

**The Edinburgh Municipal Electric Lighting Order.**—The Leith Corporation have lodged objections against the Edinburgh Electric Lighting Provisional Order. They point out that the rates of Leith are impledged similarly with those of Edinburgh in connection with the joint gas undertaking, and they protest in the strongest possible manner against the Corporation of Edinburgh having the power to transfer their electric lighting undertaking to the Gas Commissioners, and so cast the financial and other responsibilities of the undertaking upon funds in which Leith and Edinburgh are equally interested. The Leith Corporation desire the insertion of a proviso to the effect that such transfer shall not be made unless agreed to by them, and that if they consider that the price of gas supplied is higher than it would have been put but for the introduction and supply of electric light by the Corporation of Edinburgh, they may from time to time make a representation to the Board of Trade that such is the case, and the Board of Trade may direct an inquiry by a referee into the truth of the representation, and if the referee find that the price of gas is higher by reason of the exercise of the powers of the Order, he shall fix the extent to which it is so affected, and shall order a corresponding reduction of the price of gas within the burgh of Leith, the gross amount of such reduction to be recoverable from the Corporation of Edinburgh by the Gas Commissioners

**The Westinghouse Interests.**—Referring to the recent financial difficulties of the Westinghouse Company (see *Electrician*, January 16th, page 339), *Modern Light and Heat* says:—"The crisis has come at last, and George Westinghouse, jun., is seriously embarrassed financially. The story has been told by the daily press throughout the country, hence it is not necessary that we should repeat it. Let it suffice that Pittsburg capitalists have had to come to the relief of Mr. Westinghouse, and still, with all their efforts, only $520,000 is reported as subscribed, which amount has been contributed, it is stated, by forty-five individuals and corporations, Mr. Westinghouse giving as security for the amount a mortgage on his property at Homewood, consisting of twenty-three acres of land and a mansion; also thirty-five acres of land at Swissvalle and the Watts farm of twenty-three acres; also an assignment of such personal collateral as the Committee shall be able to obtain from Mr. Westinghouse. These facts, it would seem to us, argue that the affairs of Mr. Westinghouse are even worse than has been published. . . . If, as reported by the Examining Committee, the gross earnings of his various enterprises for this year amount to $16,550,000, it would appear to us that it ought to have been an easy matter for Mr. Westinghouse to raise from any one or two financial corporations of Pittsburg, or anywhere else, notwithstanding the tight Money Market, the amount that has been subscribed. . . . The Westinghouse Electric Company's debt is stated as being $3,339,900, to offset which it is credited with accounts receivable, cash, &c., amounting to $1,436,000, and material in stock amounting to $780,000. Quite a different showing from that on made in its statement the first of last June."

Digitized by Google

## INSTITUTION OF ELECTRICAL ENGINEERS.

PRESIDENTIAL ADDRESS OF PROF. WILLIAM CROOKES, F.R.S.

### Electricity in Transitu : from Plenum to Vacuum.

(*Continued from p. 327.*)

*Radiant Matter.*

By means of this tube (Fig. 9), I am able to show that a stream of ultra-gaseous particles, or radiant matter, does not carry a current of electricity, but consists of a succession of negatively electrified molecules whose electrostatic repulsion overbalances their electro-magnetic attraction, probably because their speed along the tube is less than the velocity of light. The tube has two negative terminals A, A′, close together at one end, enabling me to send along the tube two parallel streams of radiant matter, rendered visible by impinging them through holes in a mica diaphragm on a screen of phosphorescent substance. It is exhausted to a pressure of 0·1 mm. I connect one of the negative poles, A, with the induction coil, and the luminous stream darts along the tube from C to D parallel with the axis. I now connect the other negative pole, giving a second parallel stream of radiant matter. If these streams are in the nature of wires carrying a current they will attract each other, but if they

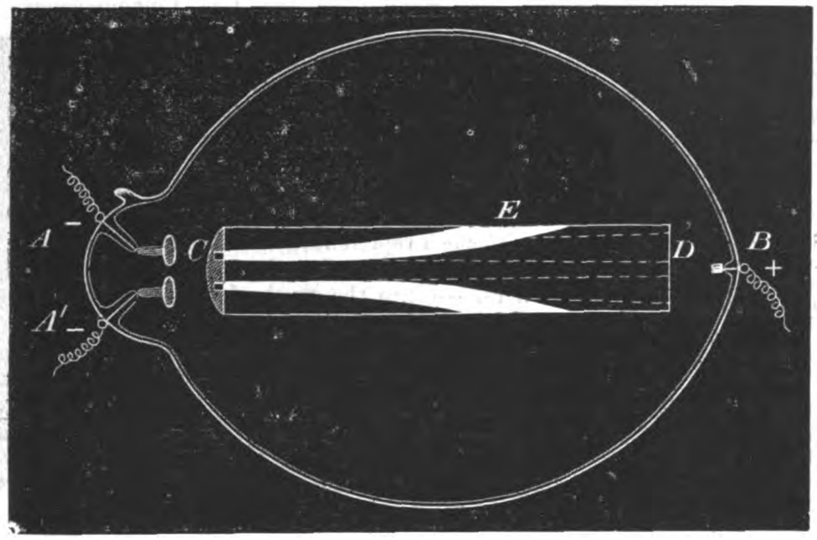



Fig. 9.—Pressure = ·1 mm. = 131·5 M.

are simply two streams of electrified molecules they will repel each other. As soon as the second stream is started you see the first steam jump away in the direction C E, showing strong repulsion, proving that they do not act like current carriers, but merely like similarly electrified bodies. It is, however, probable that were the velocity of the streams of molecules greater than that of light, they would behave differently, and attract each other, like conductors carrying a current. To ascertain the electrical state of the residual molecules in a highly exhausted tube, such as you have just seen, I introduced an idle pole or exploring electrode between the positive and negative electrodes in such a manner that the molecular stream might play upon it. The intention was to ascertain whether the molecules on collision with an obstacle gave off any of their electrical charge. In this experiment (Fig. 10, P = 0·0001 mm., or 0·13 M.*) it was found that an idle pole, C, placed in the direct line between the positive and the negative poles, A B, receiving in consequence the full impact of the molecules shot from the negative pole, manifested a strong *positive* charge. In a variety of other experiments made to decide this question, the electricity obtained was always found positive on testing with the gold leaf or Lippman's electrometer, and when the idle pole was connected to earth through a galvanometer a current passed as if this pole were the copper element of a copper-zinc cell, indicating leakage of a current to earth, the idle pole being positive. If, instead of sending this current to earth, the wire was connected to the negative pole of the tube, a much more powerful current passed in the same direction.

* M = one-millionth of an atmosphere.
1,000,000 M = 760 mm.
" = one atmosphere.

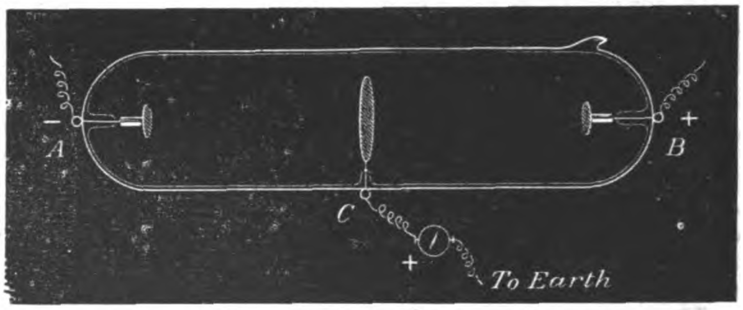



Fig. 10.—Pressure = ·0001 mm. = ·13 M.

*The Edison Effect.*

An exactly parallel experiment has been made by Mr. Edison, Mr. Preece, F.R.S., and Prof. Fleming, using, instead of a vacuum tube, an incandescent lamp. They found that from an idle pole placed between the ends of the filament the electricity always flowed as if the pole were the zinc element of a copper-zinc cell; having repeated their experiments I entirely corroborate them. I get a powerful current in one direction from an idle pole placed between the limbs of an incandescent carbon filament, and one in the opposite direction from an idle pole in a highly exhausted vacuum tube. This discrepancy was extremely puzzling, and I tested, with a similar result, very many experimental tubes made in different ways. The electricity obtained from an idle pole placed between the positive and negative terminals in a highly exhausted tube was always strongly *positive*, and it is only recently that continued experiment has cleared the matter up.

Some of the contradictory results are due to the exhaustion not being identical in all cases. In my vacuum tubes the directions of current between the idle pole and the earth changes from negative to positive as the exhaustion rises higher. Testing the current when exhaustion is proceeding, there is a point reached when the galvanometer deflection—hitherto negative—becomes *nil*, showing that the potential at this point is zero. At this stage the passage of a few more drops of mercury down the pump tube renders the current positive. This change occurs at a pressure of about 2 mm.

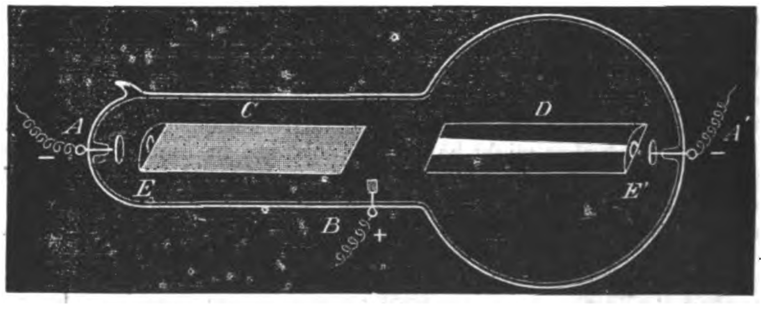



Fig. 11.—Pressure = ·0011 mm. = 1·3 M.

After this point is reached, when the induction current is passed through the tube, the walls rapidly become positively electrified, probably by the friction of the molecular stream against the glass, and this electrification extends over the surface of any object placed inside the tube. I will show you how this electrification of the inner walls of the tube acts on the molecular stream at high vacua. In this tube, Fig. 11

(P = 0·001 mm. or 1·3 M), are fixed two exactly similar phosphorescent screens, C and D; at one end of each is a mica gate, E, E', with a negative pole A, A', facing it. One of the screens, C, is in the cylindrical part of the tube and close to the walls; the other, D, is in the spherical portion, and therefore far removed from the walls. On passing the current the screen D in the globe shows a narrow sharp streak of phosphorescence, proving that here the molecules are free to follow their normal course straight from the negative pole. In the cylindrical part of the tube, however, so great is the attraction of the walls that the molecular stream is widened out sufficiently to make the whole surface of the screen, C, glow with phosphorescent light.

If an idle pole, C, C, Fig. 12 (P = 0·0001 mm. or 0·13 M), protected all but the point by a thick coating of glass, is brought into the centre of the molecular stream in front of the negative pole A, and the whole of the inside and outside of the tube walls are coated with metal, D, D, and "earthed," so as to carry away the positive electricity as rapidly as possible, then it is seen that the molecules leaving the negative pole and striking upon the idle pole C on their journey along the tube carry a negative charge, and communicate negative electricity to the idle pole.

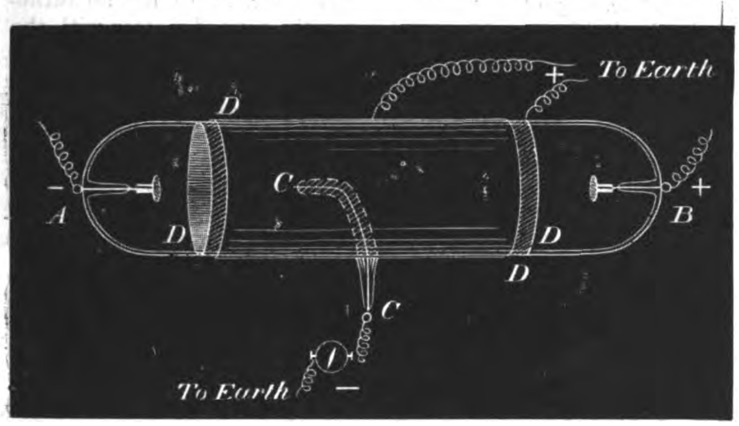



Fig. 12.—Pressure = ·0001 mm. = ·13 M.

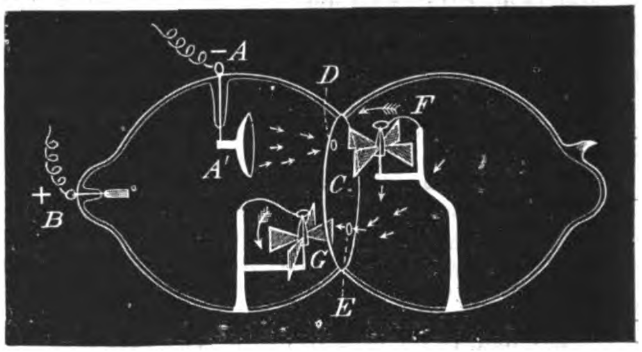



Fig. 14.—Pressure = .001 mm. = 1·3 M.

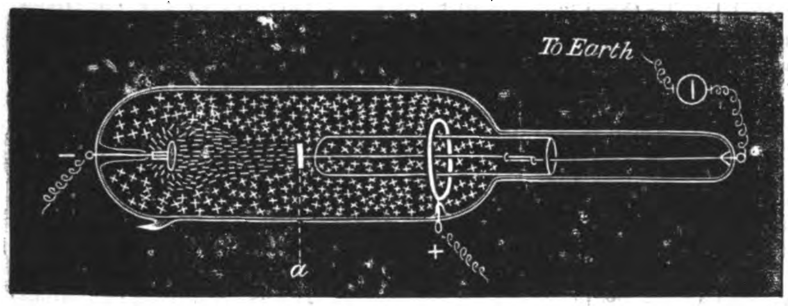



Fig. 13A.—Pressure = ·0001 mm. = ·13 M.

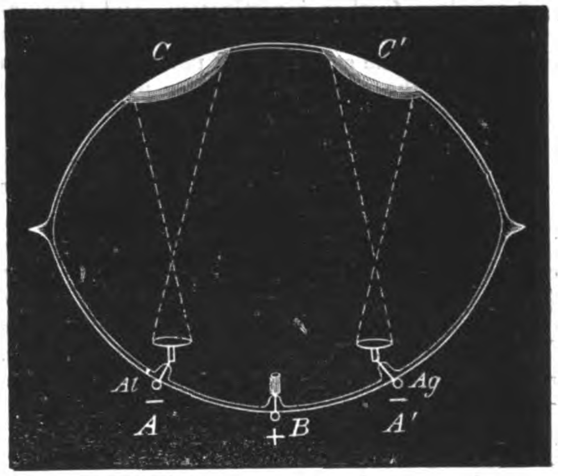



Fig. 15.—Pressure = ·00068 mm. = ·9 M.

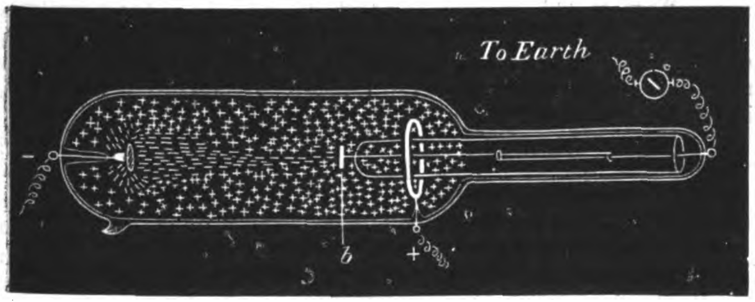



Fig. 13B.—Pressure = ·0001 mm. = ·13 M.

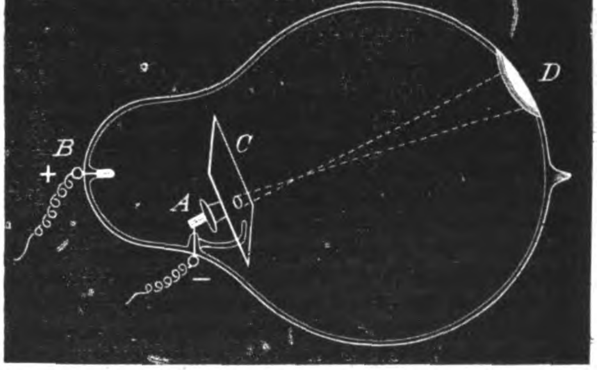



Fig. 16.—Pressure = ·00068 mm. = ·9 M.

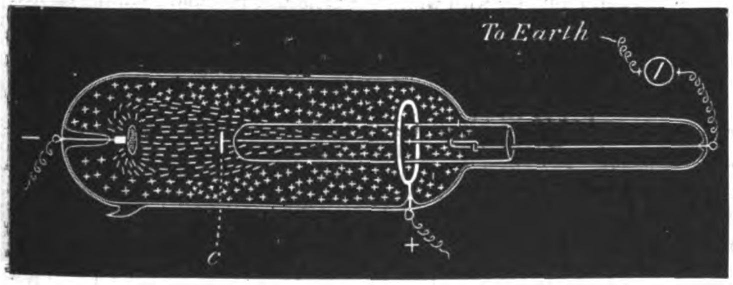



Fig. 13c.—Pressure = ·0001 mm. = ·13 M.

This tube is of interest since it is the one in which I was first able to perceive how in my earlier results I always obtained a positive charge from an idle pole placed in the direct stream from the negative pole. Having got so far, it was easy to devise a form of apparatus that completely verified the theory, and at the same time threw considerably more light upon the subject. Fig. 13, *a*, *b*, *c*, is such a tube, and in

Digitized by Google

this model I have endeavoured to show the electrical state of it at a high vacuum by marking a number of + and − signs. The exhaustion has been carried to 0·0001 mm. or 0·13 M, and you see that in the neighbourhood of the positive pole and extending almost to the negative, the tube is strongly electrified with positive electricity, the negative atoms shooting out from the negative pole in a rapidly diminishing cone. If an idle pole is placed in the position shown at Fig. 13, *a*, the impacts of positive and negative molecules are about equal and no decided current will pass from it through the galvanometer to earth. This is the *neutral* point. But if we imagine the idle pole to be as at Fig. 13, *b*, then the positively electrified molecules greatly preponderate over the negative molecules, and positive electricity is shown. If the idle pole is now shifted, as shown at Fig. 13, *c*, the negative molecules preponderate, and the pole will give negative electricity.

As the exhaustion proceeds. the positive charge in the tube increases, and the neutral point approaches closer to the negative pole, and at a point just short of non-conduction so greatly does the positive electrification preponderate that it is almost impossible to get negative electricity from the idle pole, unless it actually touches the negative pole. This tube is before you, and I will now proceed to show the change in direction of current by moving the idle pole.

I have not succeeded in getting the "Edison" current n incandescent lamps to change in direction at even the highes degree of exhaustion which my pump will produce. The subject requires further investigation, and like other residual phenomena these discrepancies promise a rich harvest of future discoveries to the experimental philosopher, just as the waste products of the chemist have often proved the source of new and valuable bodies.

*Properties of Radiant Matter.*

One of the most characteristic attributes of radiant matter —whence its name—is that it moves in approximately straight lines and in a direction almost normal to the surface of the electrode. If we keep the induction current passing continuously through a vacuum tube in the same direction, we can imagine two ways in which the action proceeds; either the supply of gaseous molecules at the surface of the negative pole must run short, and the phenomena come to an end, or the molecules must find some means of getting back. I will show you an experiment which reveals the molecules in the very act of returning. Here is a tube (Fig. 14) exhausted to a pressure of 0·001 mm. or 1·3 M. In the middle of the tube is a thin glass diaphragm, C, pierced with two holes, D and E. At one part of the tube a concave pole, A′, is focussed on the upper hole, D, in the diaphragm. Behind the upper hole and in front of the lower one, are movable vanes, F and G, capable of rotation by the slightest current of gas through the holes.

On passing the current with the concave pole negative, the small vanes rotate in such a manner as to prove that at this high exhaustion a stream of molecules issues from the lower hole in the diaphragm, whilst at the same time a stream of freshly charged molecules is forced by the negative pole through the upper hole. The experiment speaks for itself, showing as forcibly as an experiment can show that so far the theory is right.

This view of the ultra-gaseous state of matter is advanced merely as a working hypothesis, which, in the present state of our knowledge, may be regarded as a necessary help to be retained only so long as it proves useful. In experimental research early hypotheses have necessarily to be modified, or adjusted, or perhaps entirely abandoned, in deference to more accurate observations. Dumas said, truly, that hypotheses were like crutches which we throw away when we are able to walk without them.

*Radiant Matter and "Radiant Electrode Matter."*

In recording my investigations on the subject of radiant matter and the state of gaseous residues in high vacua under electrical strain, I must refer to certain attacks on the views I have propounded. The most important of these questionings are contained in a volume of "Physical Memoirs," selected and translated from foreign sources under the direction of the Physical Society (Vol. I., Part 2). This volume contains two memoirs, one by Hittorff on the "Conduction of Electricity in Gases," and the other by Puluj on "Radiant Electrode Matter and the So-called Fourth State." Dr. Puluj's Paper concerns me most, as the author has set himself vigorously to the task of opposing my conclusions. Apart from my desire to keep controversial matter out of an address of this sort, time would not permit me to discuss the points raised by my critic; I will, herefore, only observe in passing that Dr. Puluj has no authority for linking my theory of a fourth state of matter with the highly transcendental doctrine of four dimensional space.

Reference has already been made to the mistaken supposition that I have pronounced the thickness of the dark space in a highly-exhausted tube, through which an induction spark is passed, to be identical with the natural mean free path of the molecules of gas at that exhaustion. I could quote numerons passages from my writings to show that what I meant and said was the mean free path as amplified and modified by the electification.* In this view I am supported by Prof. Schuster,† who in a passage quoted below distinctly admits that the mean free path of an electrified molecule may differ from that of one in its ordinary state.

The great difference between Puluj and me lies in his statement that‡ "*the matter which fills the dark space consists of mechanically detached particles of the electrodes which are charged with statical negative electricity, and move progressively in a straight direction.*"

To these mechanically detached particles of the electrodes, "of different sizes, often large lumps," § Puluj attributes all the phenomena of heat, force, and phosphorescence that I from time to time have described in my several Papers.

Puluj objects energetically to my definition "Radiant Matter," and then proposes in its stead the misleading term, "Radiant Electrode Matter." I say "misleading," for while both his and my definitions equally admit the existence of "Radiant Matter," he drags in the hypothesis that the radiant matter is actually the disintegrated material of the poles.

Puluj declares that the phenomena I have described in high vacua are produced by his irregularly shaped lumps of Radiant Electrode Matter. My contention is that they are produced by Radiant Matter of the residual molecules of gas.

Were it not that in this case we can turn to experimental evidence I would not mention the subject to you. On such an occasion as this controversial matter must have no place; therefore I content myself, at present, by showing a few novel experiments which demonstratively prove my case.

Let me first deal with the Radiant Electrode hypothesis. Some metals, it is well known, such as silver, gold, or platinum, when used for the negative electrode in a vacuum tube, volatilise more or less rapidly, coating any object in their neigh-

* "The thickness of the dark space surrounding the negative pole is the measure of the mean length of the path of the gaseous molecules between successive collisions. The electrified molecules are projected from the negative pole with enormous velocity, varying, however, with the degree of exhaustion and intensity of the induction current."—(*Phil. Trans.*, Part I., 1879, par. 530.)

"The extra velocity with which the molecules rebound from the excited negative pole keeps back the more slowly moving molecules which are advancing towards the pole. The conflict occurs at the boundary of the dark space, where the luminous margin bears witness to the energy of the discharge."—(*Phil. Trans.*, Part I., 1879, par. 507.)

"Here, then, we see the induction spark actually illuminating the lines of molecular pressure caused by the excitement of the negative pole."—(R. I. Lecture, Friday, April 4, 1879.)

"The electrically excited negative pole supplies the *force majeure* which entirely, or partially, changes into a rectilinear action the irregular vibration in all directions."—(*Proc. Roy. Soc.* 1880, page 472.)

"It is also probable that the absolute velocity of the molecules is increased so as to make the mean velocity with which they leave the negative pole greater than that of ordinary gaseous molecules."—(*Phil. Trans.*, Part II., 1881, par. 719.)

† "It has been suggested that the extent of the dark space represents the mean free path of the molecules. . . . It has been pointed out by others that the extent of the dark space is really considerably greater than the mean free path of the molecules, calculated according to the ordinary way. My measurements make it nearly twenty times as great. This, however, is not in itself a fatal objection; for, as we have seen, the mean free path of an ion may be different from that of a molecule moving among others."—Schuster, *Proc.* Roy. Soc., XLVII., pp. 556-7.

‡ "Physical Memoirs," Part 2, Vol. I., p. 244. The paragraph is italicised in the original.

§ *Loc cit.*, p. 242.

Digitized by Google

bourhood with a very even film. On this depends the well-known method of electrically preparing small mirrors, &c. Aluminium, however, seems exempt from this volatility. Hence, and for other reasons, it is generally use for electrodes.

If, then, the phenomena in a high vacuum are due to the "electrode matter," the more volatile the metal used the greater should be the effect.*

Here is a tube (Fig. 15, P. = 0·00068mm., or 0·9 M.), with two negative electrodes, A, A′, so placed as to project two luminous spots on the phosphorescent glass of the tube. One electrode, A′, is of pure silver, a volatile metal; the other, A, is of aluminium, practically non-volatile. A quantity of "electrode matter" will be shot off from the silver pole, and practically none from the aluminium pole; but you see that in each case the phosphorescence, C, C′, is identical. Had the Radiant Electrode matter been the active agent, the more intense phosphorescence would proceed from the more volatile pole.

A drawing of another experimental piece of apparatus is shown in Fig. 16. A pear-shaped bulb of German glass has near the small end an inner concave negative pole, A, of pure silver so mounted that its inverted image is thrown upon the opposite end of the tube. In front of this pole is a screen of mica, C, having a small hole in the centre, so that only a narrow pencil of rays from the silver pole can pass through, forming a bright spot, D, at the far end of the bulb. The exhaustion is about the same as in the previous tube, and the current has been allowed to pass continuously for many hours so as to drive off a certain portion of the silver electrode, and upon examination it is found that the silver has all been deposited in the immediate neighbourhood of the pole, whilst the spot, D, at the far end of the tube that has been continuously glowing with phosphorescent light is practically free from silver.

The experiment is too lengthy for me to repeat it here, so I shall not attempt it, but I have on the table the results for examination.

The identity of action of silver and aluminium in the first case, and the non-projection of silver in this second instance, in themselves are sufficient to condemn Dr. Puluj's hypothesis, since they prove that phosphorescence is independent of the material of the negative electrode. In front of me is a set of tubes that to my mind puts the matter wholly beyond doubt. The tubes contain no inside electrodes with the residual gaseous molecules, and with them I will proceed to give some of the most striking radiant matter experiments without any inner metallic poles at all.

In all these tubes the electrodes, which are of silver, are on the outside, the current acting through the body of the glass. The first tube contains gas only slightly rarefied and at the stratification stage. It is simply a closed glass cylinder, with a coat of silver deposited outside at each end, and exhausted to a pressure of 2 mm. The outline of the tube is shown in Fig. 17. I pass a current and, as you see, the stratifications, though faint, are perfectly formed.

The next tube, seen in outline in Fig. 18, shows the dark space. Like the first it is a closed cylinder of glass, with a central indentation forming a kind of hanging pocket, and almost dividing the tube into two compartments. This pocket, silvered on the air side, forms a hollow glass diaphragm that can be connected electrically from the outside, forming the negative pole, A; the two ends of the tube, also outwardly silvered, form the positive poles, B B. I pass the current and you all see the dark space distinctly visible. The pressure here is 0·076 mm., or 100 M. The next stage, dealing with more rarefied matter, is that of phosphorescence. Here is an egg-shaped bulb, shown in Fig. 19, containing some pure yttria, and a few rough rubies. The positive electrode, B, is on the bottom of the tube under the phosphorescent material; the negative, A, is on the upper part of the tube. See how well the rubies and yttria phosphorescence under molecular bombardment, at an internal pressure of 0·00068 mm., or 0·9 M.

A shadow of an object inside a bulb can also be projected on to the opposite wall of the bulb by means of an outside pole. A mica cross is supported in the middle of the bulb (Fig. 20), and on connecting a small silvered patch, A, on one side of the bulb with the negative pole of the induction coil, and putting the positive pole to another patch of silver, B, at the top, the opposite side of the bulb glows with a phosphorescent light, on which the black shadow of the cross seems sharply cut out. Here the internal pressure is 0·00068 mm., or 0.9 M.

Passing to the next phenomenon, I proceed to show the production of mechanical energy in a tube without internal poles. It is shown in Fig. 21 (P. = 0·001 mm., or 1·3 M.). It contains a light wheel of aluminium, carrying vanes of transparent mica, the poles, A, B, being in such a position outside that the molecular focus falls upon the vanes on one side only. The bulb is placed in the lantern, and the image is projected on the screen; if I now pass the current you see the wheel rotates rapidly, reversing in direction as I reverse the current.

Here is an apparatus (Fig. 22) which shows that the residual gaseous molecules when brought to a focus produce heat. It consists of a glass tube with a bulb blown at one end and a small bundle of carbon wool, C, fixed in the centre, and exhausted to pressure of 0·000076 mm., or 0·1 M. The negative electrode, A, is formed by coating part of the outside of the bulb with silver, and it is in such a position that the focus of rays falls upon the carbon wool. The positive electrode, B, is an outer coating at the other end of the tube. I pass the current, and those who are close may see the bright sparks of carbon raised to incandescence by the impact of the molecular stream.

You thus have seen that all the old "radiant matter" effects can be produced in tubes containing no metallic electrodes to volatilise. It may be suggested that the sides of the tube in contact with the outside poles become electrodes in this case, and that particles of the glass itself may be torn off and projected across and so produce the effects. This is a strong argument, which fortunately can be tested by experiment. In the case of this tube (Fig 23, P = 0·00068 mm, or 0·9 M) the bulb is made of lead glass phosphorescing blue under molecular bombardment. Inside the bulb, completely covering the part that would form the negative pole, A, I have painted a substantial coat of yttria so as to interpose a layer of this earth between the glass and the inside of the tube. The negative and positive poles are silver discs on the outside of the bulb, A being the negative and B the positive poles. If, therefore, particles are torn off and projected across the tube to cause phosphorescence, these particles will not be particles of glass but of yttria, and the spot of phosphorescent light, C, on the opposite side of the bulb, will not be the dull blue of lead glass, but the golden yellow of yttria. You see there is no such indication; the glass phosphoresces with its usual blue glow, and there is no evidence that a single particle of yttria is striking it.

Witnessing these effects I think you will agree I am justified in adhering to my original theory that the phenomena are caused by the radiant matter of the residual gaseous molecules, and certainly not by the torn off particles of the negative electrode.

*Phosphorescence in High Vacua.*

I have already pointed out that the molecular motions rendered visible in a vacuum tube are not the motions of molecules under ordinary condition, but are compounded of these ordinary or kinetic motions and the extra motion due to the electrical impetus.

Experiments show that in such tubes a few molecules may traverse more than a hundred times the *mean* free path, with a a correspondingly increased velocity, until they are arrested by collisions. Indeed, the molecular free path may vary in one and the same tube, and at one and the same degree of exhaustion.

Very many bodies, such as ruby, diamond, emerald, alumina, yttria, samaria, and a large class of earthy oxides and sulphides, phosphorescence in vacuum tubes when placed in the path of the stream of electrified molecules proceeding from the negative

* In a valuable Paper read before the Royal Society, November 20, 1890, by Profs. Liveing and Dewar, on finely-divided metallic dust thrown off the surface of various electrodes in vacuum tubes, they find not only that dust, however fine, suspended in a gas will not act like gaseous matter in becoming luminous with its characteristic spectrum in an electric discharge, but that it is driven with extraordinary rapidity out of the course of the discharge.

Digitized by Google

pole. The composition of the gaseous residue present does not affect phosphorescence; thus, the earth yttria phosphorescences well in the residual vacua of atmospherical air, of oxygen, nitrogen, carbonic anhydride hydrogen, iodine, sulphur, and mercury.

With yttria in a vacuum tube, the point of maximum phosphorescence, as I have already pointed out, lies on the margin of the dark space. The diagram (Fig. 24) shows approximately the degree of phosphorescence in different parts of a tube at an internal pressure of 0·25mm., or 330 M. On the top you see the positive and negative poles, A and B, the latter having the outline of the dark space shown by a dotted line, C. The curve D, E, F, shows the relative intensities of the phosphorescence at different distances from the negative pole, and the position inside the dark space at which phosphorescence does not occur. The height of the curve represents the degree of phospherescence. The most decisive effects of phosphorescence are reached by making the tube so large that the walls are outside the dark space, whilst the material submitted to experiment is placed just at the edge of the dark space.

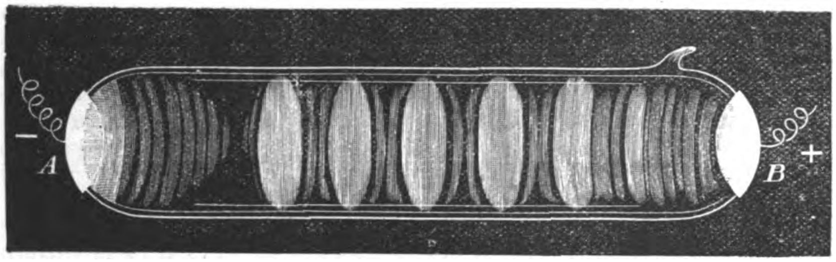



FIG. 17.—Pressure=2· mm.

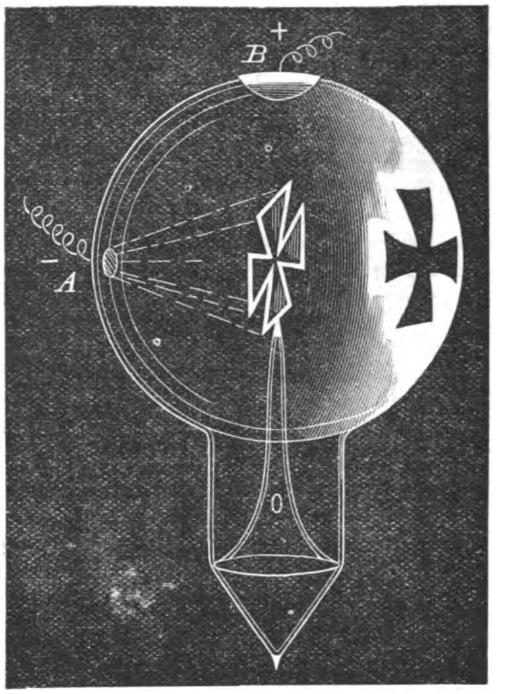



FIG. 20.—Pressure=·00068 mm.=·9 M.

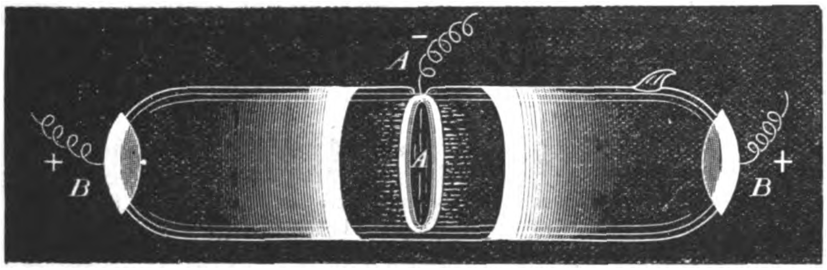



FIG 18.—Pressure= ·076 mm=100·M.

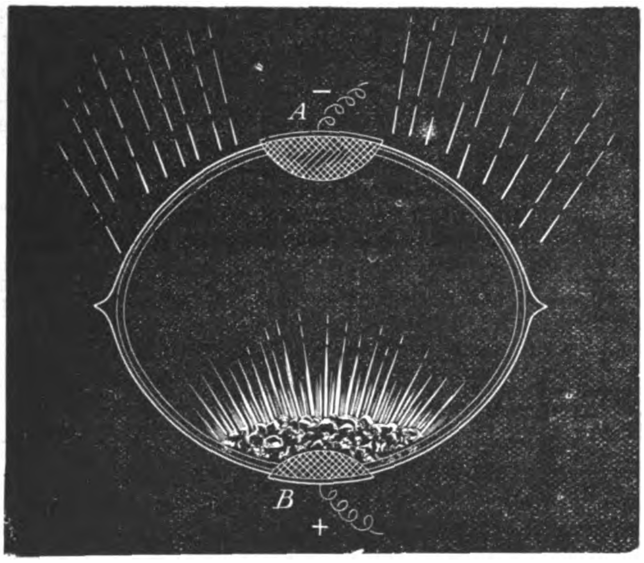
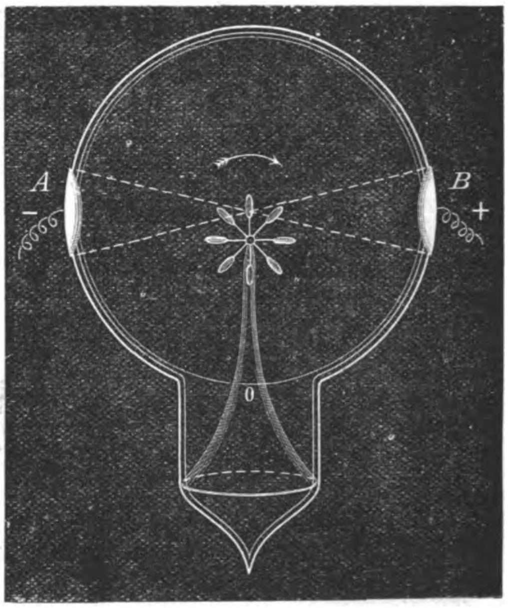



FIG. 19.—Pressure=·00068 mm=·9M.




FIG, 21.—Pressure=·001 mm.=1·3 M.

Hitherto I have spoken only of phosphorescence of substances placed under the negative pole. But from numerous experiments I find that bodies will phosphoresce in actual contact with the negative pole.

This is only a temporary phenomenon, and ceases entirely when the exhaustion is pushed to a very high point. The experiment is one scarcely possible to exhibit to an audience, so I must content myself with describing it. A U-tube, shown in Fig. 25, has a flat aluminium pole, in the form of a disc, at each end, both coated with a paint of phosphorescent yttria. As the rarefaction approaches about 0·5 mm. the surface of the negative pole A becomes faintly phosphorescent. On continuing the exhaustion this luminosity rapidly diminishes, not only in intensity but in extent, contracting more and more from the edge of the disc, until ultimately it is visible only as a bright spot in the centre. This fact does not prop a recent theory, that as the exhaustion gets higher the discharge leaves the centre of the pole, and takes place only between the edge and the walls of the tube.

Digitized by Google

If the exhaustion is further pushed, then at the point where the surface of the negative pole ceases to be luminous, the material on the positive pole, B, commences to phosphoresce, increasing in intensity until the tube refuses to conduct, its greatest brilliancy being just short of this degree of exhaustion. The probable explanation is that the vagrant molecules I introduce in the next experiment, happening to come within the sphere of influence of the positive pole, rush violently to it and excite phosphorescence in the yttria, whilst losing their negative charge.

A C B is a U-shaped tube with terminals, A and B, at each end; D and E are two mica screens covered with a phosphorescent powder, having at F and G other screens with a small slit in front, so as to allow only a narrow beam of charged molecules to pass through. At first the tube is exhausted to a pressure of 0·076 mm. or 100 M., and you see how sharp and slightly divergent is the luminous image on screen D, whilst not a trace of phosphorescence is to be seen on the screen E in the other limb of the tube. Now I

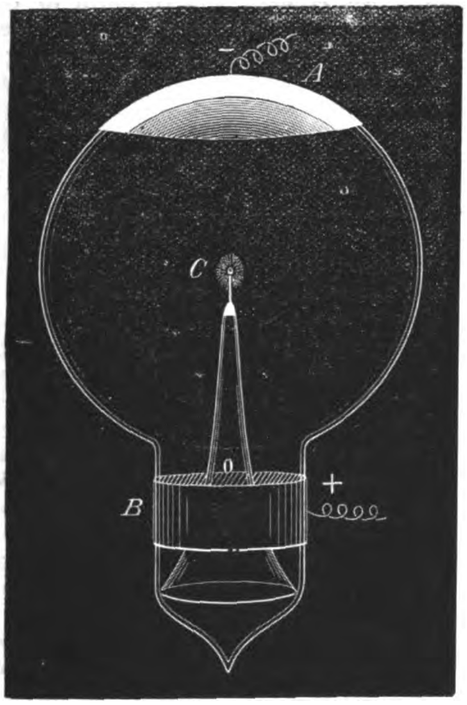



FIG. 22.—Pressure = ·000076 mm. = ·1 M

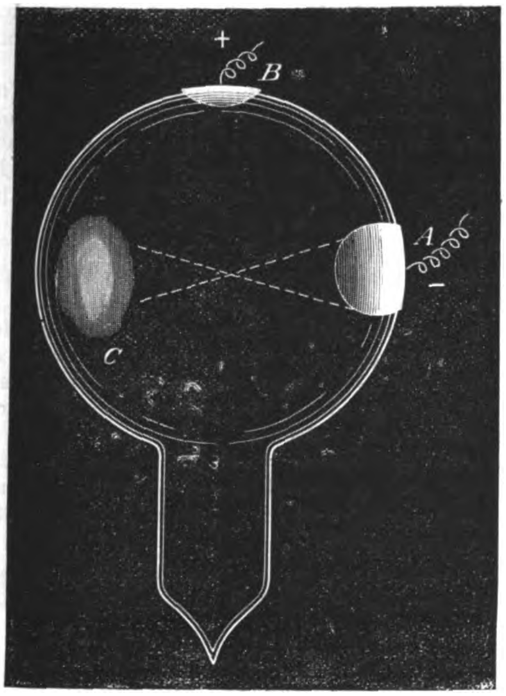



FIG. 23.—Pressure = ·00068 mm. = ·9 M.

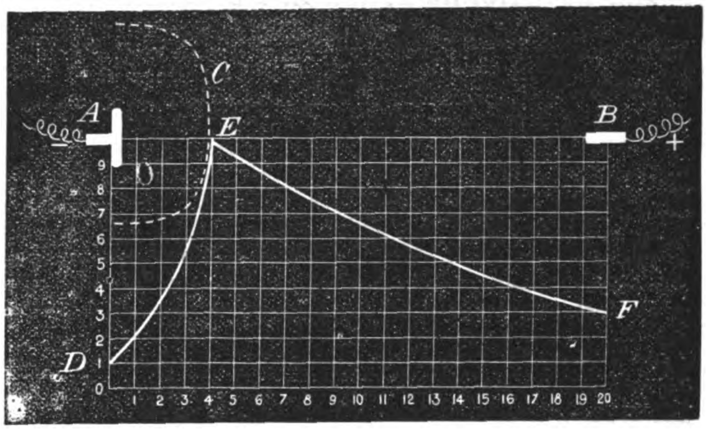



FIG. 24.—Pressure = ·25 mm. = 330 M.

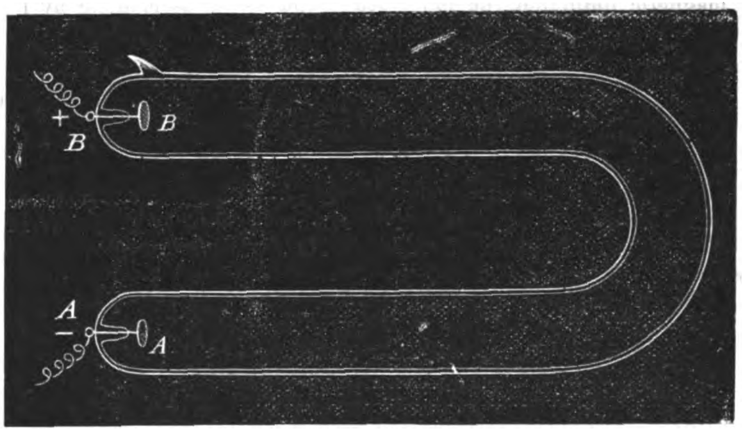



FIG. 25.

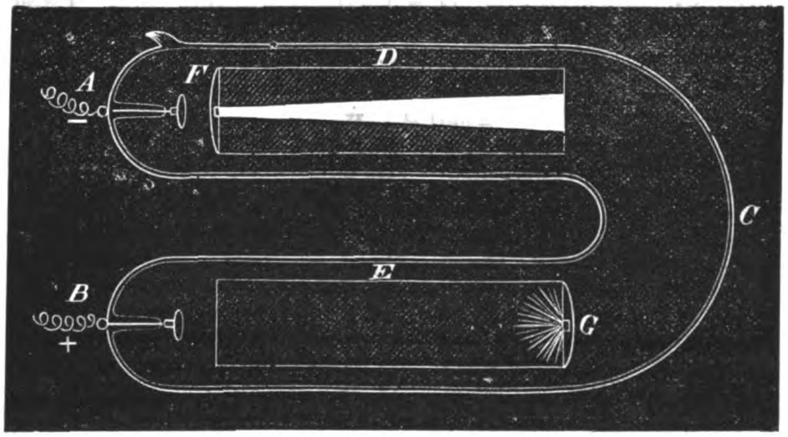



FIG. 26.—Pressure = ·076 mm. = 100 M.

*Loose and Erratic Molecules.*

In the brief time left to me this evening I cannot touch upon the mass of experiments made to render this result clear, so I will at once show you a piece of apparatus that clearly illustrates the cause of phosphorescence at the positive pole. A drawing of this tube is shown at Fig. 26, but let me first explain the effect I expect to obtain, and then endeavour to show the actual experiment.

push the exhaustion to the highest point short of non-conduction (0·000076 mm., or 0·1 M.), and the phenomena change. The initial line of light on D becomes wider and unsteady, whilst at the gate, G, a decided phosphorescence is observable entering the second screen, E. This luminosity diverges to a considerable extent, much more than did the stream of charged molecules observed in the first limb of the

Digitized by Google

tube at the lower exhaustion. This is only to be expected, inasmuch as those sparse molecules which have run the gauntlet of the crowd and have been hunted and buffeted round the corner will have little or no lateral support, but wander to the furthest part of the tube, and altogether behave differently to the orderly procession of molecules at more moderate exhaustion.

(*To be continued.*)

---

## THE ROTATIONAL ETHER IN ITS APPLICATION TO ELECTRO-MAGNETISM.

BY OLIVER HEAVISIDE.

According to Maxwell's theory of electric displacement, disturbances in the electric displacement and magnetic induction are propagated in a non-conducting dielectric, after the manner of motions in an incompressible solid. The subject is somewhat obscured in Maxwell's treatise by his equations of propagation containing **A**, Ψ, and J, all of which are functions considerably remote from the vectors which represent the state of the field, viz., the electric and magnetic forces, and by some dubious reasoning concerning Ψ and J. There is, however, no doubt about the statement with which I commenced, as it becomes immediately evident when we ignore the potentials and use **E** or **H** instead, the electric or the magnetic force.

The analogy has been made use of in more ways than one, and can be used in very many ways. The easiest of all is to assume that the magnetic force is the velocity of the medium, magnetic induction the momentum, and so on, as is done by Prof. Lodge (Appendix to "Modern Views of Electricity"). I have also used this method for private purposes, on account of the facility with which electro-magnetic problems may be made elastic-solid problems. I have shown that when impressed electric force acts it is the curl or rotation of the electric force which is to be considered as the source of the resulting disturbances. Now, on the assumption that the magnetic force is the velocity in the elastic-solid, we find that the curl of the impressed electric force is represented simply by impressed mechanical force of the ordinary Newtonian type. This is very convenient.

But the difficulties in the way of a complete and satisfactory representation of electro-magnetic phenomena by an elastic-solid ether are insuperable. Recognising this, Sir W. Thomson has recently brought out a new ether; a rotational ether. It is incompressible, and has no true rigidity, but possesses a quasi-rigidity arising from elastic resistance to absolute rotation.

The stress consists partly of a hydrostatic pressure (which I shall ignore later), but there is no distorting stress, and its place is taken by a rotating stress. It gives rise to a translational force and a torque. If **E** be the torque, the stress on any plane **N** (unit normal) is simply **VEN**, the vector product of the torque and the normal vector.

The force is − curl **E**. We have therefore the equation of motion

$$-\,\text{curl}\,\mathbf{E} = \mu\dot{\mathbf{H}},$$

if **H** is the velocity and $\mu$ the density. But, alas, the torque is proportional to the rotation. This gives

$$\text{curl}\,\mathbf{H} = c\dot{\mathbf{E}},$$

where $c$ is the compliancy, the reciprocal of the quasi-rigidity.

Now these are the equations connecting electric and magnetic force in a non-conducting dielectric, when $\mu$ is the inductivity and $c$ the permittancy. We have a parallelism in detail, not merely in some particulars. The kinetic energy $\frac{1}{2}\mu H^2$ represents the magnetic energy, and the potential energy $\frac{1}{2}cE^2$ the electric energy. The vector-flux of energy is **VEH**, the activity of the stress.

This mode of representation differs from that of Sir W. Thomson, who represents magnetic force by rotation. This system makes electric energy kinetic, and magnetic energy potential, which I do not find so easy to follow.

Now let us, if possible, extend our analogy to conductors. Let the translational and the rotational motions be both frictionally resisted, and let the above equations become

$$-\,\text{curl}\,\mathbf{E} = g\mathbf{H} + \mu\dot{\mathbf{H}},$$
$$\text{curl}\,\mathbf{H} = k\mathbf{E} + c\dot{\mathbf{E}},$$

where $g$ is the translational frictionality; $k$ will be considered later. We have now the equations of electric and magnetic force in a dielectric with duplex conductivity, $k$ being the electric and $g$ the magnetic conductivity (by analogy with electric force, but a frictionality in our present dynamical analogy).

We have, therefore, still a parallelism in every detail. We have waste of energy by friction $gH^2$ (translational) and $kE^2$ (rotational). If $g/\mu = k/c$ the propagation of disturbances will take place precisely as in a non-conducting dielectric, though with attenuation caused by the loss of energy.

To show how this analogy works out in practice, consider a telegraph circuit, which is most simply taken to be three co-axial tubes. Let, A, B, and C be the tubes; A the innermost, C the outermost, B between them; all closely fitted. Let their material be the rotational ether. In the first place, suppose that there is perfect slip between B and its neighbours. Then, when a torque is applied to the end of B (the axis of torque to be that of the tubes), and circular motion thus given to B, the motion is (in virtue of the perfect slip) transmitted along B, without change of type, at constant speed, and without affecting A and C.

This is the analogue of a concentric cable, if the conductors A and C be perfect conductors, and the dielectric B a perfect insulator. The terminal torque corresponds to the impressed voltage. It should be so distributed over the end of B that the applied force there is circular tangential traction, varying inversely as the distance from the axis; like the distribution of magnetic force, in fact.

Now, if we introduce translational and rotational resistance in B, in the above manner, still keeping the slip perfect, we make the dielectric not only conducting electrically but also magnetically. This will not do. Abolish the translational resistance in B altogether, and let there be no slip at all between B and A, and B and C. Let also there be rotational resistance in A and C.

We have now the analogue of a real cable: two conductors separated by a third. All are dielectrics, but the middle one should have practically very slight conductivity, so that it is pre-eminently a dielectric; whilst the other two should have very high conductivity, so that they are pre-eminently conductors. The three constants, $\mu$, $c$, $k$, may have any value in the three tubes, but practically $k$ should be in the middle tube a very small fraction of what it is in the others.

It is remarkable that the *quasi-rotational* resistance in A and C should tend to counteract the distorting effect on waves of the *quasi-rotational* resistance in B. But the two rotations, it should be observed, are practically perpendicular, being axial or longitudinal (now) in A and C, and transverse or radial in B; due to the relative smallness of $k$ in the middle tube.

To make this neutralising property work equally, we must transfer the resistance in the tubes A and C to the tube B, at the same time making it translational resistance. Also restore the slip. Then we can have perfect annihilation of distortion in the propagation of disturbances, viz., when $k$ and $g$ are so proportioned as to make the two wastes of energy equal. In the passage of a disturbance along B there is partial absorption, but no reflection.

But as regards the meaning of the above $k$ there is a difficulty. In the original rotational ether the torque varies as the rotation. If we superadd a real frictional resistance to rotation we get an equation of the form

$$\dot{\mathbf{E}} = \left(a + b\frac{d}{dt}\right)\text{curl}\,\mathbf{H},$$

**E** being (as before) the torque, and **H** the velocity. But this is not of the right form, which is (as above)

$$\text{curl}\,\mathbf{H} = \left(k + c\frac{d}{dt}\right)\mathbf{E};$$

therefore some special arrangement is required (to produce the dissipation of energy $k\mathbf{E}^2$), which does not obviously present itself in the mechanics of the rotational ether.

On the other hand, if we follow up the other system, in which magnetic force is allied with rotation, we may put $g = 0$, let − **E** be the velocity and **H** the torque; $\mu$ the compliancy

Digitized by Google

$c$ the density, and $k$ the translational frictionality. This gives

$$-\operatorname{curl}\mathbf{E} = \mu\dot{\mathbf{H}},$$
$$\operatorname{curl}\mathbf{H} = k\mathbf{E} + c\dot{\mathbf{E}}.$$

We thus represent a homogeneous conducting dielectric, with a translational resistance to cause the Joulean waste of energy. But it is now seemingly impossible to properly satisfy the conditions of continuity at the interface of different media. For instance, the velocity − E should be continuous, but we do not have normal continuity of electric force at an interface. In the case of the tubes we avoided this difficulty by having the velocity tangential.

Either way, then, the matter is left, for the present, in an imperfect state.

In the general case, the $d/dt$ of our equations should receive an extended meaning, on account of the translational motion of the medium. The analogy will, therefore, work out less satisfactorily. And it must be remembered that it is only an analogy in virtue of similitude of relations. We cannot, for instance, deduce the Maxwellian stresses and mechanical forces on charged or currented bodies. The similitude does not extend so far. But certainly the new ether goes somewhat further than anything known to me that has been yet proposed in the way of a stressed solid.

## PHYSICAL SOCIETY.

At the meeting of this Society, held on the 16th inst., Prof. G. M. Minchin, M.A., read a Paper entitled

### "Experiments in Photo-electricity."

The author's investigations in Photo-electricity were begun in the year 1877, the object then in view being to endeavour to obtain a solution of the problem of photography at a distance for which he had suggested the name of telephotography.

The author's earliest experiments were made with cells containing strips of silver, as electrodes, coated with collodion or gelatine emulsions of various salts of silver, and also eosine, fluorescine, and some aniline dyes, and immersed in dilute solutions of different salts of sodium, potassium, and barium, and even distilled water, the process being, of course, carried out in darkness. One of the electrodes was completely screened from light, while the other could be illuminated at pleasure. Prior to exposure the electrodes were connected through a Thomson reflecting galvanometer, and the current due to inequality in the plates allowed to subside before exposing to light. On exposing the unscreened electrode to light, a current was set up, the screened electrode being positive in some cases and negative in others, this being determined by the salts employed in constructing the cell. The more highly refrangible rays of the spectrum were found in most of the cells to give the greatest effect, but one in which an emulsion of sulphide of silver and a dilute solution of potassium sulphate was employed was most sensitive to the green rays. When an emulsion of silver bromide and a dilute solution of potassium bromide were used, the effect of passing a current through it from a bichromate cell was found to be a blackening of the immersed portion of the silver electrode connected with the carbon pole, and the immersed portion of the other electrode, though not visibly affected by the current, was turned black by means of the ordinary pyrogallic acid developing solution. Similar results were obtained when a photo-electric cell was employed in place of the bichromate cell.

Some extremely interesting results, however, were obtained with electrodes of ordinary commercial tinfoil, unprepared in any way, immersed either in ordinary tap water or in distilled water. The exposed electrode always became initially positive, but after an interval of time, ranging from a few minutes to some hours, the current was reversed in direction and of greater strength than before, and continued for many days if the exposure to light was maintained. When the surface of the tinfoil was chemically cleaned the cells became completely insensitive to light, showing that the photo-electric effects must be due to the presence of a film of some kind on the surface of the foil.

After a long series of experiments, in which an electrometer was used instead of the galvanometer, the author discovered that a sensitive surface which at once became negative on exposure to light could be obtained by coating the tinfoil with sulphide of tin, and the liquid which gave the greatest sensitiveness was methyl alcohol, prepared from oil of wintergreen. The author then described a method at which he had arrived, after a laborious series of experiments, for producing a sensitive surface, which will become positive on exposure to light. The residual effect after exposure to light takes a considerable time to disappear, but it can be rapidly got rid of by connecting the sensitive electrode with the copper, and the insensitive electrode with the zinc of a Daniell's cell. The volts developed were found to be approximately proportional to the square root of the intensity of the incident light.

One of the most curious effects observed with these cells is that after standing for some time they frequently become insensitive, and the cell can be restored to its full original sensitiveness by a slight tap to its support, or to the table on which it stands. When in the sensitive state a similar tap renders the cells insensitive, and this series of alternating sensitiveness and insensitiveness can be continued indefinitely. Cells in the insensitive state may also be made sensitive by electric sparking in their neighbourhood.

The deflection on exposure to light was much smaller when the sensitive plate was in connection with the zinc pole of the Daniell than when connected with the copper pole, and the author, in consequence of this, suggests as a possible explanation of the effect of light on the cells, that it may reduce the amount of oxygen on the films, for when the sensitive plate was connected with the copper of the Daniell the amount of oxygen on it would be increased, while it would be diminished when the sensitive electrode was connected with the zinc.

The author then referred to the so-called "selenium cells," which should more properly be termed "selenium conductors," or "selenium resistances." He stated that last year he first endeavoured to construct selenium cells, properly so-called, viz., cells in which an E.M.F. was set up by the action of light. The best effects were produced by means of aluminium electrodes, one of which was coated on one side with selenium and gradually heated until the brown colour had been attained. When, however, the aluminium plates were immersed in alcohol they became covered with a gelatinous deposit which made it necessary to find some other liquid, and after many trials *acetone* was found to give the best results. These cells differ from any of the photo-electric cells previously constructed by the author in their great sensitiveness to the light from all parts of the spectrum, the maximum effect being produced in the yellow bordering on the green.

The author, in conclusion, called attention to three problems, towards the solution of which these photo-electric cells might contribute. The first was the construction of a really scientific photometer, for purposes of comparison at any rate. Each light would be spread out into a spectrum, and the intensities of the different portions compared by means of the cells, the intensities of the different portions being proportional to the squares of the observed volts. The principle of Newton's chromatic circle could then be applied to determine the resultant intensity of the light. The second problem was the photographing of objects at a distance, and it was one which there appeared to be no prospect of solving at present, in spite of the startling stories appearing from time to time in the newspapers. The third problem was the direct transformation of radiant solar energy into useful work.

The discussion of the paper was postponed to the meeting of February 13th, when the author will repeat some of the most interesting experiments.

## MEETINGS OF SCIENTIFIC SOCIETIES, &c.

**FRIDAY, January 23rd.**

Royal Institution.

*9 p.m.* Evening Discourse: "Some Applications of Photography," by Lord Rayleigh, F.R.S.

**MONDAY January 26th.**

London Chamber of Commerce.

*4 p.m.* Meeting of the Electrical and Allied Trades' Section Committee.

Society of Arts.

*8 p.m.* Cantor Lecture II. 1. "The Construction and Capabilities of Musical Instruments," by A. J. Hipkins, F.S.A.

**TUESDAY, January 27th.**

Institution of Civil Engineers.

*8 p.m.* Ordinary Meeting. Paper to be read with a view to discussion: "Machine Stoking," by J. Fred. Spencer, M.I.C.E.

Society of Arts.

*8 p.m.* Applied Art Section. Paper to be read: "Lithography: a Finished Chapter of Illustrative Art," by William Simpson.

**WEDNESDAY. January 28th.**

Society of Arts.

*8 p.m.* Ordinary Meeting. Paper to be read: "Illustrated Journalism," by Carmichael Thomas.

Institution of Mechanical Engineers.

*7.30 p.m.* Annual General Meeting. Election of Officers. After which the following Papers will be read and discussed, as far as time permits:—"On some Different Forms of Gas Furnaces," by Bernard Dawson; "On the Mechanical Treatment of Moulding Sand," by Walter Bagshaw; Fourth Report of the Research Committee on Friction; Experiments on the Friction of a Pivot Bearing.

Digitized by Google

# The Electrician.

**Published every Friday, Price Fourpence; Post Free, Fourpence Halfpenny**
**Editorial, Publishing, and Printing Offices:**
**SALISBURY COURT, FLEET ST., LONDON, E.C.**
*Telephone No.* 2714. *Telegrams:* "ELECTRICIAN NEWSPAPER, LONDON."


*All Letters relating to Subscriptions, Advertisements and other business matters should be addressed to the Publisher, "*THE ELECTRICIAN,*" Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to "*THE ELECTRICIAN*" Printing and Publishing Company, Limited, and be crossed "Coutts and Co." All other letters to be addressed to the Editor.*

*All letters intended for insertion in "*THE ELECTRICIAN,*" or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

*"*THE ELECTRICIAN*" is published every Friday morning, in time for the morning mails. Subscribers should receive their copies by the first post on Friday morning.*

*"*THE ELECTRICIAN*" is on sale at the railway bookstalls throughout the Kingdom on Friday morning, and can be obtained of all Booksellers and Newsvendors; or direct from the Publishing Offices as above.*

*New Volumes of "*THE ELECTRICIAN*" commence in May and November.*

## SUBSCRIPTION RATES.

The rates for Subscriptions to "THE ELECTRICIAN" are as follows:—

| | 3 months. s. d. | 6 months. s. d. | 12 months. s. d. |
|---|---|---|---|
| For the United Kingdom | 5 0 | 10 0 | 19 6 |
| For Foreign Parts and Colonies:— | | | |
| Within Postal Union | 6 6 | 12 6 | 24 0 |
| Aden Borneo, Ceylon, China, India, Japan, Java, Labuan, Mozambique, New Caledonia, Persia, Philippine Islands, Siam, Transvaal, and Zanzibar | 7 6 | 14 6 | 28 0 |


## TO ADVERTISERS.

*"*THE ELECTRICIAN*" offers exceptional advantages to Advertisers.* **It has by far the largest circulation of any English Electrical paper, and circulates all over the World.**

*Particulars relating to Advertisements will be promptly forwarded on application to the Offices as above.*

TRADE ADVERTISEMENTS *intended for the current issue must reach the Offices not later than First Post on Thursday morning. Renewals of expiring advertisement orders and alterations to standing advertisements should be in the Publisher's hands by Wednesday at latest. No alteration can be made in Wrapper advertisements after Wednesday evening.*

SMALL PREPAID ADVERTISEMENTS *(for Rates see page xvii.) are accepted up to 4 p.m. on Thursday.*

## TECHNICAL PRINTING.

"THE ELECTRICIAN" PRINTING AND PUBLISHING COMPANY (LIMITED) *inform Electricians, Electric Light Engineers, &c., that they make a specialty of Technical Printing, and have a large Staff thoroughly acquainted with Electro-Technology. They can, therefore, promise Accuracy and Despatch in the Printing of Electro-Technical Literature, &c.*

## "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. (Royal 8vo.)

*Early in each year is issued "*THE ELECTRICIAN*" *ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. *The* DIRECTORY *was established in 1883, and the 1890 Edition consisted of about 850 pages of printed matter. The names and addresses of all persons engaged in the Electrical Industries at home and abroad may be relied upon as accurate. Useful Tables and Electrical Formulæ, and information specially compiled for this work are given, together with popularly-written Biographical Notices of the leading Electricians, Electrical Engineers, &c., accompanied in many cases by Portraits.*

*The 1891 Edition is now actively preparing, and Subscription and Advertisement Orders, New Names, Corrections, &c., can be received.*

## ELECTRICAL BOOKS AND PUBLICATIONS.

*All Books, Newspapers, and other publications, dealing with Electrical and kindred subjects, can be ordered direct of "*THE ELECTRICIAN*" Printing and Publishing Company, who are proprietors of the well-known "*ELECTRICIAN*" Series of Standard Electrical Works, and are agents for all the leading publishing houses at home and abroad.*


## CONTENTS OF THE CURRENT NUMBER.


NOTES ... 349
Institution of Electrical Engineers—
Presidential Address of Prof. William Crookes, F.R.S.—
"Electricity in Transitu: from Plenum to Vacuum. Illustrated. Continued ... 354
The Rotational Ether in its Application to Electro-Magnetism. By Oliver Heaviside 360
Physical Society—
"Experiments in Photo-Electricity" ... 361
Meetings of Scientific Societies. 361
MECHANICAL EQUIVALENTS IN PATENT LAW ... 362
OBITUARY.
Emile Reynier ... 363
Reviews ... 364
Electrical Distribution by Transformers from Central and Eccentric Stations. By Dr. J. A. Fleming, M.A. Illustrated. Continued ... 364
Motors for Mining Work. Illus. 368
The Intensity of Telephone Effect. By E. Mercardier ... 368
Electric Railway Devices. Illustrated ... 369
LEGAL INTELLIGENCE—
The British Tanning Company v. Groth. Illustrated. Concluded ... 369
Schoensack v. Heyl ... 373
CORRESPONDENCE—
Electric & Magnetic Theories — J. T. Sprague; Oliver Heaviside; Silvanus P. Thompson; and Oliver J. Lodge ... 374
The London County Council and Technical Education ... 376
Trade Notes and Notices ... 376
COMPANIES' MEETINGS, &c.—
National Telephone Company (Limited) ... 376
Eastern Telegraph Company (Limited) ... 378
The Direct United States Cable Company (Limited).. 379
Anglo-American Telegraph Company (Limited) ... 380
New Companies Registered ... 381
City Notes, &c. ... 381
Companies' Share List ... 382


## NOTICE.

**With our Next Number we shall issue a Coloured Map showing the Electric Mains laid in the London streets up to January 1, 1891.**

## MECHANICAL EQUIVALENTS IN PATENT LAW.

It may safely be said that until the passing of the Electric Lighting Act of 1888, more money changed hands in connection with electrical patents than was made in legitimate electrical trading. Under the more healthy conditions and sound work of to-day patents are but means, and subordinate means, to an end; and not being so frequently bought and sold they are not so often produced for that purpose. But patents and patent rights, representing as they do an important a portion of the invested capital of many companies, and forming in many cases the acquired capital of so many individuals, are of weighty interest to the electrical profession. Scores of electrical engineers have acquired sufficient knowledge of patent law to draw up very fair specifications, and many of the lesser patent agents seem to expect of their electrical clients, if not a ready-made draft specification, at all events a document which needs but little re-modelling. This being so, patent cases of a typical character, especially if they be not too protracted, are of considerable interest, since from the arguments and judgments may be gleaned a knowledge of the important points with far less labour than from a dry treatise on the subject.

Without wishing to encourage amateur specification-drawing, we would remark that the gist of the subject lies in the proper appreciation of what can, and what cannot be patented; and the chief points in which a patent is liable to be bad. It is hardly fair to divide these into intentional and unintentional cases, but of the former, an infringement by a "colourable imitation" may be taken as an example, while an invalidation by prior publication is an instance of the latter. Since an idea or a principle cannot be protected by a patent, but only the method by which it can be carried out in practice, the inventor either describes and claims as many different methods as he can think of, or divides them into several different patents, so that if one is faulty the others

Digitized by Google

will still be valid. Then when his invention turns out to be a good thing, and attracts the attention of other workers, they cannot be blamed if they discover some other device which the inventor overlooked, and though the credit of the idea or principle may be his, their more perfected arrangements may perhaps supplant the less mature designs of the original patentee. But of another class are they whose ingenuity is directed, not to new methods, but to close imitations of those which have proved to be successful. Of these colourable imitations, one of the most common is that in which the result achieved by the original invention is arrived at by a slightly altered arrangement of parts. Had Mr. MORDEY done nothing more than build a FERRANTI dynamo with a fixed armature and revolving magnets, it would probably have been held that such a machine was an infringement of FERRANTI'S patent, since the dynamical action and the electrical result would have been identical, with the sole advantage of dispensing with collecting brushes. Mr. MORDEY, as all the world knows, did something very different from this, as he marvellously simplified the field-magnet part, and cheapened its construction.

One man may take the invention of another, as, for example, BINNS' knot-tying mechanism, which was patented for tying warps for weaving, and may apply it to sheaf binding, if the inventor only specified that one purpose of tying warps. While some machines, depending merely on the relative motion of two parts, as in a dynamo or a coffee mill, will produce exactly the same results if the moving part be fixed and the stationary part be moved, there are obviously many machines in which such an interchange would be absurd and would give no result whatever, as, for example, a MORSE sounder with an armature fixed and with the magnet and its attachments free to move. A great number of cases have been decided upon the question of mechanical equivalents, such as the well-known PROCTER v. BENNIS, where a mechanical stoker with a coal spreader keyed on a moving shaft was imitated by a similar spreader swung upon a fixed pin. On the other hand, there is the classical example of WATT'S sun-and-planet motion, which he devised (though in one sense a mere mechanical equivalent) in order to avoid the use of the crank, which, though his own invention, had been patented by one of his own employés.

In approaching the question whether a device is a mechanical equivalent in the sense in which such would constitute an infringement of a patent, the first thing to examine is the result intended, next the method, and lastly the means employed. At first sight it certainly appeared, during the patent case tried last week, that to rotate a frame containing hides in a stationary vat, or to cause the vat to rotate while the frame was fixed, was very similar to the modified arrangement of the coffee mill or the dynamo to which we have alluded; and curiously enough, the relative movements in the two cases are closely comparable, though the result would be totally different. In the latter arrangement the bulk of the liquor would remain stationary, and that very part would rotate which in the former and practical arrangement is retarded, the cause in each case being the skin friction of the sides of the vat. In a case cited last week, woollen goods were finished by pressing between hot metal surfaces. In one patent these were flat, and were moved by screws or hydraulic pressure, and in another, hot rollers were used, and it was decided that there was no infringement. Here the results were the same, and the method, that is the use of hot metal surfaces, was the same, but the means were different.

There have been cases where owing to an extraordinary comprehensiveness of definition it has been impossible for any intending competitors to avoid the use of means which might be held to be mechanical equivalents of an important part of an invention. In the telephone transmitter patent the well known combination of parts called a microphone were made to vibrate by means of a diaphragm, and so wide did the definition of a diaphragm become that it eventually embraced everything by which a microphone could be set in vibration. Patentees who are ambitious and desire to have a far-reaching patent would do well to forsake the vulgar tongue for any high-sounding terms that they can find when describing their apparatus. A filament of a glow lamp, it has been said, may be as thick as a cow's tail; for if it be long enough to reach to the moon it might fairly be called a filament. It has been cynically remarked that the acme of invention in a patentee is to invent a new name for an old device, and thereby secure a monoply for everything that a benevolent judge can be induced to consider as described by that name. If every carbon wire is to be described as a "filament," and every conceivable vibrating organ a "diaphragm," it is useless to discuss what devices are or could be the respective mechanical equivalents of these things. Equivalence has a different meaning in different departments of science. In one sense the substitution of a solution of chloride of nickel for sulphate of nickel in a process for nickel-plating, is the substitution of a chemically equivalent material. But the chemist would emphatically deny that any chloride can be the equivalent of any sulphate, unless used in certain exact combining proportions. A chemically equivalent quantity is not by any means necessarily an equivalent for the purpose of an industrial process. We could adduce a few instances of what may be called electrical equivalents, but it would be invidious to draw attention to them. The fertility of inventive genius has happily been so great that electrical inventors have managed to keep clear of each other as regards means and method; and this is remarkable since the objects are so few in comparison with the multitude of patents. Enormous numbers of arc lamps have been called forth by an immense amount of mechanical ingenuity, and they can be classified into orders and genera, but there seems to be room for all of them—at least, for all the fairly successful types—without any allegations of infringement.

The able speech of Mr. MOULTON, of which a brief report will be found in another column, dealt most exhaustively with this question, and the case which he thus successfully defended, apart from the legal point relating to the International Convention, was of a very typical character, and one which will take its place among the many instructive decisions of patent law.

## OBITUARY.

### EMILE REYNIER.

We have to record the death of M. Emile N. Reynier at the early age of forty.

M. Reynier was born in Paris on May 17, 1851. He was apprenticed to a tinman in 1865, and to an engineer in 1867. From 1868 to 1875 he was engaged in commercial pursuits, but devoted his leisure to mathematical and scientific studies. In 1875 M. Reynier made his *début* in commercial electricity by his invention of metal-coated carbons for arc lamps. In 1878 he brought out an incandescent lamp which worked in the open air. In 1880 he invented his regenerating alkaline battery, but soon abandoned it in favour of the Faure accumulator, with the inventor of which M. Reynier long worked. From 1881 to 1888 he occupied himself with the question of accumulator traction, a new theory of the chemistry of the storage battery, the propulsion of torpedoes,

Digitized by Google

&c., &c. It was during this period that M. Reynier published his chief works: "Les Piles Electriques et Accumulateurs" (1884), "Les Accumulateurs Electriques" (1885), and the "Traité de l'Accumulateur Voltaïque" (1888), the latter of which is now translated into English. In 1889 M. Reynier brought out his "accumulateur à compression externe," which, in the opinion of some, marks a decided step in advance in the history of the accumulator, and a description of the latest modification of this accumulator appeared in a recent issue of this journal.

## REVIEW.

**The Comprehensive International Wire Table.** Compiled by WILFRED S. BOULT, Assoc.M.Inst.C.E. (Published by the Compiler, 60, Castle-street, Liverpool, 1890.)

This most exhaustive wire table surpasses any previous effort of the kind. The first useful wire table that we remember was that given by Mr. J. T. Sprague in his "Electricity." One of the earliest commercial tables was that of Messrs. Glover and Co., but of late years they have become innumerable. The table before us is by no means a single sheet, but occupies 51 pages of a crown folio volume. The pages are arranged in columns, each column being devoted to one size of wire or cable. The columns contain diameters in inches and millimetres, areas, relations of weight and length, current densities, resistance and length and resistance and weight, and a number of figures relating to the heating of conductors according to Mr. Kennelly. The columns are numbered from 1 up to 452, but these figures have no meaning other than that 452 different sizes of wire are dealt with. Among the areas we find "circular mils" and "circular millimetres," a most confusing, ungeometrical and objectionable idea. A circular inch, according to this system, is the area of a circle whose diameter is one inch. However, the worst that can be said is that two lines of these valuable tables are superfluous.

In giving the sectional area and weight of stranded cables a correction for the lay has been allowed, but it is not at all clear what this correction is. Taking the author's figures, he gives ·023461 as the area of 7/16 B.W.G.; this is 7·0702 times the area of a single strand, or an increase of 1·003 per cent. But the area of 7/16 S.W.G. is given as ·0229, which is 7·12 times, or 1·72 per cent. increase. Again, the area of 19/18 B.W.G. is given as ·036546, or 19·388 times, or an increase of 2·04, while 19/18 S.W.G. is ·0319, or 19·29 times, or 1·52 per cent. increase. These are but trifling discrepancies, and it is very possible that different makers employ different pitches in the lay of their cables. If the increase in length be 2 per cent., it means that the pitch is about 20 times the circumference of the cable.

But the question of the resistance is not so easy to arrive at. If there were no lay, but say seven straight wires, the resistance would, of course, be one-seventh of one wire. If they were practically insulated from each other, the resistance of a given length of cable would be *higher* than that of seven straight strands in the proportion of the increase of weight or length of each. But the author assumes that it is *less*—that is to say, that it is proportional to a cylinder of the given weight and length. This question presented itself to us some time ago. We inquired from more than one maker as to the actual facts experienced, and we learn that it is usual to reckon the resistance from the weight and length, as in the present tables. In the absence of any definite information from actual measurements, we are inclined to think that it would be safer to divide the resistance of a single wire by seven or nineteen, as the case may be, but if any of our readers can throw light upon the question we should be glad to hear from them.

The matter does not at first sight appear to be important, but the resulting difference of 2 per cent. in volts at the end of a cable, one way or the other, is of no little importance.

The only other suggestion we have to make with respect to these excellent tables is, that the gauge number and name should be given in more prominent type, as at present it is somewhat difficult to find any given size.

## ELECTRICAL DISTRIBUTION BY TRANSFORMERS FROM CENTRAL AND ECCENTRIC STATIONS.*

BY DR. J. A. FLEMING, M.A.

*(Continued from page 302.)*

*Station Measuring Instruments.*—In connection with the Thomson-Houston transformer system there are some very ingenious measuring instruments specially devised for alternating currents. There is, for example, an amperemeter and voltmeter (*see* Figs. 26 and 27) which act on the same principle. A light brass arm, swinging on almost frictionless bearings, moves in a vertical plane, and carries at its extremity a small horse shoe, or U-shaped piece of soft iron. A flat circular bobbin of wire, wound on a split brass spool, is fixed with its plane vertical, but centre eccentrically

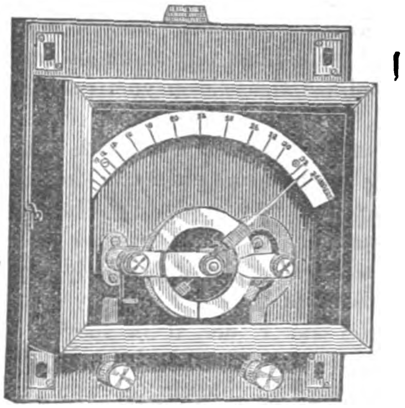


FIG. 26.—Alternating-Current Ammeter.

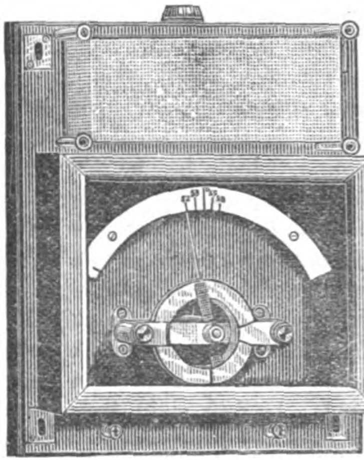


FIG. 27. Alternating-Current Voltmeter.

situated with respect to the pivot of the needle. The U-shaped piece of soft iron embraces the coil, and its motion round the pivot is constrained to be simply a movement nearer to or further from the inside surface of this circular coil. When a current passes through the coil of wire it creates a non-uniform magnetic field in the interior of the coil which is stronger near the inside surface of the coil than it is at points nearer the centre of the coil. The soft iron tends to move from places of weaker to places of stronger field, and in so doing moves the arm to which it is attached round its pivot, and displaces the index arm. This arm carries a counterbalance so fixed that the magnetic force on the iron is opposed by a force due to gravity, and the position which the needle takes up under the influence of these opposing forces is one which is dependent on the strength of the field in the interior of the coil, and therefore of the strength of the current in the coils. The force on the iron due to the current in the

* All rights are reserved.

Digitized by Google

coils is one which depends partly on the strength of the field at the spot where the iron is and partly on the rate of variation of this field from point to point in the circular space. If the spool is wound with coarse wire the instrument may be graduated arbitrarily, and by comparison with a standard as an amperemeter. If the coil is wound with fine wire, and has a German-silver resistance coil in series with it, then the instrument may be graduated as a voltmeter. In the station such a voltmeter is worked off the secondary of a small reducing transformer, which takes current from the mains, and series to measure the primary pressure. These instruments, of course, require to be graduated by comparison with an electro-dynamometer for the particular periodicity for which they are to be used.

*Street Lighting by Incandescent Lamps.*—In addition to the incandescent lighting by single and grouped transformers, the Thomson-Houston Company have elaborated a very good system of street lighting by incandescent lamps which meets the demand for such public lighting over considerable districts in which it would not pay to put down transformers and work the incandescent lamps in parallel off the secondaries. This proves itself in practice to be quick and efficient. In order to keep the current constant for each series line a current indicator is placed on each line in the station, and a switch by means of which one to five relief lamps may be thrown into the circuit. As long as the proper number (viz. 40) of lamps are burning on each series line the current indicator shows a current of 3·5 amperes, but if one lamp breaks or is extinguished the resistance of the circuit falls at once and the current rises. This is shown by the current indicator, and the attendant then switches on one or more relief lamps to restore the current to its proper value. When the broken lamp is replaced by the patrol the current again falls, and the relief lamp in the station is switched off. This series system may be worked by means of a constant potential alternator and primary lines merely for street lighting alone, but it is more frequently used in conjunction with transformer lighting. In this last case the constant potential primary lines are laid about in a district, and from these primaries are taken off not only the distributing conductors to supply the house transformers, but also the series lines for the street incandescents. The arrangement of circuits is then that shown in Fig. 29. Instead of employing the system of

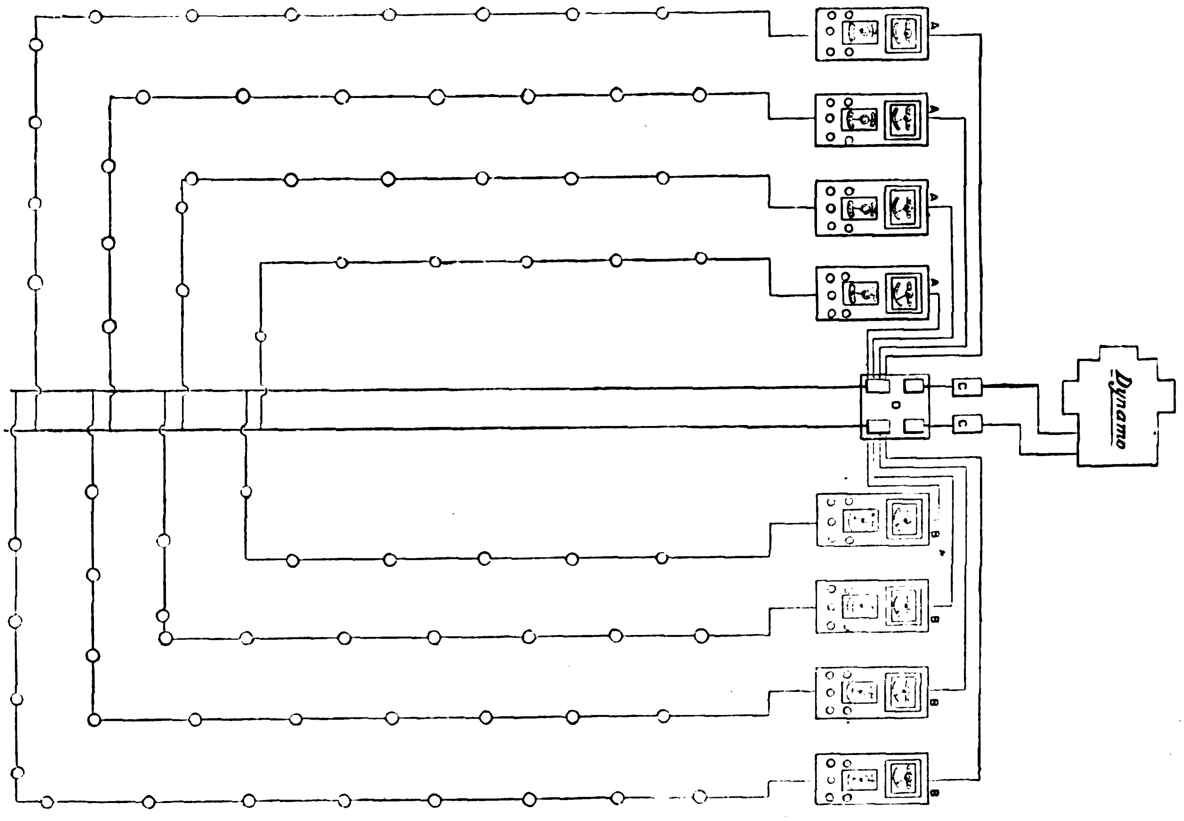



FIG. 28.—Street Lighting by Incandescent Lamps. Diagram No. 1, showing Street Circuits of 40 25 candle-power 25 volt Lamps, or 50 20 candle-power 20 volt Lamps.

system of street lighting consists in running sets of incandescent lamps in series off the primary mains of the transformer circuits. A series circuit starts (see Fig. 28) from a point on one primary of the transformer circuit somewhere in the station, and carries a series of incandescent lamps. This line terminates somewhere or other on the other main primary, and as many of these series lines are run as may be necessary to fill up the district to be lit. The lamps used for this street system require a current of 3·5 amperes, and are of 20, 25, and 40 candle-power. The 25 candle-power lamp is largely used for street lighting. The socket used with the lamp is provided with a spring cut-out, similar to the Thomson Protective Device, the function of which is to keep the circuit closed in the event of the breakage of a lamp. The film is capable of standing the 25 volts required to work the lamp, but in the event of the lamp breaking the full pressure of 1,000 volts is thrown on the film, immediately breaking it through, and thereby short-circuiting that socket. This device relief lamps and current indicator on a bank board, another device is employed sometimes, which consists in using a double socket and double lamps at each spot. One of these lamps only is in the circuit at one time. If its mate breaks, then the second lamp is automatically thrown into the circuit, and keeps a light alive at that place. There is in this case a relief lamp to every lamp, instead of merely five relief lamps in the station. In either case a system of transformer lighting for houses is combined with the street lighting, and the incandescent street lighting is specially applicable in the case of scattered villages and small towns or suburbs, where arc lighting would be impracticable. In connection with this system of street incandescent lighting, light trussed poles of iron are generally used, which carry the overhead series line and also the brackets for the street lamps (*see* Fig. 30). This system of street lighting is being considerably extended. In Malden, Mass., a suburb of Boston, U.S.A., a city of 20,000 inhabitants, street gas lamps have been entirely replaced by about 800 25 candle-

Digitized by Google

power incandescent lamps on this system. The same system is in use at Newton (700 lamps) and Watertown, Mass.; West Point, Va.; Melbourne, Australia; Osaka, Japan; and many other places.

### Thomson-Houston Company's Central Stations. Salem Station.

One of the most complete of the Central Electric Supply stations erected and equipped by the Thomson-Houston Company is that at Salem, Mass., U.S.A. Electric lighting began at Salem in 1881, by the erection of a very small arc-light plant, and has been several times remodelled and extended. Quite recently an exceedingly fine station for an output of 1,700 horse-power has been erected at Salem, and although arc lighting forms the bulk of the work done, yet as there is associated with it alternate-current machinery for incandescent lighting, it may properly be described here. Early in 1888 a site for the new station was secured on Burley Wharf, Peabody-street, close to water, and the erection of the station was begun. The service of lighting was begun in September, 1888. At the beginning of 1890 the current was being supplied for 120 private arc lamps, 180 city arc lamps, 53 incandescent street lamps (series system) of 65 candle-power, 44 of 32 candle-power, and 2,000 of 20 candle-power. The arc-light dynamos are in number 11, of 30 lights each; the incandescent 2, of 400 lights each; 2 of 650 lights each, and 1 of 1,300 lights, and also current is supplied for 50 horse-power in motors. The details of the construction of the Peabody-street plant are as follows:—The station was designed by Mr. Henry C. Patterson, chief engineer of the Thomson-Houston Electric Company. In the construction of this station it was found necessary to drive about one thousand piles of oak and spruce. The piles are held firmly together by an immense bed of concrete made of Portland cement and broken stone two feet thick. On this bed the foundations for engines and shafting were constructed, which foundations are exclusively of granite laid in cement.

In equipping this plant it was thought advisable to install at first one-half of its present capacity. This was done by the erection of two compound condensing engines of 350 horse-power each, and one engine of 160 horse-power. All three engines belt to the same shaft (*see* Figs. 31 and 32), making it possible by the use of clutches to run any one of the engines on the same shaft at one time. In case of accident a defective engine can be shut down, and the load at once taken up by the others. Space is reserved, and foundations are already prepared, for two more engines of 350 horse-power each, and additional shafting. This makes the total output of the plant 1,660 horse-power. The engines are condensed by means of a surface condenser, which returns the condensed water directly back into the boilers, but passing on the way through economisers.

The boiler-house is 90ft. long by 50ft. wide; has space for ten boilers of 125 horse-power each, four of which are already installed with the Jarvis furnace. The boilers are also placed upon granite foundations which rest upon piles, as in the previous case. They are constructed in the most approved manner, from specifications furnished by the engineering department of the Thomson-Houston Electric Company. They are of the ordinary tubular type, 72in. in diameter and 17ft. long, made with extra strong seams and steel tubes, braced in a thorough manner, and having a working pressure of 125lb. to the square inch. The piping of this plant has been carried out with consideration for future output of 1,660 horse-power, and all main steam pipes, as well as exhaust pipes, are large enough for this full duty.

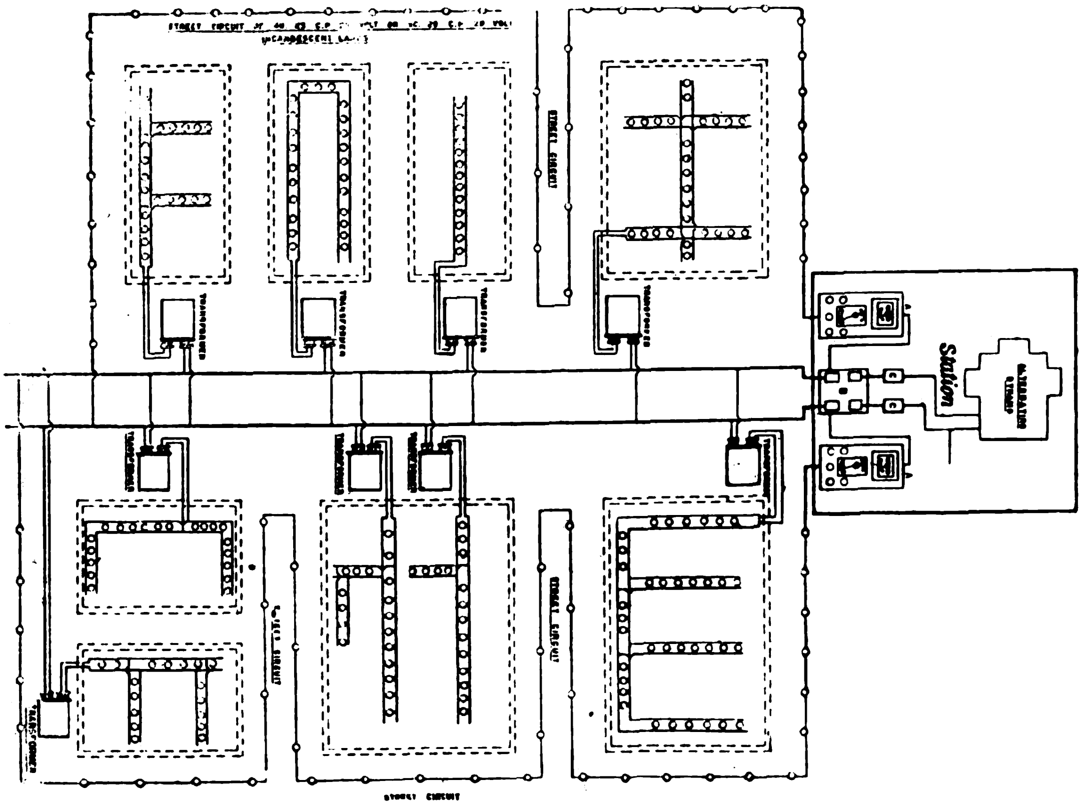



Fig. 29.—Street Lighting by Incandescent Lamps. Diagram No. 2, showing Street Lamp Circuits as arranged in connection with House-to-House Lighting with Transformers.

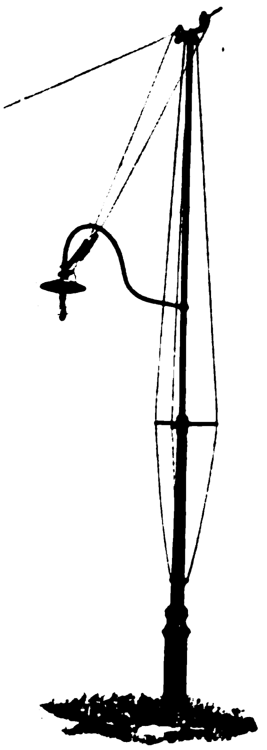


Fig. 30.—Light trussed pole for Incandescent Street Lighting.

The second floor of the main building, which is 115ft. by 66ft., is utilised for machines with a capacity of forty-five Thomson-Houston dynamos, fifteen of which were installed at once. The remainder of the second floor, not used for this purpose, is divided into offices, work-rooms, testing-rooms, toilet-rooms, &c. The coal shed has a capacity for 2,000 tons.

The brick chimney of this plant is 130ft. high, and 13ft. square at the base. The chimney is square in form, with a round core 72in. in diameter at the bottom, and 76in. in diameter at the top. The structure contains 250,000 hard bricks laid in cement, and also 41 perch of granite in the foundations, which rest on 60 oak piles firmly bound together by 3ft. of Portland concrete. This chimney has a capacity of 1,500 horse-power.

Digitized by Google

The entire work of construction, the building, and the placing of the engines, boilers, and machinery was carried out under the direct supervision of Mr. Patterson. In the construction of this plant, it has been Mr. Patterson's endeavour to construct one of the most economical and best running stations possible, and also of an original design. As the Salem Company had increased their plant twice before the construction of this plant, it was their desire to build one of such magnitude as to be entirely sufficient for the future; and as at present they are exerting about 600 horse-power, it would seem that there is ample in reserve for some time to come. Believing that in the construction of an electric light station the best is

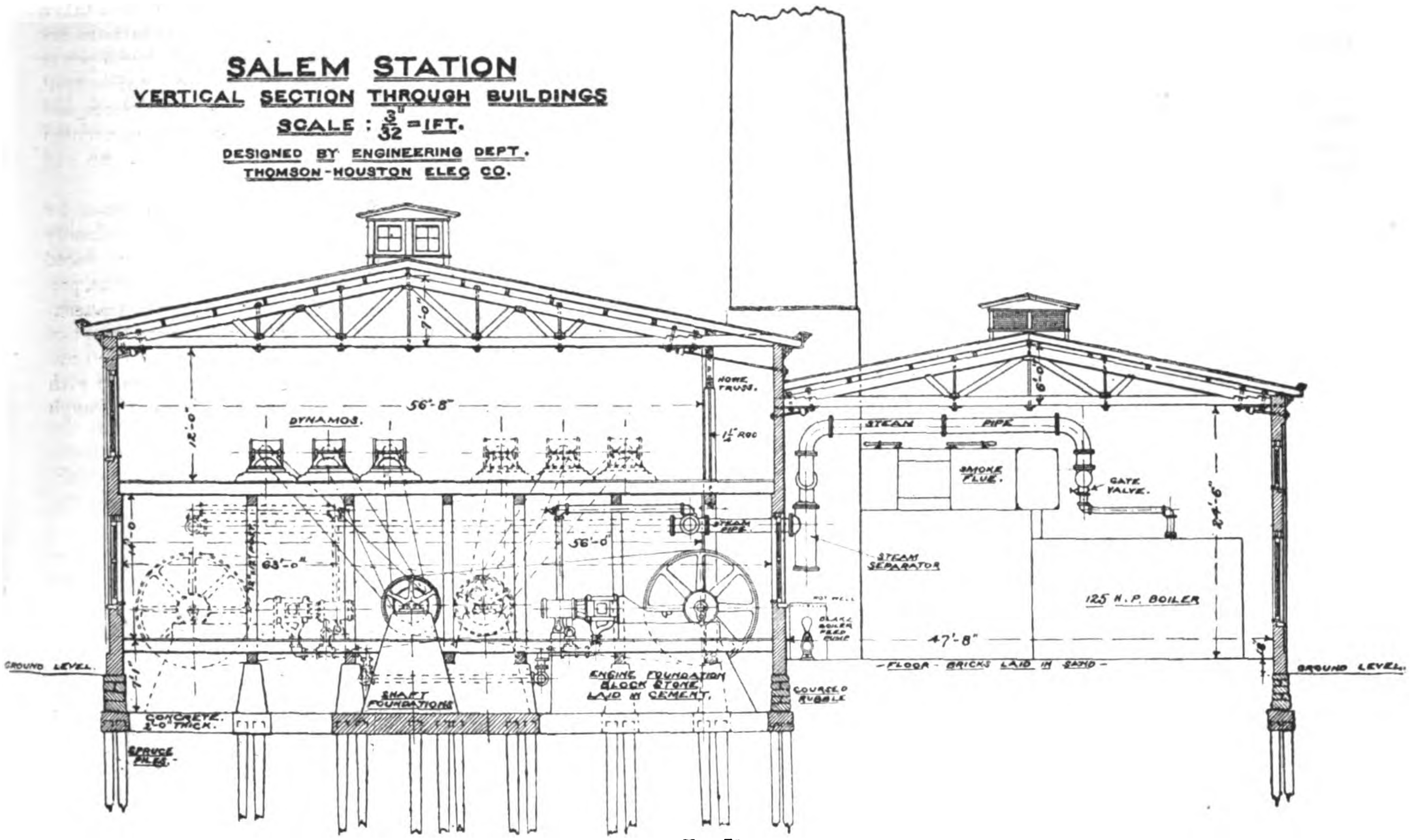



Fig. 31.

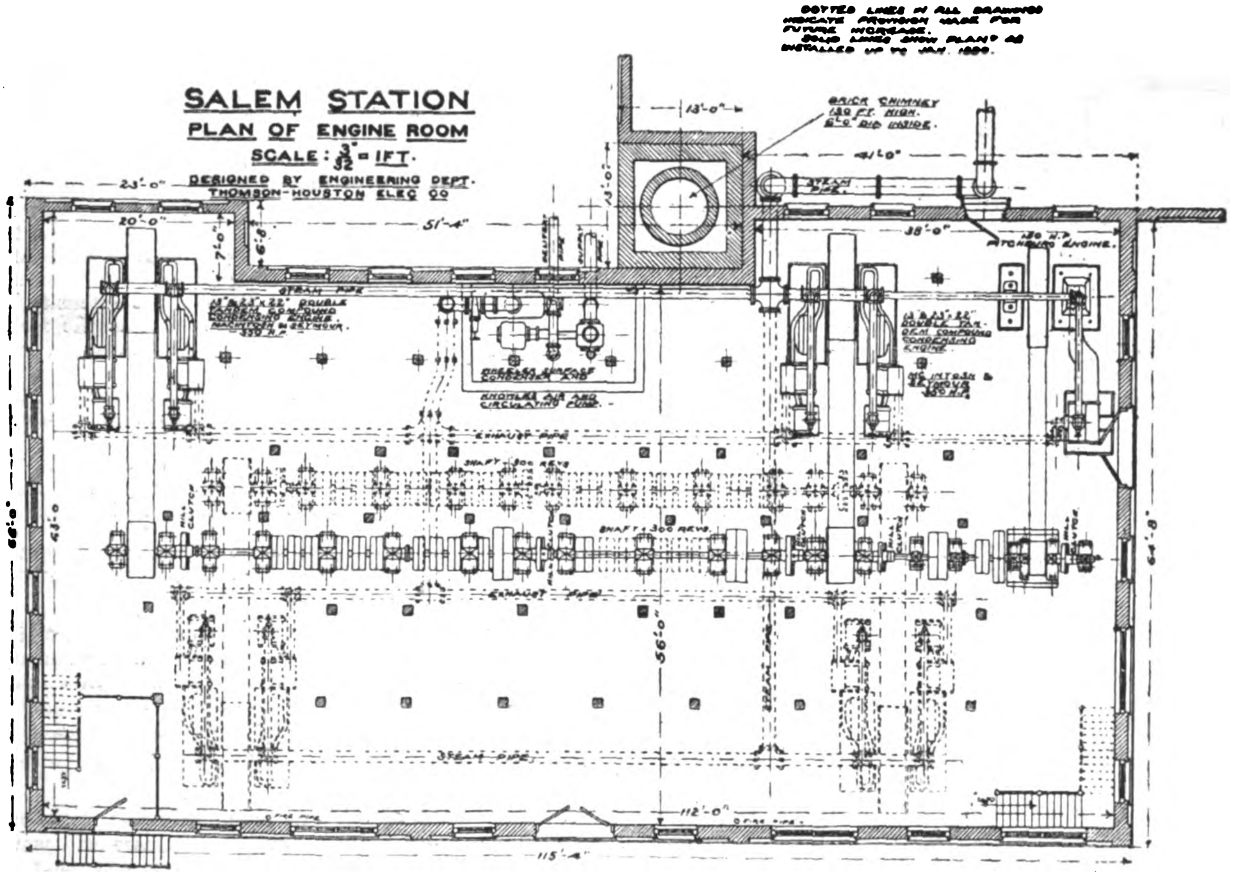



Fig. 32.

Digitized by Google

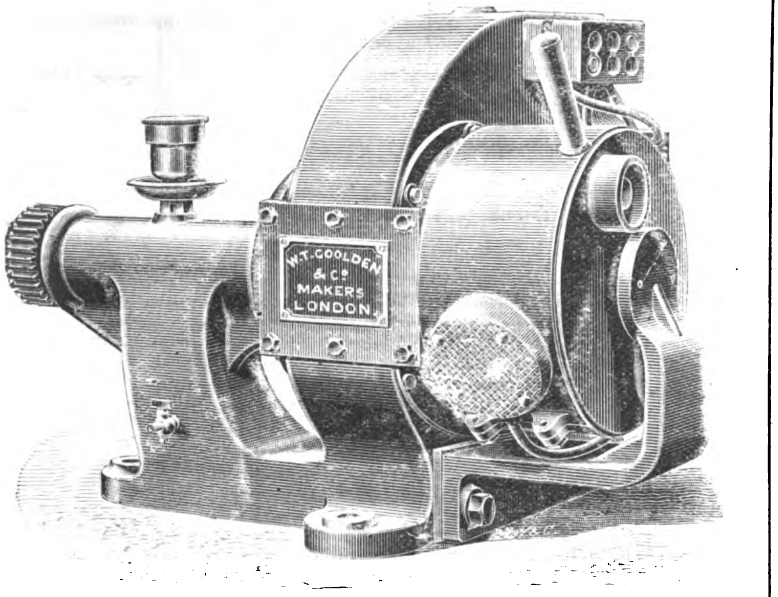
none too good, and that a station should be attractive to the employés, the Salem Company has provided all necessary accomodation for them with the later addition of a library, which is filled with the latest electrical books and periodicals entirely at the disposal of the employés.

In regard to the economy of the steam plant, the change from high pressure to compound condensing, and their present location, has been highly satisfactory, the average coal bills being reduced 50 per cent. since getting the new station into successful operation. This is due to better facilities for getting coal, as also to more economical engines. At a recent preliminary test made with Georgia Creek Cumberland Coal and steam pressure at 110 pounds, the boilers showed an evaporative power of 9·7 pounds of water per pound of combustible. The engines, which were developing a variable load, from 192 to 419 horse-power, showed an economy of 1·8 pounds of coal per horse-power per hour.

*(To be continued.)*

## MOTORS FOR MINING WORK.

Within the last few years—almost it might indeed be said within the last few months—electricity has found a promising field of utility in the application of dynamos and motors to the




various operations of mining. One of the first firms in this country to realise the amount of work which was awaiting the electrical engineer in this direction was Messrs. Goolden and Co., who soon recognised that mining plant had to be designed on very different lines to electrical machinery intended for ordinary above-ground purposes. One of the principal difficulties likely to occur in connection with mining work is the very rough conditions and dirty situations in which the motors have to be used, and a further difficulty in coal mines is the danger that occasionally arises from the presence of explosive gases. For ordinary purposes, even in coal mines, it may be safely assumed that the motor will not be working in an explosive atmosphere, and it is, therefore, sufficient to carry out the arrangement first used some years ago by Messrs. Goolden and Co. of enclosing the whole armature and brushes in air-tight and dirt-tight coverings. These coverings are sufficient to exclude an explosive mixture for many hours, and before such mixture finds its way into the neighbourhood of the armature or brushes the condition of the atmosphere will have been noted by the attendant, and the current cut off.

The annexed illustration shows one form of Goolden mining motor, in which the complete enclosing of the armature is one of several important features. The construction of the armature is unusually strong, since the wires are keyed in every position and insulated from the core and from one another by means of mica. This has enabled these motors to be used for driving hauling machinery, subject to great vibration and shocks, by the use of gearing, thus doing away with belts, chains, and other forms of connection, all of which have proved in practice to be unsuitable for working, at all events, where portability is a *desideratum*, which is the case with the bulk of mining machinery. The enclosure of the armature has been supposed by some to be impossible, on the ground of the want of ventilation; and in the discussion on mining motors, which took place some two years ago at Sheffield, at the meeting of the Mining Institute, several eminent electrical engineers stated that in their opinion it was impossible to work a motor thus enclosed. It is sufficient to state that even at that date Messrs. Goolden were using motors working up to 30 or 40 horse-power with such enclosed armatures. In cases where it is desired to make a machine absolutely safe in an explosive mixture, Messrs. Goolden employ an arrangement in which the volume of gas enclosed in the cover of the brushes in contact with the commutator is as small, or less, than that enclosed in an ordinary safety lamp; and, therefore, should ignition result, the volume of gas compared with the length and cooling surface of the outlet is such that no flame will appear externally. These motors are now being widely adapted for use in electric coal-cutting machinery, electric pumps, electric haulage, and rock-drilling plants.

## THE INTENSITY OF TELEPHONIC EFFECTS.*

BY E. MERCADIER.

The intensity of the action of a telephone depends principally on the thickness and diameter of the diaphragm, the strength of the magnetic field, and the shape of the magnetic field, and of the magnetising coils. I have already investigated the influence of the thickness of the diaphragm, in a contribution to the *Comptes Rendus*, in April, 1889, and shown that for every telephone with a given magnetic field there is a thickness of diaphragm which gives maximum effect.

*Influence of the diameter of the diaphragm.*—Knowing the thickness of the diaphragm for maximum effect, we can vary its diameter. If we do this we discover that there is also a particular diameter, which gives the best effect. This may be attributed to two causes:—(1) The magnetic field only produces a sensible effect on a limited portion of the diaphragm. So that if we increase the diameter we also increase the proportion of the diaphragm, which, from the point of view of induction, is inert, and do not increase the part subjected to induction. (2) By progressively increasing the diameter, we, doubtless, augment its flexibility, and thus assist its movements; but, on the other hand, we also increase its mass, and consequently render its movements more difficult. For the necessarily limited variations in magnetic intensity, it follows from this, and experiment, moreover, confirms the fact, that the diameter, which produces the best effect, must be greater the stronger the field. We thus see how telephones of large diameter, and relatively strong magnetic field, like the Gower, Pollard, and other instruments, do not give better results than instruments with weaker fields and smaller diameters, as the D'Arsonval, Ader, and Aubry telephones. Hence, if we wish to obtain the maximum effect with a given telephone, it is necessary to proportion the thickness and diameter of the diaphragm to the intensity of the magnetic field.

*Influence of intensity of magnetic field.*—This influence is far from being as great as is commonly thought. I carried out a long series of experiments on this point, magnetising the soft iron cores of the magnetising spirals by means of an electro-magnet, instead of fixing them as is usual on the poles of a permanent magnet. In this manner it is easy by varying the strength of the exciting current to produce magnetic fields of widely different intensity. On gradually increasing the strength of the field, a limit is soon attained, after which the telephonic effect is not sensibly increased. This is because the diaphragm rapidly becomes magnetically saturated and an ever-increasing number of lines of force pass across it, as one can see by throwing iron filings on it. Hence an increasing proportion of the magnetic field is useless, so far as the production of telephonic effects is concerned. It must moreover, be remembered that these effects are due to deformation of the lines of force of the field, and that the stronger the magnetic field the more the lines resist deformation by the waves coming from

* From the *Comptes Rendus*, Vol. CXII. No. 2.

Digitized by Google

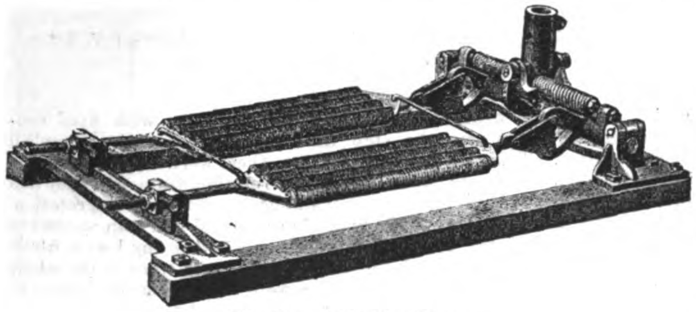
the voice, and the energy of these waves is necessarily limited. This applies equally well to the receiver, in which the energy of the voice waves is replaced by the energy of the electric waves, which the transmitter has produced. We can thus explain the want of success of the many attempts which have been made to increase the intensity of telephonic effects by increasing the strength of the magnetic field, and how, finally, practical men have decided only to use instruments of small dimensions (which are consequently more manageable) with relatively weak magnets.

*Influence of the shape of the magnetic field and of the coils.*—It may be said, without exaggerations, that all possible shapes have been tried, but it is evident that, other things being equal, theoretically the best shape is that in which the lines of force are perpendicular to the direction of the coils. That this is so, indeed, M. D'Arsonval has shown in his telephone, and my own experiments on this subject corroborate this conclusion. Moreover the variation of the shape of the field (the source of telephonic effects) can be facilitated by increasing the mobility of the field, and this can be increased to a certain point by increasing the mobility of the magnet, and of the cores of the coils. This result was recently obtained by Aubry, who fixed the magnet to a vibrating plate, but there is a limit to this which must not be passed, and which experiment determines.

It follows from these well-known effects, which I have pointed out, and from my own investigations, that to obtain the maximum effect from a telephone it is necessary:—(1) To increase the mobility of the lines of force. (2) To pass as many lines of force as possible through the coils in a direction perpendicular to them. (3) To diminish the thickness of the diaphragm, until this is just sufficient to absorb the greatest number of lines of force existing in its vicinity. (4) To increase the ratio of the volume of the diaphragm under induction to the total volume, which necessarily leads to diminution of the diameter up to a certain point.

## ELECTRIC RAILWAY DEVICES.

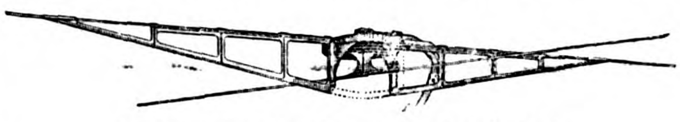
The development of the overhead system of electric traction in the United States has given rise to a great variety of clever devices. In our issue of December 12th we gave an illustrated description of an ingenious trolley base devised by Mr. Charles Lieb, of New York. The trolley base illustrated herewith is one which is, perhaps, not quite so ingenious, but it is one which has been used with success on over 1,000 electrical cars. It is the joint invention of Messrs. Albert and J. M. Anderson, of Boston. The figure



The Boston Trolley Base.

shows the base of the trolley with the pole removed. It will be seen, says the *Electrical World*, that the movement of the trolley pole in a direction parallel to the length of the car, whether forward or backward, brings the eight longitudinal spiral springs into tension. These springs are hung to the rocker arm by a method which provides in a very ingenious manner for maintaining a constant tension in all positions of the trolley arm. The forward and backward motion of the trolley arm brings into action the one or the other of two independent centres between the springs and the rocker arm, and this arrangement is such that a very slight motion in the trolley will put the springs under tension. The movement of the trolley pole at right angles to the length of the car is provided for by an axis of suspension at right angles to the main axis and by two spiral springs placed as shown. All these springs have suitable adjustments for regulating the tension.

In a recent issue the *Electrical Engineer* of New York describes the Bagnall Trolley Wire Crossing Device. In the erection of overhead trolley wires, where the tracks of one company cross the tracks of another, the company first to erect their trolley line will obviously have the right to the most favourable position, that is, the under position. The company last on the ground are required to take the upper position. Their cars are, therefore, left without current while passing the crossing. The current must be shut off from the motor before reaching the crossing so as to avoid arcing at the crossing gap. The Bagnall trolley wire crossing, manufactured by the Emerson Electrical Manufacturing Company, of St. Louis, is designed to avoid this difficulty and maintain continuity of the current to the trolley arm while passing such a crossing. The accompanying illustration shows a perspective view of the device. To the upper trolley wire is attached a bridge-piece of light lattice casting, at the centre of which is a gap through which the under trolley wire passes. It is attached to, but insulated from, the bridge by means of a disc of insulating material placed in an inverted cup at the centre of the bridge. A curved lever hinged to the upper side of the insulator cup rests by the action of gravity in the position shown. The passage of a trolley wheel along the wire from right to left will carry the lever along with it, and thus bridge over the gap as shown by the dotted lines and maintain a continuous connection between the upper trolley wire and



Bagnall Trolley Wire Crossing for Electric Roads.

the trolley wheel. After the trolley wheel has passed over the gap, the lever is released and falls by gravity into its former position of rest. The hinge and guides of the lever are protected by a hood—not shown—as a protection against ice. In fixing this crossing in position it is not necessary to cut either of the trolley wires. It is attached directly to the upper trolley wire by means of clips and solder, and the under trolley wire is attached in the same way to its insulator web. In case of slackening or changing in position of the trolley wires, the clips can be unsoldered, and the bridge moved along in the direction necessary to secure the readjustment and then soldered again.

## LEGAL INTELLIGENCE.

### British Tanning Company v. Groth.

THURSDAY, JANUARY 15TH (*continued*).

Mr. MOULTON, Q.C., in addressing the Court in support of the defendant's case, said that in this action he had one great advantage, and that was that the nature of the case was such that the evidence that had been given—and which he might say, and he thought his lordship would agree with him, had been given very fairly by the witnesses of the plaintiffs. But they had certainly given him evidence on which he should be prepared to submit that the plaintiffs' case had broken down. He did not think his learned friends had fully appreciated the case that had been made on either of the two main points—that of anticipation by prior publication and the point of the convention; in fact, he thought he might say that his lordship had shown he was considerably ahead of them in appreciating what the defendant's case was. It was a case, in his opinion, that depended on some very fundamental matters in patent law, principles that would scarcely be denied by his learned friends, and the application of those by the Court in the way laid down again and again by many judges and by many Courts. To the particular specification in this question he should submit that was sufficient to decide this case on the evidence that had been put before his lordship for the plaintiffs. It had been said again and again there were three duties on a patentee; he must first make an invention; secondly, he must describe it; and he must, thirdly, delimit his invention. Our law was not like that of other countries, because a patentee described or delimited at his own peril. If the patentee made his narrow he had the additional security of showing that it had not been anticipated; if he claimed widely his patent was much more valuable if it could be sustained, but if in any portion he was anticipated his patent was bad. As his lordship was well aware that was left to the patentee to do at his peril. What were the principles of interpretation applied to a patent? The Courts more and more every day were getting fairer, not by having what in many cases in olden time was an exceedingly benevolent neutrality, but in trying to hold the scales evenly between the public and the patentee. He could cite a dozen cases in which the Courts had said they were not to strain a patent, either in favour of a patentee or of the public. Of old there was a notion there were monopolies; then came the natural reaction. There was what was called the beneficent interpretation in favour of the patentee, but now the Courts saw there were neither of those things right nor fair; what they must do was, they must try and fairly construe as between the patentee and the public, having a bias for neither. What was the material construction? A patent in its novelty, in its description, and in its delimitation had always to be judged by the knowledge of the time, and to be taken as being addressed to persons who possessed substantially that knowledge. He thought that would be taken and would be accepted by the Courts at the present time as the real material on which the Court had to do the whole of its construction, and on what the inference had to turn.

The ambit of the patent was to be determined by the construction of the specification in view of the knowledge at the time as possessed by

Digitized by Google

those people to whom the patent was taken to be addressed; that was, the people who were in the trade or profession who had to deal with the particular subject matter, and the Courts had again and again said that the Court was to instruct itself up to the point, to take the evidence of experts, and it might take evidence as to the state of public knowledge so far as possible, to put the Court in the position of one of the persons to whom the patent was addressed. Once having done that, the whole responsibility was upon the Court. They judged of the validity or invalidity of a patent by whether or not it was valid or invalid at the moment when it was applied for, and they judged of the ambit of a patent in the same way. The ambit of a patent could neither be increased nor decreased, except by way of alteration by disclaimer, which was not the question here. Let him apply those principles to this patent; first of all, let him put himself in the position of a person who was a tanner at the time the patent was first taken out. In the first place, they had it that tanning was well-known for more years than one could count—perhaps even as far back as the time when Noah took to business again—to be a process in which skins were turned into the more durable article, leather, by the absorption of the tan liquor through the orifices of the skin; and it was known perfectly well that these skins took away the tanning substance from the portions of the fluid nearest the skins, and therefore those, excepting by the slow process of diffusion, were impoverished, remained impoverished, and the action got less and less active as that impoverishment went on. What did practical people do? It was fully realised why they took out the skins and moved them about; it was to keep the liquid well mixed up and all equally charged. The result of that was that people said they would substitute a mechanical disturbance for hand labour, and plant after plant was laid down for this purpose. In the plaintiffs' process they had a description given of a huge barrel with rows of pegs inside. The barrel was about one-third filled when the hides were thrown into it with the tanning liquor and some other ingredients. Then when it was turned round the hides got heaped up on one side so that they were always working against that weight. The hides rolled over against each other and splashed in the water. The consequence was that so much power was used in moving these and wasted in the friction between the hides that they actually raised the water 10 or 20 degrees in temperature. This rise of temperature came from the churning of the hides, and was confined within the barrel. His lordship would see that a vast amount of motive power must be used in the turning and wasted, but it had been said by Mr. Blackmore that the increased temperature in consequence was one of the most important parts of the plaintiffs' invention. Because it was absent in the defendant's process Mr. Blackmore said they could not tan the hides under 35 days.

But let them see if there was not another factor. The hides were rolled over and over, and Mr. Blackmore said that was one of the things that would affect the tanning. Let him go on. There was one thing that everyone admitted, viz., that the bending of these hides over one another produced a special suppleness, and that if they did not want it they had to use it with only a small amount of hides; whatever charge they used they must produce this suppleness, this rolling and kneading action. The only effect of the rotatory drum, added to all the previous methods and subsequent methods of mechanical motion in tanning, was just to freshen the liquor. The liquid moved in a body, and, if he might say so, it was something like the way in which the articles were dashed in bleaching; they were thrown over and over, and they had a violent action for the purpose of effectively doing these things. He should show presently that it was admitted by the patentee, and relied on by the patentee, that this rotatory drum was a specially effective tanning agent, with advantages of its own as contrasted with other methods used in tanning. He would not go into the other instances of motion which they proved existed, but he stopped here to explain the state of knowledge at the date of the plaintiffs' patent. One had to put one's self in the position of persons knowing and familiar with those things, both in justice to the patentee and in justice to the public.

Now he went to the patent, and here he was in a most peculiar position, a position, he admitted, of advantage to him. He had got two patents, and it sufficed for his purpose to show that he was outside either for this reason. His learned friend said with regard to the patent in the convention, that if a person at that date came into England within seven months of taking out a patent in France, and took out a patent for the same invention in England, his patent was valid in spite of prior publication in England. Let him point out what that led to. If the English patent was wider than the French one, then he had not patented the same invention; he could not patent A in France and then come to England and patent A plus B, and say he had a right to antedate his patent. The Patent Office was now so strict that he believed they insisted that the specifications should be in the same terms. But he said, that if he could show the invention patented in France was outside the French patent, his learned friend was in this dilemma, either it was the same ambit, and was right, or it was wider, and he could not take advantage of the convention. What he was going to do was to ask his lordship to take the French patent with him, and to put himself in the position of persons of those days who knew the principles of tanning, and that movement had been obtained in all sorts of ways, but that a special way had not only obtained movement, but had special advantages; he asked his lordship to do as the Court ought to do, to construe fairly as soon as he had the knowledge of the time. He would now begin—"The idea of applying electricity to the tanning of skins in pits has already been entertained, and the various inventors who have tried that process have all ascertained the favourable intervention of electricity from the point of view of rapidity of tanning." That said frankly enough it was well known by many inventors that electricity would accelerate tanning, and it was frankly admitted by Mr. Swinburne that meant the absorption of the tanning from the liquid. "On the other hand, the utilisation of rotatory drums for the tanning of skins produce economical advantages which are too well known for it to be necessary to repeat it here." Now, what did the patentee say? He said he appealed to French tanners; they knew how well the rotatory drum had gone; it kept it all in, it got warm, it splashed, and it made the things supple. Those economical advantages, as they saw, were attributed by the patentee to the rotatory drums, and that the rotatory drums had special advantages possessed by no others; that it was so well known there was no need to repeat it. "We have conceived the idea of applying electricity to this latter mode of tanning—that is to say, tanning by rotatory drums, by placing the skins in contact with the tanning juices in the interior of revolving drums." Was it possible for any patentees to have said more, to let an honest member of the public reading that know what the invention was, and coming to the delimitation of the invention, would he not say to himself, the patentees meant to combine the advantages of the rotating drums and electricity by applying electricity to the hides while they were in these revolving drums? "By this combined action of electricity and rotation in the apparatus an extremely rapid tanning is obtained." He treated as co-ordinate the electricity and the revolving drum; he used the same language to people knowing the object of one and the other, and it would be just as fair to say that something else besides electricity was included as something else besides revolving drums. He (Mr. Moulton) called that an honest specification, and he thought his lordship would see it was thoroughly honest from beginning to end. There was no attempt to hedge, and there could be no doubt that a person who used these words with an intention of going beyond them would have been deliberately deceiving the public. The patentee said that in order to carry out this process of rapid tanning by the double action of electricity and rotation, they had had to adopt the construction of the rotatory drum. By adopting that scheme meant the obtaining the passage of the electric current through the drum. What did the inventors consider to be the invention? They had made a rotatory drum, and to adapt electricity to it they fixed

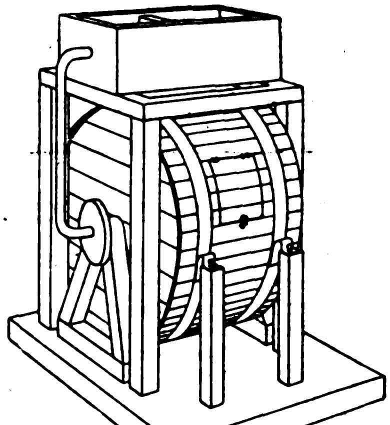


FIG. 1.—Worms and Balé (plaintiff) Machine. Model "S.P.T. 3."
(See *The Electrician*, Vol. XXV., p. 37.)

on the rim of the drum two parallel rims of copper with fixed conductors inside. That was the step that enabled them to accomplish their invention. Taking a rubbing contact they were always applying the electricity which would pass through the rotating drum, and they had solved the problem of combining the advantages of electricity and rotation. The inventor had stated what his invention was, and if a man wanted to limit himself to that, he (Mr. Moulton) doubted whether any better words could have been used; he could not see an ambiguous word in the whole article. It was perfectly well known there were other forms of motion to which electricity could be applied, and that the patent could not claim all of them; but this was an attempt to ride in a wider meaning than the patentee meant, or than the public understood, and that was what he (Mr. Moulton) protested against. The meaning of the patent was settled the moment the patent was taken out; it was the meaning which a person well instructed in what was the knowledge of the time would fairly—trying neither to widen nor to narrow—understand the patent to be, and who, knowing the state of knowledge at the time, must come to the conclusion these people claimed what they had stated and described, viz., a device which, by using a rotating drum with circular electrodes and rubbers, enabled them to get the well-known advantages of the rotating drum and electricity; that they never patented anything else; and that if that was established the Court would not widen the specification. The Court would not, because it thought the patentee might have claimed more, alter his claim and make it more than he felt it to be. When they came to read the French specification, one could not come to any other conclusion than there had been no infringement, for it was not suggested that what the defendant did was either to use the rotating drum or to get the well-known economical advantages of the rotating drum. He would point out that it was admitted that the defendant did not by his process get the well-known advantages of the rotating drum, and Mr. Blackmore said it would take 35 days to complete the operation of tanning, and that, apart from electricity, the defendant's method would fail. He thought Mr. Blackmore rather overdid it. The defendant did not think so poorly of his method, and he (Mr. Moulton) did not think the plaintiffs thought so poorly of it, or they would not have given them so many eminent people in the witness-box or have brought the action; but that was a detail. What the defendant said was that it was not the same

Digitized by Google

appliance as the rotating drum, and since the plaintiffs had claimed only the advantages of the rotating drum, that therefore they could not now turn round and say that the defendant, who had not used that, had infringed their patent.

At this stage the further hearing was adjourned until Friday morning.

FRIDAY, JANUARY 16TH.

The hearing of this action was resumed before Mr. Justice Romer on Friday, when

Mr. MOULTON, Q.C., continued his remarks to his lordship on behalf of the defendant. He said that when the Court rose the previous night he was going through the French patent in order to show the patentees there only claimed the application of electricity to one particular form of tanning plant; it was a combination of a drum and electrical action, that the patentees treated as two co-ordinate factors, the rotating drum and electricity. Whatever might be the result of the matter on the legal point, he felt sure that the patentees, Messrs. Worms and Balé, never intended to do more than claim a combination of a rotating drum and electricity, and if they obtained anything more it would be because the law forced it on them. He was now going to examine into the proposition, aye or no, did English law give a patent any wider meaning than a man meant it to have, provided he used words which fully carried out his meaning? He was not going to say a man might not draw a patent and give it a wider meaning than he meant, but taking the words used and the meaning they would bear to the instructed people at the time, which was the meaning they must suppose he had, was there any doctrine in English law that gave a patent a wider meaning than that? He submitted there was none; there was no authority and no reason for it. That was the point of the case The advisers

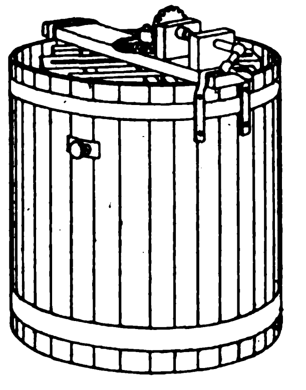


FIG. 2—Groth's (defendant Rotary Machine. Model "S.P.T. 1."

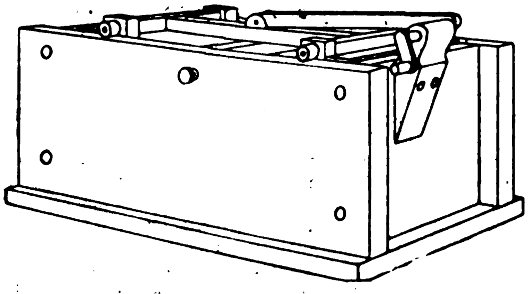


FIG. 3.—Groth's Reciprocating Machine. Mode "S.P.T. 3."

of the patentee said he might have made a broader claim, as they did not find that anybody claimed electricity with mechanical motion. If the patentee had claimed that it would have been safe, but he would show they asked them to read this claim, or the broadest claim the patentee could have made in the light of subsequent knowledge. That, he said was not permitted in English law. They had a right to stake out their ground, but they did it at their own peril; if it was too wide a plot it was bad until it was altered, and if too narrow they had that and nothing else. The late Master of the Rolls said, "The claim shows all that he keeps for himself, and everything without that claim is not his." Here he said these persons had a knowledge of many ways of applying motion; when they came to stake out their plot they said they claimed the rotating drum and electricity. Whether it would have been possible to make a wider claim, they did not do so, and now he said his lordship could not read that to be a claim generally for combining motion, which at that time had been done in many other ways with the rotating drum, and electricity. If he could convince his lordship of that, the whole of the evidence of the plaintiffs went, for every one of the experts was obliged to admit that it was because of the two factors, motion and electricity, that they considered the defendants an infringement of the plaintiffs' patent; in other words, if those were sufficient to constitute an infringement, it must be that the patent generally was for a combination of those two things. Suppose a man was to use instead of a rotating drum a sphere rotating upon a horizontal axis, the answer would be it behaved as a drum, the motion of the hides, the plashing in the water, the giving off of gases, everything was the same, and there a sphere and a drum were identically the same things; they had only coloured their invention.

Mr. JUSTICE ROMER: It appeared to me earlier in the case, and still does appear to me, that the real question here I have to try is whether or not the form of instrument you may use, apart from electricity, comes substantially within the meaning of the tanning machine known as the rotating drum.

Mr. MOULTON said that was exactly what he was about to argue, and the instance of the sphere he meant to be an exact instance of that, aye or no, did it come substantially within the meaning of the rotating drum? That was what he was leading up to when he said he would meet the question of a mechanical equivalent. That which was protected was that which was specified, and that which was held to be an infringement must be an infringement of that which was specified. Defendant's process was nothing like a rotating drum, and the accident that it was round was due to the fact that it was convenient to try it in a tub, a brewer's mash tub, but it practically was a pit; they had a cage or framework, and it need not revolve, but move forwards and backwards. All these were familiar characteristics to persons acquainted with tanning, but none of them would call the defendant's moving frame a rotating drum. The issue to be decided was whether a person at that date would have taken defendant's models to be, in the language of tanners, a rotating drum, and to be referred to by Worms and Balé in that way.

Mr. JUSTICE ROMER: You are going to call evidence? On the plaintiffs' side there is not much evidence directed to the present state of the tanning trade.

Mr. MOULTON said he would call a witness who would prove that. There had been a question about mechanical equivalent. The first thing necessary for a thing to be a mechanical equivalent was that it should be an equivalent, so that the world could say it was a mechanical equivalent. It could not be said that defendant's model was the mechanical equivalent of the plaintiffs', when the action upon the hides was so different.

Mr. JUSTICE ROMER: It is not a question whether it is a mechanical equivalent for the purpose of motion at large, but whether it is so far the class of motion covered by the rotating drum.

The ATTORNEY-GENERAL said the better expression would be a known alternative.

Mr. MOULTON: A known alternative for producing the same thing; it must produce the *same* thing, or it could not be an equivalent. His learned friend said that the drum was necessarily a mechanical equivalent for a cage revolving in a vat. If his learned friend went to a fair, and bought a merry-go-round, he might succeed; but if he put the people in a revolving drum, and told them they would be equally successful with that, he thought he might have some trouble (laughter). So far as tanning was concerned, the defendant's process was totally different from the treatment the hides were subjected to in a drum, and it was no use saying it was a known equivalent. There might be cases in which the drum might produce the same mechanical action, the hides might be stretched in such a way that the action would be the same as in defendant's model, but before it could be a mechanical equivalent they must show it produced the same result. The moment they considered it in that point of view the possibility of equivalents went at once, and that was why he asked if there would be a good patent for the plaintiffs' model? Of course there would. It was a very daring thing to use the hides in the way they were used in the rotating drum, because it spoiled some leathers whilst it improved others, but they were no more equivalents than two broadly different modes of action, therefore he said they were not mechanical equivalents. Bodies stretched upon a frame, and then turned round, were not known substitutes, because they would not do one thing for the other. In the same way sweetmeats rolling over one another and rolling against each other.

The ATTORNEY-GENERAL: Really we know nothing about sweetmeats. There is deal of this scientific evidence that does not come from the witnesses.

Mr. MOULTON said it was used as an argument. His argument was that the plaintiffs must prove that the defendant's process was equivalent in its action to theirs, and in this first stage the plaintiffs broke down entirely.

Mr. JUSTICE ROMER: Mr. Attorney-General, for the explanation of the Court, may I ask whether you contend that under Section 103, when there has once been a Convention with any foreign country, that a person who applies for protection rather than a patent, that person must only obtain the limited term, or has he his choice open?

The ATTORNEY-GENERAL said that since the new rules he could not deny that a person had his choice, but before the new rules were framed that was not so. He should put it as argument before his lordship that the patent must be dated back, and if not, the result would be that the term of the patent would be shortened at the other end.

Mr. Justice ROMER: Between 1883 and 1885?

The ATTORNEY-GENERAL said the new rules were dated May 15, 1888.

Mr. MOULTON said they were merely rules made under the Act. He must not be taken as admitting there was no way of persons informing the Patent Office of any point they wanted to raise. The new rules were not a fresh enactment.

Mr. JUSTICE ROMER: That does not relieve the difficulty in the Attorney-General's way; he would have to argue the effect of the rules was to alter the effect of the statute in a very serious point; that the effect of the statute was to deprive the inhabitants of such foreign country of their choice which was restored to them in the rules.

Mr. ALFRED WILSON, a practical tanner, was the first witness called, and he stated that he had been engaged in the tanning business for a period of over 30 years. Prior to the year 1887 there had been various means of mechanically moving hides whilst in the process of tanning. He had worked with some of them himself; he had worked with the form of dipping the hides up and down on a frame, and with the American rocker.

Digitized by Google

The ATTORNEY-GENERAL said he understood this evidence was being taken not for the purpose of narrowing his specification, but to improve the knowledge of the Court.

Mr. JUSTICE ROMER: Certainly, that is so.

Examination continued: There were several methods of motion. He had seen both defendants' modes. The round one (Fig. 2.) was novel as far as the mechanical arrangement was concerned, but the vat was an ordinary one used in many Continental States. The mechanical arrangement caused the hide to rotate and the liquor also. The mechanical arrangement would work equally well in any other shape. An instrument known as a rotating drum, similar to that of the plaintiffs' (Fig. 2.), was known in the tanning trade.

In cross-examination by the ATTORNEY-GENERAL, he had never seen a cage on a vertical shaft in which skins were suspended. He had seen hides suspended on a drum, the shaft horizontal and turned round in tanning liquor. The axes were immersed in the liquor, which went over the whole framework. That formed the patent.

Mr. JUSTICE ROMER: Was that a distinct patent from the other?

The ATTORNEY-GENERAL said that whether a patent or not made no difference for his purpose, as they were not set up as anticipations.

Cross-examination continued: Provided there was clearness for the skins to fall over, it made no difference whether it was a pit or a drum.

Re-examined: In the case of tanning on the outside of rotating drums, the skins were attached to movable sticks placed on the drum and practically forming the drum. They were fastened only at one end, and rubbed and fell against one another in the operation.

Dr. RIDEAL, Lecturer in Chemistry at St. George's Hospital, said he had given attention to the subject of tanning. He knew the various forms of plant used in tanning before the date of 1887. He had heard the various forms given for motion in use before 1887, and he agreed with those descriptions. There were also several other forms to those described of the use of motion so as to keep the liquid fully charged with the tanning. He knew of the process of tanning in a revolving drum, a process that was always accompanied with a great rise of temperature and pressure. The absence of air in an enclosed drum also affected the tanning process. The hides by being beaten about lost a considerable quantity of material, such as gelatine and albumen, which was beaten out of the hides by the operation of the revolving drum. This made the hides more supple when finished. Such a drum was used for special kind of work. He had seen both defendant's models, and believed these two forms were about equally efficient when used under the same conditions. They were used with an open top, except that a board was placed on the top to prevent the liquor splashing out. The operation to which the hides were subjected was not the same as the operation in the revolving drum, and he did not agree with some of the witnesses yesterday in that respect. In both of defendant's forms the hides were suspended, whilst in the revolving drum they were loose. In the two forms of the defendant's apparatus the hides were placed parallel to the electrodes, whereas in the revolving drum the hides would be at right angles to the plane of the electrodes. The defendant's two forms were similar in that respect, and, therefore, differed from the revolving drum. There was no rise of temperature or kneading of the hides in defendant's process, whilst these actions took place in the revolving drum. These matters affected the result of the tanning, and he should think the defendant's process was best for sole leather, the plaintiffs' being better for kips and bazils. Prior to 1887 a form of tanning was known to tanners as tanning with the rotating drum. He should certainly not call either of defendant's models a rotating drum.

Cross-examined by the ATTORNEY-GENERAL: He gave this evidence as an expert witness, and not as a practical tanner, though he had tanned skins. The defendant's process required, when worked alternately day and night, about a month to repeat the tanning process. He had never heard that if worked consecutively the process required only 80 or 90 hours. He had seen motion and electricity applied for a period of eight or ten hours. He had never tried to tan consecutively by the process for four or five days. From the rate at which tanning took place in the eight or ten hours, he should say it would not tan in four or five days; he should be very much surprised if it did. Leaving electricity on one side, he considered the principal object of the rotatory drum was to produce the suppleness that was important in kips and bazils and all soft leather. Undoubtedly one of the objects in keeping hides immersed and the tanning liquor in motion, was to bring a stronger liquor to bear on the hides. The principal object in the defendant's apparatus was to cause a uniform action of the liquor and electricity on the hides. It was only an advantage to remove the gelatine and albumen in the case of soft leathers. Speaking generally, he should say that no gelatine or albumen was taken out by the defendant's process, and he should not use defendant's apparatus to produce soft leathers. He was not chemist to the syndicate, and had nothing to do with it. Mr. Groth asked him to examine his work, and he did so. He had seen defendant's original specification, and he thought to describe the apparatus as a revolving drum was a peculiar word to use.

In re-examination Dr. RIDEAL said that upon a vertical axis the hides could not tumble over one another as in a revolving drum. In a revolving drum the hides lost in weight, but gained in softness. The revolution of the cage in defendant's apparatus moved the fluid.

Mr. A. TROTTER said he had given great attention to electricity and mechanism. He had been to the Grange, Bermondsey, and seen the defendant's process in work frequently. He had, in co-operation with the last witness, made experiments in the tanning produced there. With regard to the results produced by the two machines used by the defendant, they found them to be almost identical as measured by the absorption of tannin. As to the amount of power required to work them he should estimate it was about one-eighth of the power required to work the plaintiffs' apparatus. He should think that defendant's reciprocating machine would require one horse-power to work and the round model considerably less, whilst the plaintiffs' would take at least seven horse-power. Nothing could be more different than the effect upon hides in a revolving drum and these placed in a drum with a vertical axes. A vastly smaller effect would be the result if the cage were held fast, and the vat rotated, compared with a stationary vat and a rotating cage. The only motion that could be produced would be due to the friction on the sides of the vat. If the vat were turned round and the cage kept fixed, the motion would obviously be where there were no hides, that is, nearest the walls of the vat. It appeared to him that the effect of the electricity in the plaintiffs' machine must be somewhat localised; and if he might take Prof. Sylvanus Thompson's evidence, in which he said the current was more dense under the shaft, it would be more localised than he had previously estimated. In defendant's round model it was almost uniform, and the hides had every opportunity of presenting themselves to its action, and in the reciprocating machine it was as uniform as any current could possibly be.

Cross-examined by the ATTORNEY-GENERAL: He should hesitate very much to accept the statement that it only took 1½ horse-power to work the plaintiffs' machine. The electrical action upon the hides was better in defendant's process than the plaintiffs', because it was more uniformly produced. Beyond that he did not suggest any difference.

This closed the defendant's evidence, and

Mr. MOULTON said, that having addressed his lordship so recently and so fully, he did not intend to say more than a few words. The only new point was with regard to the interpretation of the specification. The learned Attorney-General had put in a specification of the defendant's, but the complete specification completely corrected the use of the word "drum." What his lordship had to decide was the meaning of a public document, and the substance of the case, apart from the construction, was the question, aye or no, was what the defendant did a case of tanning in a rotatory drum as understood by tanners. Not one of the witnesses said that what the defendant was doing would be called using a rotating drum. He submitted that the plaintiffs had chosen for the patent a narrow ambit, and that the defendant had succeeded, and if he succeeded on that, he ought to succeed also on the question of the invalidity and non-infringement.

Mr. JUSTICE ROMER asked Mr. Farwell, who was about to reply on behalf of the plaintiffs, whether, after the passing of the Patent Act, the plaintiffs could not have applied for a patent for the full period, and not have applied under Section 103.

Mr. FARWELL submitted there was at the time no distinction in the form of the application. With regard to the point of infringement, his lordship had heard the various witnesses, and it came back to whether it was or was not a colourable imitation. All they said was that the hides might more or less be tumbled over. According to the plaintiffs' system, in their machine it appeared from the evidence, if they desired to tan, not rendering the leather supple, it was simple to do so by adding to the strength, diminishing the number of hides in the machine, and working the machine slowly, so that they could tan hides for all purposes in the machine invented by the plaintiffs. Did it make any real difference that the defendant said by his process they could only tan in one way? It really came back to this. They found the two processes; they found motion, leaving out the question whether it was rotatory or not; the only distinction between the two processes was that the skins were doubled up more in one than the other; the gist of the matter was electricity applied to motion. They had in both the same tanning liquid and acceleration, and having the same rotatory motion, so that everything was common except that the defendant's rotation was done by means of rotation inside the barrel instead of, as in the plaintiffs', the barrel rotating with the hides inside. The only distinction the defendant could point to was that in plaintiffs' it was more adapted to produce soft leather, and in producing sole leather they had to vary the mode of operation; that was really the only distinction. Because the defendant took a variation of the plaintiffs' invention did not make it less an infringement, nor was it less an infringement because it had not the advantages that plaintiffs possessed. His lordship had the case fully before him, and he would leave it in his hands.

Mr. JUSTICE ROMER then delivered judgment. He said: The two points in this case I have to consider are—first, invalidity of the patent owing to prior publication; secondly, the infringement. I will deal with the question of validity or invalidity first. The point is a very short one. The patentees in this case, before they obtained their patent in England, had patented the invention in France, that an abridgment of the description of the invention as contained in the French patent was published in this country through an American translation before the date of the English patent. It is admitted by the plaintiffs that that would be such a publication as would vitiate the patent in England, except, as they say, for the special provisions of Section 103 of the Patent and Designs Act of 1883 and the amended Act. Now there are, no doubt, some difficulties in the wording of that Act, but it appears to me that, notwithstanding the passing of that Act, from the time of it and throughout to the present, any person applying here for an English patent who had previously obtained a patent in a country with which a convention had been made according to the Act had a double right, he could apply for the restricted patent or restricted rights given him by Section 103; or, if he was under the impression that the foreign patent had not been published here, he still had the right to obtain the ordinary patent for the full period. The two rights would be distinguished when you looked at the width of the patent he obtained, by seeing the date of it, because if he had obtained the limited rights given him by Section 103 his patent would have to bear the same date as, according to the Act of 1883, the protection obtained. The date of the patent, in fact, would show the right he had obtained. In this case it is clear that the patentees did not limit the claim or obtain the limited right. Their patent dates from the date of the application in this country. It does not bear the date it would have done had the patentees obtained the limited rights given them by Section 103. In my judgment, Sub-section 2 of Section

Digitized by Google

103 has been read as part and parcel of the whole section. I do not think it was intended to extend the rights of a patentee who chose in this country not to come and avail himself of special provisions in the Act. It is true that at the date the patent in this case is obtained there was no difference to be made in the form of application for the patent, whether the applicant was applying for the limited rights under Section 103 or the more extensive rights, and it has been suggested that the patentees in this case have intended to obtain the limited rights given by Section 103. In my judgment the date of the patent is conclusive. If there has been any mistake, it is a mistake of the patentees themselves. It was for them, if they wished to avail themselves of the benefits of Section 103, to take care they obtained the proper form of patent; and even if it were not their fault, it was their misfortune, or the plaintiffs' misfortune, and as the same result arises it appears to me, therefore, that the plaintiffs cannot avail themselves of the protection of Section 103. The patentees in this case ran their risk for all I know, and it is probable they were not aware and had no reason to believe there had been any prior publication in this country of their invention in any form or shape, and that being so they decided to obtain, and did obtain, the full rights, and chose deliberately not to take the lesser rights which they might have obtained under Section 103. In my opinion it was never intended by Sub-section 2 of Section 103 to apply Sub-section 2 to all cases of patents where the patentee had previously obtained a patent in a foreign country, but only apply it to the general provisions of Section 103 to cases where the patentees wished to avail themselves of the privileges given by that section. This judgment of mine decides the action, but the evidence has been gone into with regard to the second point of it, and it is necessary, on the question of costs, or at any rate advisable, having heard the evidence, and having the point fully before me, I should also decide the second point, which is one of some nicety, that is, the question of infringement. The key to the decision of this part of the case lies in considering what it was that the patentees in this case meant. To judge that rightly, full consideration should be given to the state of the tanning trade at that time. The original method of tanning, the old method, may be called a stationary method. The disadvantages attending that system was that it took a long time to properly tan the skins. It was found that to improve the rapidity of the process, motion was essential, a continual freshening whereby the liquor could be brought more continuously and uniformly in contact with the skins, and hence arose what may be called the second step in the tanning process, and which I might well call the dynamical process, the process by which between the liquor and the skins motion was produced by artificial means. In the course of time several means were discovered for producing such motion between the skins and the liquor, some of which had special advantages, some of which were more acceptable to certain tanners than others, and several of which were patented. Then came what I gather from the whole evidence was, to the tanning trade at any rate, considered a very great improvement, and certainly it was one which was patented, that is, the system which, on the whole evidence before me, I understand to be meant by the rotatory drum. In that case the liquor and the hides were all put inside a revolving cask or drum, which had pegs or other means by which, in the interior of the revolving cask or drum, the hides were from time to time lifted up, plashed down or, as it has been termed, churned about in the liquor. That was considered by the tanning trade in its effect and operation a very considerable improvement. It had certainly, I gather from the evidence, particular advantages which it possessed over all its rivals. So far as I can gather from the evidence, the splashing or churning was of a particular character; it bent the skins about, and the effect of that was to render the skins supple. Whatever may be the process you are pursuing, to practical tanners the result was in any case that it did improve tanning and shorten the process. Tanning, like many other processes, is one about which it is difficult to say that in each case you can indicate clearly and precisely what it is that operates to make the tanning good or speedy. It might be very difficult to point out why one machine does the work better than another machine, but that was the position of the tanning trade when this patent I have before me was patented, subject to one more observation I must make as to the state of electricity. Electricity had been previously known as a means of improving tanning by shortening the period of tanning. Prior to the date of the plaintiffs' patent it had only been applied to what I have described as the stationary method of tanning; it had not been applied to any of the various methods which I have described as dynamical tanning. Then comes the plaintiffs' patent. What did the patentees patent? It is conceivable, though I think there would have been difficulties in the way—it is conceivable that the patentees, if they had chosen, might have patented the application of electricity to all the various methods of what I have called dynamical. It is clear that if they had done so their patent would have run a great risk of attack, even if they had not extended it quite so far as that. The question is, what did they do? That depends on the construction of the patent. In my judgment it is clear that both by the provisional and the final specification, and from the description of the invention in the French patent, that the only combination claimed was a combination of electricity applied to tanning as affected in rotating drums, drums containing the hides and tanning liquor. The words are the same in both the provisional and complete specifications, and in my judgment it is clear, knowing the state of the tanning trade at that time, that they chose, whether deliberately or not I am not concerned with, to limit their patent to the well-known drum in which the hides and the liquor are contained. When that point is arrived at, the rest of the case becomes comparatively simple. I have only to consider whether what the defendant is doing here is applying electricity to that well-known method of tanning by the rotating drum I have mentioned, or is using the rotating drum colourably or substantially. In my judgment, on the whole evidence this is not. The evidence on the subject stands thus:—The plaintiffs produced several scientific witnesses of eminence, but they only produced one practical tanner. I do not intend in this judgment to go through the evidence in detail. The conclusion I have come to with regard to the plaintiffs' scientific evidence is that when carefully considered it only amounted to this. As scientific men, chiefly electricians, they knew that the reason why the plaintiffs' invention succeeded, and had shortened the period of tanning, was because of the simultaneity of the application of electricity to hides in motion in liquor, however that motion was affected. Knowing that, they then assume that this is the plaintiffs' invention or the patentee's, and, moreover, that the patent is for that invention, and on that footing they say in effect that what the defendant is doing is something substantially the same or equivalent to what the plaintiffs set forth in their invention, and they would clearly be right, if they were right in the point that plaintiffs' patent was for the brain invention that I have indicated. Prof. Silvanus Thompson, in answer to a question put by the Court—for plaintiffs' counsel did not direct the attention of the witnesses to this point of the case—said, "I should call S. P. T. 1"—that is to say, the round model which was one of the two forms of the defendant's—"a rotating drum for purposes of producing motion as between the hides and the liquor." That is to say, motion generally, but only for that purpose, so that Prof. Silvanus Thompson, thinking about the motion of hides and liquor generally would consider that a drum for that purpose. But even for that purpose he would not call S. P. T. 2, which was the other form with which the defendant was tanning, a rotating drum at all. Another witness of the plaintiffs, Mr. Swinburne, said that the hides in defendant's machine received different treatment to those in the plaintiffs', but he considered the two processes as mechanical equivalents. That is the plaintiffs' testimony. The only practical tanner is Mr. Blackmore, whose evidence in itself was almost fatal to the plaintiffs'. The only practical tanner the plaintiffs bring forward was almost shocked at the idea that S. P. T. 1 and S. P. T. 2 could be said to be the same kind of machine as S. P. T. 3, which was the plaintiffs' machine. In a practical tanning sense he said they would not work at all. That is the plaintiffs evidence. I need not refer in detail to the defendant's evidence; it negatives the idea which has been suggested on behalf of the plaintiffs that what the defendant is doing is applying electricity to tanning by means of a rotatory drum. In my judgment it is not a mechanical equivalent for a rotatory drum. In one sense, and in the sense in which the plaintiffs' scientific witnesses use the expression, it is a mechanical equivalent for producing motion generally if that was what the Court had to consider; it is not a mechanical equivalent for the purpose of tanning, and especially tanning by which is well understood by a rotatory drum. Neither in my judgment is it a colourable difference, nor can it be said to be a well-known equivalent to produce the same result in the sense in which that expression has been used. Bearing in mind what I have said as to what the patent of the plaintiffs' is, in my judgment the defendants are not infringing this patent; they would possibly have infringed the patent if it had been for the extended process referred to by the plaintiffs, and it had been patented for that. That is not the case, and the plaintiffs' action, therefore, fails on both points, and must be dismissed with the usual result.

Upon an application for costs on the higher scale,

Mr. JUSTICE ROMER refused the application, but directed that the costs of the motion for an injunction, if not provided for, should be costs in the action.

---

## Schoetensack v. Heyl.

This was an action, which came on on the 14th inst., before Mr. Justice Mathew and a special jury, to recover two sums of £500 and £50 paid by plaintiff to defendant, on the ground that plaintiff was induced to pay the same by defendant's fraudulent representations.

Mr. Kemp, Q.C., and Mr. Ashton were for the plaintiff; Mr. Bigham, Q.C., and Mr. E. Harrison for the defendant.

The plaintiff's case, as opened by counsel, was shortly that in April last he became acquainted with the defendant, who introduced to his notice a certain compound which he had invented, and which was to be used for the purpose of covering cables, instead of the indiarubber at present in general use. On account of its low price the profits would be large, as large a profit as 60 per cent. being probable. The plaintiff formed a good opinion of the invention, and thought a company might be formed to work the United States patents. This view was shared by the defendant, who was willing to give plaintiff an option of purchasing his rights. Plaintiff, however, was anxious to know if the invention was likely to have any commercial value, and asked defendant if the matter was still in an experimental stage, or if orders were being given. Defendant assured him that certain orders had been received, and that amongst others he had the promise of a large order from a Mr. Gray, of the India Rubber, Gutta Percha, and Telegraph Works Company in London. An agreement was then proposed, and on the next occasion of the parties meeting the defendant said he had a verbal order for 50 tons of his compound from Mr. Gray. On the faith of that statement, and that defendant said the material was past the experimental stage, plaintiff was induced to enter into an agreement with the defendant and pay him the sum of £500, and in addition a further sum of £50 to bring his cousin Dr. Heyl from America to assist him. Matters went on until the month of June when a second agreement was proposed, but defendant declined to sign it, and finding that defendant in fact had no order for 50 tons, and that the compound was only in fact being experimented with, he commenced this action.

Mr. GEORGE SCHOETENSACK, of 17, Gracechurch-street, examined, said he was the plaintiff, and that in April last defendant was introduced to him by a Mr. Schultze. But for the statement by the defendant that he had an order from Mr. Gray for 50 tons, and that his compound was no longer in a merely experimental stage, he would never have paid the £500, nor the £50 to bring over Dr. Heyl. The agreement was signed on April 16th. The order was a verbal one, but he pressed defendant to get it in

Digitized by Google

writing. On May 21st, however, he saw a letter written by Mr. Gray to the defendant, from which he gathered that the India Rubber Company were only experimenting with defendant's compounds.

Cross-examined by Mr. BIGHAM, Q.C.—As soon as he saw defendant he formed the idea of forming a company to take up the patent. He did not remember taking any steps to prepare a prospectus. The prospectus of the Anglo-American High Voltage Compound Company, capital £100,000 was one he had prepared to work the defendant's invention. A Mr. Nightingale found the money with him and formed a syndicate. He had wired to Heyl on May 7th desiring him to wire to the India Rubber Company to send their order at once, or it could not be executed. When he sent that message he did believe an order had then been actually given. The only reason why, when on May 21st he found out that the Company were only experimenting with the compound, he did not charge the defendant with fraud, was that his friends thought it better to wait and see what course events would take. June 19th was the first charge made in writing, and on that day a writ was issued, but he had been "cool" in his manner to defendant since he saw the letter of May 21st, although he was negotiating other patents with him during that period. It was the fact that he was to pay all preliminary expenses, but it was untrue that he had paid the £500 for the option, and that it was to be the defendant's in any event, whether the Company was formed or not.

Mr. NIGHTINGALE, a bedding manufacturer, examined, said he was plaintiff's partner in the matter.

Cross-examined by Mr. BIGHAM, Q.C.: He was only an amateur electrician, and had not much technical knowledge of cables or the compounds used to coat them; but nowadays every educated man had some knowledge on the subject.

The defendant, GEORGE EDWARD HEYL, in his evidence, denied entirely that he had ever spoken to the plaintiff of an order, verbal or otherwise, for 50 tons from Mr. Gray. All he told plaintiff was that Mr. Gray had given him two orders of half a ton each, presumably for the purpose of experimenting on cables.

Cross-examined by Mr. KEMP, Q.C.: He had been pressed by plaintiff to get a written order from Mr. Gray, but that, he understood, was for purposes of the prospectus. It was not to get a written order for what he had said Mr. Gray had given him verbally. Mr. Gray had not, in fact, given him any large order, nor had he ever represented to anyone that he had done so.

Counsel on either side having addressed the jury,

Mr. JUSTICE MATHEW summed up, and commented on the gravity of the charge made by plaintiff against defendant. It was certainly most curious that two business men like plaintiff and Nightingale, dealing with matters which they could have had all put in writing, when they came to enter into the contract with defendant, did not put a word in as to the conditions on which the £500 was payable.

The jury immediately found a verdict for defendant.

Judgment accordingly.

## CORRESPONDENCE.

### ELECTRIC AND MAGNETIC THEORIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With regard to your note to my letter (p. 340), permit me to say that I have read and studied with close attention everything that has come in my way on these subjects, as well as witnessed and examined such experiments as are within my reach. This study, and my intention to keep thoroughly up to date, is largely the cause of the delay in issuing the third edition of my "Electricity," good part of which has been printed some time since. I have read Dr. Lodge's book, to which you refer me, more than once, and have just run over it again. I find in it nothing whatever which explains the fashionable adoption of these theories, no single line to show that ordinary matter does not cover the ground, and will not explain the whole. Dr. Lodge's book is most interesting; it is filled with ingenious hypotheses and excellent illustrations of their imaginary working out. But that is all; and what I ask for is, not hypotheses as to what the ether can do if it possesses certain properties, but some sort of evidence that it does possess them.

A reference to your Vol. XIV., p. 150, first column, will explain why I invite "so high an authority as Mr. Heaviside" to furnish this, when about to work the theories out for our advantage. He there says:—"Ether is a very wonderful thing. It may exist only in the imaginations of the wise, being invented and endowed with properties to suit their hypotheses: but we cannot do without it." Then he appears to be overwhelmed by the horrid suspicion that this is really the truth, that these "properties" are mere ghosts, and exclaims, "What vanity is this the philosophers are striving after? Is it not 'science falsely so called!'" Surely I may justly inquire how this ghost has been laid, and the perfect faith attained, which is expressed § 5, p. 258.

As myself one of the "anti-mathematicians," against whom Mr. Heaviside directs such heavy blows, p. 330, I may as well explain that they fall harmless. I know of no one, who can be fairly called capable or intelligent, who says the things which are attacked: none such could doubt the high value of mathematics. What is objected to is the constant practice of mathematicians, who having applied all their powers to a mere guess (or in more dignified terms, an hypothesis), proffer their results as "facts" or proved truths. The "mill" illustration, which I have used more than once, means the same thing as the old proverb, that no amount of the most perfect machinery can produce a silk purse out of a sow's ear. The developments of a guess have no more real value, let them be couched in ever so elaborate a formula, than the original guess. Now the ether itself is a hypothesis (may be of wise men, and possibly the mathematicians cannot do without it); its properties are deliberately invented in order to enable it to get round some of the difficult parts of nature. Well, we anti-mathematicians see and say that the mathematical development of them in no way proves their existence, and Mr. Heaviside admits this to all intents in § 10.

Now you tell me in reply to my showing that matter does actully make the vibrations attributed to the ether, that to transmit them it must "be about a thousand million times more rigid than steel; no known form of matter would suffice." This is one evidence of the mischief done by inventing imaginary properties of ether instead of studying the real properties of matter. What is rigidity but some strong attraction among the ultimate particles? Well, I quote Dr. Lodge: "The force between two atoms is a trillion times greater than that of gravity at the earth's surface." Surely we have here something to work at along with the actually known vibrations of those atoms. Just think: we have an exhausted vacuum tube; it contains two things, myriads of millions of gaseous atoms, which we know a great deal about, and (probably) ether, of which we know nothing at all. If we have to do a little hypothesis, which is likeliest to have this rigidity, the matter or the ether? At any rate, we may surely attribute it as justly to one as the other. And here let me say that Dr. Lodge remarks as to ether, "the assuredness with which it is experimented on." I should be grateful for reference to the records; as yet I am only surprised at the assuredness with which improved assertions about it are made and obediently accepted, even although Sir W. Thomson himself says as to them, "Alas, we are only led on to inscrutable difficulties."

I contrast with these assertions and hypotheses the true scientific work shown in Prof. Crookes' address, and the admirable series of experimental demonstrations, where he carries us almost into the ether itself, and yet shows that the despised "common matter" is the source of all the phenomena. In all that fine address I only notice the word "ether" once, and that in reference to the transmission of light, a field which it has long occupied, and in which we may leave it free occupation, at all events as regards space outside matter.—Yours &c.,

JOHN T. SPRAGUE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In answer to Mr. Sprague's request (p. 340), I would willingly do what he wishes if I could. But I must take exception to his initial statement. I have myself spoken plainly enough:—"As the subject is intrinsically a mathematical one, I shall not scruple to employ the appropriate mathematical methods when required" (p. 258). And I am afraid that if I am to get on at all, the employment must be very frequent. I believe, however, that many who will take the trouble to study (rather than read like a novel) will be able not only to understand, but also to learn to use the appropriate mathematics themselves. It is not meant to make difficult, but to make easy, when one has found how to use it.

I am certainly a little surprised at Mr. Sprague's attitude towards the theory of propagation in time through the ether. Perhaps, however, it would somewhat facilitate matters if Mr. Sprague would conceive of the ether as a kind of matter. We

Digitized by Google

know very little about it, but I certainly think propagation in time through something we choose to call ether has been demonstrated for electrical disturbances.—Yours, &c.,

January 17, 1891. OLIVER HEAVISIDE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I, too, shall become a fossil! Were it not for the mention of my name by Mr. J. T. Sprague, in his letter on p. 340 of your current issue, I would not for a moment intervene between him and Mr. Heaviside, whose views he opposes. But as I see he has not understood what I have said on a former occasion, and attributes to me views that are certainly not mine, I ask permission to occupy your columns for a brief space.

Mr. Sprague says that I have referred to a large class as "half-educated" electricians, called so "because they have not surrendered the teachings of experiment, the belief that Ohm's law represents actual facts of nature, and the faith that electric currents are conveyed by the 'so-called conductor.'" Belief and faith are in themselves no part of science. Even if they were, the passage which I have quoted from Mr. Sprague's letter is a most grotesque and inverted representation of my own views.

Let me deal with the three points separately. First, they are called "half-educated" electricians because "they have not surrendered the teachings of experiment." On the contrary, it is because the teachings of experiment in the hands of Faraday proved that the medium surrounding the so-called conductors of the current, is affected by the flow of the current, that I, following Maxwell, and Poynting, and Heaviside, am compelled to take into consideration not simply the wires, but also the medium by which they are surrounded, and to inquire how far the medium is concerned in the transference of energy. If I did not thus follow the teachings of experiment, but remained wilfully blind to the experimental facts, I should be worse than a half-educated electrician who did not know that there were any such facts.

Secondly, they have not surrendered "the belief that Ohm's law represents actual facts of nature." Nor have I, nor has Mr. Heaviside, nor has Prof. Poynting. We all hold that Ohm's law does truly represent actual facts of nature. Not all the facts of nature. Mr. Sprague will readily admit that Ohm's law does not represent the facts of gravity or of static electricity. It does not profess to represent these facts. Neither does it represent the facts about spark discharges, or about currents that are rapidly varying their strength: it does not profess to do so. Dr. Ohm, who first propounded it, expressly propounded it as a law to represent the facts of electric currents *which are flowing steadily*. Only a half-educated electrician would dream of applying a law that is true for steady currents to currents that are not steady, and to which the law in its usual form does not, in fact, apply. I shall come back to this matter presently.

Thirdly, they have not surrendered "the faith that electric currents are conveyed by the 'so-called conductor.'" Nor have I, though with me it is not faith but demonstrated truth, and the teachings of experiment have compelled me in following Faraday and Poynting to modify what I was at one time taught to understand the meaning to be attached to the words "electric currents." I don't in the least object to a half-educated or a whole-educated electrician still saying that the conductor conducts the current. But if he goes on either to say or to imply that the *energy* is transferred along the wire, and not across the medium, then he fails to understand the inner significance of those facts about the surrounding medium, the discovery of which was begun by Faraday and has been continued down to the present day. It is the teaching of these facts of nature as to the part played by the medium in conveying the energy laterally into or out of the conductor, which the half educated electrician too often fails to apprehend.

I now come back to Ohm's law, the law governing the flow of steady currents. Does Mr. Sprague pretend that Ohm's law, pure and simple, is applicable to alternating currents? If he takes an electro-magnet, the resistance of which is, say, 5 ohms, and applies to it an alternating electromotive force of 100 volts, as measured by a Cardew's voltmeter, does he mean to imply that the current which, as calculated by Ohm's law, ought to be 20 amperes, will be, in fact, 20 amperes? And is he prepared to maintain that Ohm's law is applicable to currents just at starting, whilst still in what Continental electricians call its "variable period"?

With respect to the transfer of energy laterally through the medium, into or out of a conductor, surely Mr. Sprague does not intend to fly in the face of facts. Will he maintain that in the case of the induction of a current in a closed circuit, on turning on a current in a neighbouring circuit, the energy is *not* transferred out of one circuit and into the other, laterally to the wires? Or is he prepared to say that when there is induction between one part of a circuit and another part of the same circuit, the energy transferred from one part of the circuit to the other part of the same circuit, is not transferred through the surrounding medium? Is the lateral transfer of energy across the medium a fact, or is it not?

No one regrets more than I, that in defence of scientific progress I should have to cross swords with Mr. Sprague, from whose writings twenty years ago I learned many things. I little thought then that the time would come when I should have to plead with one who then was so far ahead of the current science of his time, that he should not now throw the weight of his authority against the more modern views which are the outcome of, and, as I hold, logical and legitimate deductions from, the facts relating to the part played by the medium in the propagation of electric actions from one point to another.

The harm that is done to progress by the dead weight of old and inadequate notions is truly deplorable. Books like those of Lardner, which forty years ago were in the forefront of science, are now simply a curse to it. Even Fleming Jenkins' handbook, which twenty years ago came as a revelation to those electricians who were not cable-engineers, is doing harm by the presence in it of statements and inferences now known to be incorrect. And my own little text-book of ten years ago, though the attempt has been made in successive editions, as far as the exigencies of printing from stereotype plates would permit, to keep it up to date, is deplorably behind the time, and must either be rewritten or cast aside as a bar to progress. And now, when I find my former mentor, Mr. Sprague, for whose independence of thought and sterling worth I have always had and shall ever have the most sincere esteem, dropping down from the position of pioneer to that of pessimist, I shudder to think of the time when *I, too, shall become a fossil.*—Yours, &c., SILVANUS P. THOMPSON.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am glad to see that Mr. J. T. Sprague has taken the Queen's shilling, as Mr. Huxley puts it, in favour of what may be perhaps called "the old views" of electric and magnetic action, although what change of view has occurred has been really more of the nature of development than of revolution; because hitherto the so-called "new views" have been accepted with but little discussion or comment, and that is never satisfactory. The best service one can do to a true theory after its promulgation is to pick holes in it or suggest a rival one, for by that means one finds out of what metal it is made. Mr. Sprague long ago arrived by his own methods and insight at various true ideas concerning electrostatics, at a time when the ordinary text-books were very much at sea; and if he gives us the benefit of his critical acumen, untrained in recent advances though it may be, especially if he can divert Mr. Heaviside from tirades against "anti-mathematicians," and get him to give us either some more solid investigation or else some vivid explanation, he will be doing good service.—Yours, &c., OLIVER J. LODGE.

## BOOKS, &c., RECEIVED.

"Annuaire pour l'An 1891." (Paris: Gauthier-Villars et Fils.

"Proceedings of the Royal Society." Vol. XLVIII., No. 295. (London: Kegan Paul, French, Trübner and Co.)

"Electricity: The Science of the Nineteenth Century." By E. M. Caillard. (London: John Murray.)

Digitized by Google

## THE LONDON COUNTY COUNCIL AND TECHNICAL EDUCATION.

The Special Committee of the London County Council, appointed in October last to consider the subject of the application of any further receipts from the new taxes on beer and spirits, with express reference to the question whether any, and, if any, what proportion of such further amount as might be received should be applied to technical education, have just issued their report, and recommend—

(1.) That the sum to be received from the beer and spirit duties on account of the current financial year over and above the £140,000 which has been placed to the credit account of the general county account, and which is estimated to be about £23,000, be devoted to the furtherance of technical education in London.

(2.) That the money be given to the following institutions in the form of capital grants to be expended (save where specially ordered otherwise) in buildings, fittings, apparatus, or plant to be used exclusively, or at any rate mainly, for the purpose of imparting technical education to persons of the artisan or labouring classes :—

| Institution. | | Amount of Grant. |
|---|---|---|
| Borough-road Polytechnic | | £4,000 |
| Battersea Polytechnic | | 4,000 |
| Chelsea Polytechnic | Conditionally upon the schemes being carried out within two years | 2,500 |
| St. Pancras Polytechnic | | 3,000 |
| Holloway Polytechnic | | 3,000 |
| Regent-street Polytechnic | | 4,000 |
| Working Men's College | | 500 |
| Joint Committee of School Board, City and Guilds Institute, and Drapers' Company (having due regard to 52 and 53 Vic., cap. 76, sec. 1 (1) | | 1,000 |
| National School of Cookery (for training teachers) | | 500 |
| University Extension Scheme (to organise lectures for artisans at low rates of admission) | | 500 |

Finally, the Committee recommend that a sum not to exceed the estimated produce of a 1d. rate be devoted to technical education in London ; and that a standing committee on technical education be appointed. The Committee's report will be considered by the London County Council at its next meeting.

## TRADE NOTES AND NOTICES.

ERRATUM.—In our trade note of last week we notified that the Woodhouse and Rawson Electrical Supply Company were continuing the manufacture and supplies of incandescent lamps made under licence from the "Brush" Electric Light Company. This should read, the "British" Electric Light Company.

KEY'S ELECTRIC COMPANY (LIMITED).—This Company announce that they have opened at Nos. 122 and 124, Charing Cross-road, Oxford-street, London, W.C., show-rooms and warehouses for the sale of electrical machinery, fittings and apparatus, and further announce that they have been appointed representatives in this country of the well-known Berlin firm, the Allgemeine Elektricitäts Gesellschaft. They have on view in the new show-rooms a large quantity of electric light fittings, instruments, motors, &c. Further particulars will be found in our advertisement pages.

ELECTRIC LIGHTING OF WYNYARD.—One of the largest private house electric light installations in England will be that at Wynyard, Lord Londonderry's country seat, in Durham. This installation, the contract for which has recently been given to Messrs. Drake and Gorham, will comprise 753 incandescent lamps, together with a steam power electric gererating plant of the necessary large dimensions. Mr. A. A. Campbell Swinton has been appointed consulting engineer to superintend the work on Lord Londonderry's behalf.

SANITAS COMPANY (LIMITED).—We have received from this Company a complete list of their well known manufactures. A large quantity of articles similar to those made by the Sanitas Company must be in general use in large engineering establishments, and we can speak from experience, covering a long period, of the value of the Sanitas Company's specialities where large bodies of workmen are employed.

## COMPANIES' MEETINGS & REPORTS.

### The National Telephone Company (Limited).

A meeting of the shareholders of this Company was held on Wednesday at the City Terminus Hotel, Cannon-street, Mr. Frederick Richard Leyland presiding.

The CHAIRMAN said: Gentlemen, this is not one of our usual meetings, where the Directors have to place before the shareholders certain resolutions to be passed. It is really more in the nature of a conference which the Directors desired to have with the shareholders, so as to explain to them what is the present position of the Company now that the first of their key or master patents has expired. At first we thought that we might, and that it would be our duty to, intimate our views to the shareholders by means of a circular, but it would have had to be a very elaborate and very detailed one, and we could not depend upon which way the different sections of shareholders would regard it. Consequently, we came to the conclusion that the best and wisest thing to do was to meet our shareholders face to face and place our views before them, and thus to have the advantage of any suggestions or remarks on the subject that no doubt will be made by gentlemen in this room. With these few preliminary observations, I will go first into the accounts as made up to the 31st October last, that is, for the first six months of the current year. They have not been audited, and there is no necessity, I think, to audit them ; but I can give you now what the result is for the six months. The accounts show that the Company has earned in those six months a net profit of £108,170 19s. 11d. This sum, together with £11,113. 9s. 7d., which was brought from last accounts, leaves an amount of £119,284. 9s. 6d. standing to the credit of profit and loss account on October 31st. Out of that sum we have paid you an interim dividend amounting to £62,973, and we had then on hand £56,311. This sum, together with the profits that will be made in the second six months of the year, you will have to dispose of at the next annual general meeting. Now I have put before you the bare figures of the result of the six months working, and I think you will agree with me that they show a very satisfactory advance indeed on the profits of last year. I dare say you all remember pretty well what the results were then. I have got in my hand and no doubt you have all got it at your offices, the statement of accounts of April, 1890. The revenue account there for the twelve months showed a profit, carried to net revenue, of £185,754. The same profit on that revenue account for the six months to Oct. 31, 1890 is £104,763. Now, if you divide the £185,754 for the twelve months by half you would have then about £92,874, but instead of that you have got, as I have said, for the six months I am dealing with £104,000. Now what does that show? Last year, you remember, we called up a sum of £260,000 by an issue of 52,000 new ordinary shares. We strongly recommended that course to the shareholders as being a wise thing, and we assure them that our conviction was that new capital would give you just as good a profit as the old capital had previously done. That has turned out to be the case. The capital on April 30, 1890, was £2,204,000. The result of revenue account showed a profit of £185,754, which means a percentage of about 8¼. We did not divide that. We were content—and I think wisely—with 6 per cent. dividend, the other 2¼ being carried, under the advice of the Board, principally to reserve. Now with reference to this issue of £260,000 of fresh capital, what does the increase of revenue amount to? The increase of the profit on revenue account was £11,891. What does that give you on that £260,000? It is as nearly as possible 8¼ per cent., just the same as you had on the larger capital. I think that is a desirable thing, because the bigger your Company is the stronger and more impregnable you are against competition. What, then, happened after October 31st, the date to which these accounts are made up? Up to December 31st the rates remained the same, and there was the ordinary normal increase of the business, and we can see clearly enough that for the two months—that is, from October to December—the ratio of increase in the profits will be maintained, and I think slightly exceeded. But after that date, on January 1st, when the first key patent that I spoke of expired, we thought it a wise thing (although the second key patent does not expire until July, 1891, seven months after) we thought it the wisest thing was to make a reduction of rates to subscribers, and to make it at once, just as if both patents had expired. The first result of that is, of course, that the revenue is reduced. But, on the other hand, there is one thing that we have to take into account, and that is, that the reduction of rates we believe will bring on to the system a great number of additional subscribers who would not otherwise have come on ; and in that way we shall gradually recoup the whole of that loss, and, I think, more quickly than you may imagine. Now let us see what the indications are. From April to October, 1890, the increase in the number of subscribers was 1,940. Dividing this by the number of weeks—26 weeks—that would give you an average of about 75 or 76 subscribers per week. Again, what has been the increase in the number of subscribers during the first three weeks of the present month? They amounted to 651. If this rate of progression is continued—and I see no reason why it should not—I feel convinced that it will be but a comparatively short time before the whole of the loss caused by the reduction in our rates will be recouped ; and of one thing I am perfectly certain, you will have an infinitely stronger business. There is no business so strong as a large one that can work economically. As I have said over and over again, I do not think the possession of a monopoly, as we have had now for many years, is an unmixed blessing. Gentlemen, I have now explained the position of the Company from the point of view of its revenue and profit-earning power. I must next deal with it from the point of view of its capital expenditure. In this Company every increase of the business necessarily involves an increased expenditure on capital account. You cannot link up a fresh town ; you cannot even put on an additional exchange without incurring some capital expenditure. It is unavoidable so long as we pursue the policy that we have up to the present always thought to be the best—that is, the policy of extending and developing our business by covering all the available ground. I think that the statement I have made to you, and the figures I have put before you, all point in the same direction—namely, that that policy is a good and safe one, and one that we ought to stick to as being the sheet anchor of this Company. I spoke at length very much in the same sense at our last meeting, and I believe the feeling of the shareholders went thoroughly with what were the views of the Directors on this point. What did we expend then on the first six months on capital account? We expended in that period on the construction of exchange lines, trunk lines, and private lines the large sum of £96,970. A considerable portion of that—about £40,000 or £45,000—consisted of expenditure in linking up different towns in the provinces.

Digitized by Google

I have a list of them here, but I am not going to inflict on you the reading of it, but I may say that the number of them altogether is 244. We have not let the grass grow under our feet. All those towns are now in communication with each other. That is what I believe will prove the salvation of this Company. It must necessarily do so. Any competitor coming into our district can give only a local service, unless he is prepared to spend the enormous amount of money we have spent in linking up nearly all the different towns in the kingdom. Now, I am glad to say, that of that £96,000 we spent the greater portion of it by October 31st, and it is now yielding a very satisfactory and growing revenue. Of course when you link up a town you do not expect next day to have the whole thing in full working order. It is necessarily a gradual operation; but we are so satisfied with the result of that, that we are actively continuing up to the present day on the same lines to cover the ground whenever we can advantageously. Wherever there is a fair chance of getting a suitable revenue we are bringing the towns gradually into communication with our main centres in the different provinces. Well, this is a very big expenditure, and an increasing one. I remember at the last meeting there was one shareholder who got up and suggested that we should not get into debt, but that we should confine our extensions to the amount that we put to the credit of reserve fund. Certainly that is one policy to pursue, but what does it mean? It does not mean covering the ground and developing our business; it means restricting it within very narrow limits. What would be the result of following such a policy? You would find plenty of people who would only be too glad to take the business that you did not care to do yourselves. Well, I for one am not going to advise you to adopt such a policy as that. At the last meeting I spoke on this point, that increased capital must be obtained; and I told you then that the Directors had not made up their minds as to what the best mode of raising that would be; that is to say, by Preference shares or by Debentures. We have since considered the matter thoroughly, and we have come to the conclusion that the best thing for the Company is to raise that money by Debentures. I think it is the cheapest way of doing it, and it avoids many of the complications that must arise with Preference shares. There are two classes of Preference shares, and it would never do to have a third. We should have to make some arrangement for sweeping off the others, and merging the whole into a larger stock, so that, I think, as all the Directors do, that Debentures are preferable. Having come to this conclusion the Board intend under the powers given to them by the Articles of Association to issue perpetual Debenture stock which we think is the best form of issuing it—that is, to issue that Debenture stock from time to time as it is necessary for the purposes of the Company. But we must have a care of one thing, and that is, when we commence to issue these Debentures we must make it part of a very large sum—not necessarily to be issued—but we must make it part of a large creation of Debentures so that any subsequent amount that we may issue will rank equally. There will be no First, Second, and Third Debentures, and all that complication. I propose, and the Board fully considered, and also propose, that we should create as large an amount of the Debenture stock as our Articles of Association authorise us to do. We are limited by the Articles not to exceed one-half of the capital, and I think our wisest course is to create that stock, and issue it as required. As to the first issue, it may be asked how are we to deal with that? In the first instance, when we do issue Debentures, they must be first Debentures. We cannot, as I have said, think of a Second Debenture stock, and we propose that in our first issue we raise enough money to pay off, as we are entitled to do, the existing Debentures, that is, a sum of about £80,000. We will give the holders the option (and many of them I know will be only too glad to avail themselves of it) of taking their Debentures, not in cash but in other Debentures of the Company. I am quite sure it will be a much better position for them to be in to be holders of Debentures in a large stock like that which will certainly be quoted on the Stock Exchange, and largely dealt in, than to be Debenture-holders as they are now in a small issue of £75,000, for which there is neither sale nor purchase. Having dealt with that £80,000, what is the next thing we have to deal with? We have to repay the capital account that £97,000 we spent up to the October 31st last, out of the revenue. That must be replaced, and I think then we ought to hold in hand a sufficient amount to carry us on to the end of this year, so that we shall not be continually coming to you suggesting fresh capital. Fresh capital will have to be raised if this business goes on, unless you make up your minds to relinquish—and I do not think you are likely to do that. We have been working the matter out, and we think that the first issue ought to be something between £300,000 and £350,000. Now I have given you pretty nearly all the main facts of the position. Our view of that position is that it is very favourable, and that it gives, and ought to give, every shareholder great confidence in the future of this Company. The Directors feel it. At the same time I should be glad, and the Board would be glad, to listen to any suggestions and remarks from shareholders. We, in fact, invite them. The position to us seems clear, but it may not be to some of you, and we should all like to hear what the shareholders may have to say on this point, so that we may be able to answer any doubts in their minds, or explain anything that to them may be obscure. There is no resolution to be proposed.

Mr. BIDEN asked what was the proportion of working expenditure to income, and for what term the Debentures were to be issued?

The CHAIRMAN: I think I did state that my view is that a permanent Debenture Stock would be the best thing.

Mr. BIDEN: You think that better than for, say, a period of 21 years?

The CHAIRMAN: I think so; but at the same time I should be glad to listen to anything you have to suggest on the matter.

Mr. CHIPPERFIELD suggested that the list of the 244 towns linked together might be circulated with advantage among the shareholders. He thought they ought to be in possession of this information. He wished to know whether Southampton was one of the towns included in the list.

The CHAIRMAN: It is not in the Company's district. We have, however, covered about three-parts of England already.

Mr. CHIPPERFIELD understood from what had been said that the issue of the new Debentures would be taken up largely by the holders of the existing issues.

The CHAIRMAN: The present Debentures are what are called Perpetual Debenture Stock, and amount to £73,000; but the Company has the right of repaying them at any time they like on the payment of 10 per cent. premium.

Mr. CHIPPERFIELD asked what was the interest paid on the present, and what it was propsed to pay on the new Debentures?

The CHAIRMAN: What is paid on the present is 4½ per cent. What will be paid on the new issue I cannot tell you, but you may depend upon it, we shall get it at as cheap a rate as we can. As regards the suggestion about the list, we shall have it printed and circulated.

Mr. WATSON desired to know what untoward consequences would result from the expiration of the second patent.

The CHAIRMAN: The first result when the patent expires is that all the world can use it. Up to the present nobody could interfere with us. We had practically a monopoly. When these two patents expire everybody can interfere with us. But what has been the line of policy we have pursued? I explained at the last meeting, and I will explain it again now, it has been to cover the ground, to be the man in possession, and to bring your working expenses down as much as possible. The bigger the business the less must be the proportion of working expenditure per subscriber. That is the line of action we have been steadily pursuing, and that is what I have always recommended. What the ultimate result of it may be neither I nor anyone can foresee. I feel confident that the indications are strong that the loss we suffer in the first instance by a reduction in our rate will be recouped to us by an accession of additional business, but I cannot prophecy more. You are as able to judge for yourselves as I am. I have got every confidence, and so have the Board.

Mr. WATSON asked what was the danger, so far as the Directors knew, of the possibility of rival companies being established?

The CHAIRMAN: There is none that we have heard of except in the case of one company that is now starting in Manchester, and they have experienced difficulty in getting their money up, which is only £40,000.

Mr. SALTER said there had been considerable expenditure in connection with through-speaking between Manchester and London. Might he ask whether that was likely to turn out satisfactorily? What was the reduction that had been made in the rate?

The CHAIRMAN: In the main towns, such as Manchester, Liverpool, Glasgow, and Bradford, the reduction has been from £15 to £10.

Mr. SALTER: What about London?

The CHAIRMAN: We have made no reduction in London on the exchange tariff, and I think there is some reason for it. The rate the people in the provinces pay is for a radius of one mile—in some cases even lower. The radius of London is very much greater than that, in addition to which the expenses in the Metropolis are enormous. They are double what they are in any other place. It is impossible to get out of that. I think that this is a sufficient reason for the difference between London and the provinces being kept up. I think, however, the main thing with regard to London is not so much a reduction of the rate as an increase of efficiency. That is what we have been driving at. We have had our hands full. We have done a great deal, but a great deal still remains to be accomplished. That, in my view, is the main thing with regard to London, not the reduction of the rate.

Mr. SALTER: Has the through-speaking turned out satisfactorily?

The CHAIRMAN: The amount of revenue that we have derived from that up to the present time is only small, but we have had several inquiries about it, and I am disposed to think that we shall have to consider whether that is not one way of making this line a good profit-earning line. The inquiries that we have had are from people who have a large business connection in Manchester, London, and Liverpool, who wish to have a line to themselves, or, at any rate, between certain hours of the day; or, as others put it, a combination of two or three or four individuals want to have a line during the whole of the day time between them. Then there is the question of the night time, when there is a good deal of correspondence for the newspapers, which require the line at night. The number of calls from London to Liverpool, Manchester, Leeds, Birmingham, and other places has not been very large up to the present time, but it will grow.

Mr. ELLIS asked whether the poles or supports carrying the existing wires from Birmingham to Manchester and elsewhere would suffice to carry a large addition of wires.

The CHAIRMAN: Certainly.

Mr. ELLIS: So that any reasonable number of new subscribers could be put on?

The CHAIRMAN: Quite so.

Mr. LOWE asked how the reserve was invested.

The CHAIRMAN: I told you at the last meeting that we came to the conclusion to invest our reserve fund in our business, and so we did. The view that we took of it was that it would be impolitic to raise capital and keep our money in reserve in some good security not subject to fluctuations, and get only 2½ to 3 per cent. for it. We could not see the policy of calling up capital which would cost us 4 per cent., for the sake of putting money into a security which would yield us 3 per cent.

Mr. FALCKE asked whether by a reduction of their rate in London they would not secure a large accession of business?

The CHAIRMAN: I must say that is not my impression. I think a more important thing is to get the service efficient, which will take some time and a considerable amount of money.

Digitized by Google

The CHAIRMAN, in answer to Mr. Biden, said that the working expenses in proportion to the gross revenue for the past six months came to exactly the same as it did last year—namely, 40 per cent. Last year your total income was £364,704, and in the half-year ended April 30th it was £205,678. The Secretary has worked out the expenses, and he tells me they come to 40 per cent. in each case.

After some further remarks from Mr. BIDEN,

The CHAIRMAN, in reply, said: Everybody knows perfectly well how this Company was amalgamated. It was amalgamated on the basis of the market value of the three companies—or rather on the basis of one-sixth less, which we were obliged to adopt for some reasons connected with the Post Office. Now, you call that a heavy capital. I have read some newspaper articles, and the writers call it watering the capital. That was the real way in which the amalgamation was brought about. How could you expect to amalgamate on what had been paid on the shares originally? The shares had a well-ascertained value on the market, and that was not only goodwill. Take the case of the United. Their capital was £500,000, but, like wise men when their business was profitable, they did not divide their profits up to the hilt. They put large amounts to the reserve, to the debit of their revenue account, for depreciation, and all this they invested in the business. Do you think the shareholders did not know that quite as well as other people? You may shake your head, but that is the fact. You take our 40 per cent. of working expenditure, and you compare that with the railways, but I ask what in the name of fortune has this Company to do with railways? They are two entirely different businesses. You must consider this, that that 40 per cent. must be of course a higher percentage when it comes on to a lower tariff. We have been having monopoly prices up to the present, but that time has gone by now. You say that other companies can do the work cheaper. I do not think they can, and I believe the best plan is to let them find that out for themselves. You say that the London people grumble at the high rates. I have heard a good deal of dissatisfaction expressed, and I have had many complaints made; in fact, I have invited people to send in complaints, and I have looked into them as far as I personally could, but I have not found people grumbling at our high rate; it has always been at the inefficiency of the service. That is my experience. Yours is different, but I must really go by my own. You talk of its being a desirable thing to have 3, 5, and 7 years' agreements. That is what we have been going for all the time, and we have got plenty of them. I will not publish in the papers our revenue from week to week, or give a monthly account of our expenditure, unless I am told to do so by the shareholders.

A SHAREHOLDER asked whether they were on good terms with the Post Office?

The CHAIRMAN: Yes; very good. The soreness there was on the subject of the amalgamation has worn off, and we are on very much better terms.

Dr. GALE thought that no company could stand against the National Telephone Company so long as they continued to pursue the policy hitherto adopted.

Mr. LEEK (Manchester) endorsed the statement of the previous speaker.

Mr. RIDSDALE advised them to introduce a Bill into Parliament giving them statutory powers.

The CHAIRMAN: As the Company increases the volume of its business that will become a matter of necessity, especially in London. We have felt that, and it is a matter that is now engrossing our attention. The fact is we are about to draw up a Bill, and we ought to try and pave the way as much as we can for its favourable reception when it gets into the House. If any of the shareholders here have any influence in that direction, and will exercise it, it will materially benefit the Company.

On the motion of Mr. CHIPPERFIELD a vote of thanks was passed to the Chairman, and the proceedings terminated.

---

## The Eastern Telegraph Company (Limited).

The 37th half-yearly general meeting of this Company was held on Thursday, the 15th January, at Winchester House, Old Broad-street, under the presidency of Sir John Pender, K.C.M.G.

The SECRETARY (Mr. George Draper) having read the notice convening the meeting, and the minutes of the last meeting, which were confirmed,

The CHAIRMAN said: Gentlemen, before entering upon the business of the day, I think I may fairly congratulate you on the year that has passed as being a successful year for the Company, and also to express the hope that the year we have entered upon may be a prosperous one for the Company, all our associates, and all those interested in it. As usual, I will go into some of the points in our report, so that we may draw the leading figures from them.

Our revenue, from all sources, for the half-year ended September, 1890, amounted to £352,873, as against £351,014 in the corresponding period of the previous year, showing an increase of £1,859. Analysing this revenue, we find a falling off in our receipts for telegrams exchanged with South Africa, of over £5,000. In addition to this, the dividend that we have had on our investment in the South African Company is £5,900 less than in the corresponding six months, so that we may put down a loss of £11,000, as attributable to the collapse of speculation in gold mining and diamond shares in South Africa. Our Egyptian, Greek, and Turkish traffic also shows a decline of some £1,600, but this decrease is made up by a growth of over £12,000 in our Indian, Trans-Indian, and Spanish traffic, and by increased dividends on our other investments of £2,000. For the six months we show a gross increase of £1,859. The total working expenses for the half-year to September, 1890, amounted to £91,723, as against £87,730, or an increase of £3,993, the details of which are as follows:—General expenses in London were £8.502, against £8,410, or an increase of £92. Working expenses at stations amounted to £68,435, against £64,712, or an increase of £3,723, the principal item being £2,657 in the salaries of our foreign staff. A number of our more advanced probationers were transferred to the staff at Porthcurnow, Gibraltar, Malta, and Zante, in connection with the full working of the triplicate cable and the increase in the number of messages carried. Additional probationers were engaged to fill the vacancies thus caused. This, together with additional pay granted to some of the staff, accounts for the increase. There is also an increase of £639 in repairs to stations, buildings, &c., the most important repair being at Alexandria, where rather extensive alterations and improvements are being carried out. The amount written off for depreciation of cable stock is £802 more than in the corresponding period, owing to our having a larger stock of spare cable. The amount carried to maintenance ships reserve fund is only £2,500, as against £5,000 in the previous half-year, the other portion having been contributed by those telegraph companies who have hired our ships during the half-year. Expenses in connection with the Paris Telegraph Conference, which appear in our revenue account this time, amounting to £981, is an exceptional item, but a very necessary one, and I think I may safely say that full value has been received for this expenditure. Expenditure attending repairs and renewals of cables amounted to £31,477, against £49,634, or a decrease of £18,157. Full details of the expenses of the ships, &c., and value of cable used will be found on reference to abstract C of the accounts. The amount of cable used on repairs during the half-year was exceptionally small, and our ships have been several times employed in cable laying and repairing work for other companies. The credits derived from this source have been applied in reduction of the ships' expenses, &c.

The summary of the half-year's revenue account is as follows:—Increase in gross revenue and amount brought forward from last half-year, £3,369; decrease in total expenses, £13,678. We are, therefore, after providing for all expenses and interest charges against revenue, able to pay the usual interim dividend at the rate of 5 per cent. per annum, to carry forward to next half-year's account £78,195, against £61,151, or £17,044 more than in the corresponding period of 1889.

Now, gentlemen, I think that that condensed statement of our affairs must be a very satisfactory one to you all. (Hear, hear.)

I cannot sit down without saying a further word on the telegraphic system, although I have said so much on previous occasions. Still, telegraphy is a never-sleeping, ever-moving system, and even when we come here in the morning, probably before we have been an hour in the business, we find a cable has been broken or a cable has been repaired. It has become so much now a matter of form with us that the anxious days we used to have are no longer experienced. But we have always to look forward to such a day as this, when we have to come and account for our doings to you for the previous six months, and to produce to you your usual, I hope, satisfactory dividend. That is our ambition, and so far we have been fairly able to realise it.

I think there are times when we may with perfect propriety give a short condensed review of our position. I may say to-day that we are in a thoroughly satisfactory state. We have not increased our capital to any extent, but yet we have laid down cables that cost nearly a million sterling, which we have taken from the reserves and revenue. If you have not got very large dividends, you have got behind you so much strength in the dividend you are getting that the value of your shares, as appears by the market quotations, is increased in consequence of that great backing.

I think I may mention to you what has been done in a silent yet very satisfactory way. We have duplicated, triplicated, and quadrupled many of the cables in our system. In all that additional strength which we have been giving, we have been carrying out the policy we have always observed, of being ahead of the requirements of the public.

I have indicated to you on previous occasions that that was our strength; and when we found that a new departure was going to take place with reference to the Australian colonies—an endeavour on their part which was very strongly supported by the companies—to reduce the rate to South and West Australia from 9s. 4d. to 4s., we felt that if that was to be successful we must practically double the amount of traffic over our system. That traffic has to come largely over this system, and consequently it would never have done for us to be behind. We are now about to lay a third cable from Aden to Bombay, which, with the cable we laid last year in the Red Sea, will enable us to carry satisfactorily this large increase of traffic from Australasia which we are looking forward to. I might give the sections of the cables that we have duplicated, triplicated, and quadrupled, for there is a list of them here, but I need not trouble you with such details. It will be sufficient for me to say that there are twelve which have been duplicated, one triplicated, and two have been quadrupled, so that you see we have carried out what I have always said. No single line of cable is to be relied upon. You must have a duplicated system, and if you can have a triplicated or quadrupled system you are so much stronger still.

I have referred in my remarks to the African traffic not being good. Those who have been watching over this "dark continent" and the spurt that is taking place there, with the speculation that has been going on, never expected that that would last for ever. But it is not likely to die, and we see now that there is evidence of that movement again. There is no doubt at all that as that feature develops so will our traffic move forward.

Now I think I have pretty nearly exhausted all I had intended to say to you, namely, that the extensions that are going on—and we are doing them without issuing new capital to a very large extent—we are doing them to meet a decided demand, and in incurring this expenditure we are adding very materially to the value of your property. I hope we shall be able to continue such dividends as we have been giving you, add

Digitized by Google

to our Reserve, and occasionally increase our bonus. With these remarks, I beg to move the adoption of the report.

The MARQUIS OF TWEEDDALE: I beg to second the resolution.

The CHAIRMAN: The resolution is as follows:—

"*That the report and accounts of the Directors to the 30th September, 1890, submitted to this meeting be, and the same are hereby, received and adopted.*"

That has been moved by myself and seconded by Lord Tweeddale, the Deputy-Chairman. If any gentleman desires to make any remark or to put any question, I shall be very glad to answer him as usual. If not, I shall put the resolution to the meeting. (The Chairman then put the resolution to the meeting, which was carried unanimously). The next resolution is one which affects me personally, so that it must be dealt with by the Deputy-Chairman.

The MARQUIS OF TWEEDDALE: The resolution I have to move is:—

"*That Sir John Pender, K.C.M.G., who now retires, be and is hereby re-elected a Director of the Company.*"

I do not think it is necessary for me to add one single word to that resolution. Every one present must have recognised long ago the admirable manner, the conspicuous ability with which Sir John Pender has conducted the affairs of this Company, and, therefore, I am quite sure that the shareholders will accord their unanimous support to this resolution.

Mr. GEORGE GARDEN NICOL; I have great pleasure in seconding the resolution. Associated as I have been with Sir John Pender from the commencement of this Company, I can bear willing testimony to the attention, tact, ability, and energy which he has shown in the conduct of its affairs, and I am sure you will agree with me that he is the right man in the right place. I hope he may be long spared to preside over this Company.

The MARQUIS of TWEEDDALE put the motion to the meeting in the usual way, and it was carried unanimously.

The CHAIRMAN: I thank you very warmly for again returning me as a Director of this Company. It is a Board that has worked almost as one man. I believe that each of the members of the Board is proud to occupy a position on it. It is a Board respecting which we have interests apart from making money. We have a belief that in the work we are doing, we are doing something to leave the world a little better, stronger, and more united than it was before. The next duty I have to perform is a very pleasant one, namely, to propose the following resolution:—

"*That the Marquis of Tweeddale, who now retires, be and he is hereby re-elected a Director of the Company.*"

Now, gentlemen, Lord Tweeddale has been associated with these Companies from their inception. He has not been a fancy Director, as a great many people have been disposed to say regarding men of high position and title. He has been a working Director—a man with a good head and great energy; and, as has been shown since he became associated with us, many other people are very desirous of getting the benefit of his energy in institutions larger than this, or quite as large, and I therefore move with great pleasure this resolution.

Mr. J. DENISON PENDER: I have great pleasure in seconding the resolution.

The CHAIRMAN put the motion in the usual way, and it was carried unanimously.

The MARQUIS OF TWEEDDALE: I have to thank you very warmly for the kind way in which you have received this resolution.

Mr. HURST, a Shareholder: I have had the honour of being a shareholder in this Company for a great many years, and I certainly never felt more satisfied or such satisfaction as I do at the present time. The auditors have done their work exceedingly well, and I am convinced that with regard to the Eastern Company we must all feel that we have got a most excellent and valuable security, one of the safest and best that I know of. We can sleep quietly in our beds about it, and feel satisfied that we shall have our dividend paid as has been the case in the past. I was extremely pleased to hear one thing which must be gratifying to you all—that even an increased dividend is almost anticipated by the Chairman. That is very satisfactory! As I have said, the auditors have done their work exceedingly well, and I may add that in a great Company like this the work of the auditors is not a trifling affair, but a matter requiring great consideration and great attention, and you must have competent and first-rate men to enable you to do the work in the manner in which it should be done. You have all read the accounts and examined them carefully, and I think everyone will agree with me that this work has been done well. The whole of the work of the Company, in fact, has been carried on in so admirable a manner that I think few companies in this kingdom or the world can compare with it. It is a great and wonderful concern, and such a one that, when I became a shareholder, I hardly expected that its ramifications could have been carried on so well and so successfully as they have been. I will now read the resolution which I have risen to propose:—

"*That Mr. Henry Dever and Messrs. Welton, Jones, and Company, both of whom now retire, be and they are hereby re-elected auditors of the Company for the current year at a remuneration of £100 each.*"

I have great pleasure in proposing that resolution.

Mr. MUIR: I beg to second that.

Dr. WALLER: I had risen to second this resolution. I have to make one observation, and only one, on the meeting to-day, and that is that it is so pleasant. I do not mean to refer to the eloquence of our Chairman—that is a matter which we all know. The eloquence I admire to-day is one that is generally unusual, that is, the eloquence of silence in the body of the hall. It is golden. We are reduced very often to listen to very disagreeable discussions. To-day there has been nothing but the most eloquent silence prevailing.

The CHAIRMAN: This resolution has been proposed and seconded.

The motion was then put, and carried unanimously.

Mr. GRIFFITH: I am sorry that my partner is not present to hear the very courteous remarks of the shareholders in proposing this resolution, but I will convey them to him, and I beg to return to you on his behalf our best thanks.

The CHAIRMAN: That finishes the business of the meeting, and I am very much obliged to you for giving us your company.

Mr. BURT: It is not often that I have the pleasure of sitting on this side of the table. As you have mentioned my name, I think I may take the opportunity of proposing a vote of thanks to the Chairman. There are few gentlemen here who have heard more speeches from the Chairman than I have, and I agree with the gentlemen on the other side, that I have never heard a more eloquent speech than I have to-day by the Chairman and one that could be more satisfactory to you. Moreover, there is this satisfaction: When one hears a good speech there is often very little truth in it, but so far as I know what the Chairman has told us to-day is simple solid fact, and we have to rejoice that this Company is in the position it is, that the Board is constituted as it is, and that we have a gentleman like Sir John Pender in the chair.

The resolution being seconded,

Mr. BURT put the motion in the usual way, and it was carried unanimously.

The CHAIRMAN: Gentlemen, it is a source of great satisfaction to me to find a good feeling growing in the body of the hall in favour of the people behind this table. It is quite true that we have had a great deal to bear sometimes; but conscious that the duty we are performing was a right and straight one, we have never felt aggrieved—we knew it was all going right. It has been a hobby with me for many years this—submarine telegraphy, and it was equally a hobby with my colleagues. So long as we continue to work as one man you may be sure that it will continue to be a success. It is a great and growing concern, a concern which must grow as the world grows; and the more people get accustomed to telegraphy the less will they be able to do without it. It was one of the luxuries of life, it is now a necessity, and it will be largely extended as the world grows richer. When I see you again I shall have visited some of our distant stations, in all probability. I think it is a wise and proper thing to look occasionally into those places beyond the sea. We know that a great deal depends upon those places being properly and well conducted. It is encouraging to our young men on those stations to see someone representing the Company visiting the stations, and that is going to be my mission the next two months. I beg to thank you, gentlemen, again.

The proceedings then terminated.

---

## The Direct United States Cable Company (Limited).

The twenty-seventh ordinary general meeting of this Company was held at Winchester House, 50, Old Broad-street, on the 16th inst., under the presidency of Sir John Pender, K.C.M.G.

The SECRETARY (Mr. T. Finnis) read the notice convening the meeting, and the minutes of the last ordinary general meeting.

The report of the Directors and statement of accounts were taken as read.

The CHAIRMAN: Gentlemen, I will follow up the practice which I have observed on many previous occasions, when I have had the pleasure of meeting you, of going over the figures of our report, because really on the present occasion that is almost all I have to refer to. The year has been rather an eventful one in some respects, commercially, both here and in America. At the same time, I think that England has come out of it in a marvellously satisfactory way, and let me hope that being the beginning of a new year we are making a new departure in commerce, and that such departure may be largely beneficial to our telegraph system generally. There is a saying—very often a true one—that no news is good news, and as I have nothing very striking to say to you as to what has been done last year, you may take it that it has been fairly satisfactory, though not so satifactory as I could wish to see. I should like to see us go back to our 5 per cent. dividend, and the only way that I can see of doing so is by encouraging the development of telegraphy between the old and the new world, and in that way we shall get a substantial return. The money earned from the Atlantic traffic to-day is about the same in amount that it was when it was conducted at a very much higher tariff. But other companies have come in to compete for and to share that traffic with us, and it is now the cleverest fellow that is likely to get the largest amount of it. I may say that the Company which I have the honour to represent has done its work very well, and has earned its fair share of the traffic, and as long as the gentlemen who sit here with me remain here, we shall not be backward in that respect. At the same time, people entertain rather peculiar notions with regard to these things. It is sometimes said "that new brooms sweep clean;" and we have to contend against these new brooms, and we have often to show them that, with experience, the old broom will very often beat the new one. With these remarks I will now refer to the figures showing our working during the last six months. The revenue for the half-year to December 31st, after deducting out-payments, amounted to £43,347; and the working and other expenses, including income tax, but excluding cost of repairs, absorbed £17,556, leaving a balance of £25,791 as the net profit of the half-year, making, with £968 brought forward from the previous half-year, a total of £26,759, which has been appropriated as follows:- Interim dividend of 3s. 6d. per share for the quarter to September 30th last, £10,624; interim dividend of 3s. 6d. per share to December 31st, £10,624; balance carried forward, £5,511. The revenue for the half-year shows an increase of £990, equal to 2¼ per cent. as compared with that for the correspond

Digitized by Google

ing period of 1889. The development of the traffic, though slow, appears to be progressive. The working expenses in London have been so very nearly the same as in the corresponding period that a comparison of the items need not be made. The total (as shown by abstract "A") is £45 less than in 1889. The expenses at stations (as shown by abstract "B") exhibit an increase of £1,856, due to two causes: Firstly, and chiefly, to our having now to bear the whole of the expenses of the New York Office, instead of one-third only of those expenses as in 1889, as explained to the general meeting in July last; and secondly, to the prosecution of an active canvass for business on the Continent of Europe, as well as in the United Kingdom and New York and Boston, accounting for the greater portion of the increase in the item of printing, stationery, and advertising. The reserve fund, after being debited with £1,629 for cost of repairs, and credited with £4,307 for interest on the investments, now stands at £252,678. The investments, as heretofore, continue to be worth much more than the figure of cost at which they stand in the balance-sheet. Gentlemen, these are the items to which I desire to refer, so that they may be impressed on your minds. I began my remarks by what I should probably have said at the present moment; but what I want to point out is this, that in July last, and this day twelve months, I went so exhaustively into the position of this Company, that when I read my two speeches this morning, I was rather astonished that I had so completely taken up every point with regard to the position of the Company, its past, its present, and its future, and I satisfied myself that the best thing I could do, after having read these figures to you, was simply to tell you that you must wait for six months in order that I might get something new to mention. In the meantime you are going to get the same dividend that you received last year, and which has been paid for the last two or three years. We hope that it will continue, and I should be very much disappointed if it went backwards. But you may rest assured of this, that it will require all our exertions to keep it up because the competition at the present moment between the different companies is very keen indeed, and everyone is doing his best to secure for his own company a fair share of the current traffic. I am a strong believer myself in the increase of telegraphy generally, and therefore I feel satisfied, looking at the part we are playing in submarine telegraphy, that we shall not lose any opportunity of maintaining our position, and if we can get, by a little extra exertion, a little more than our neighbours, you may depend upon it we shall do so. With these remarks I beg to move,

"*That the report of the Directors, dated January 5, 1891, together with the statement of accounts to December 31, 1890, annexed thereto, be and the same are hereby received and adopted.*"

Mr. W. FORD seconded the motion.

A SHAREHOLDER suggested that instead of the item of messages in the revenue account being lumped with the remark "after deducting the rent of wires," the two should be separately shown.

The CHAIRMAN said that the matter would be considered, and if, having regard to their arrangements with other companies, they could act upon the suggestion, they might do so.

Another SHAREHOLDER asked whether the Chairman could give them any idea as to the probable result, favourable or otherwise, of the litigation referred to in the sixth paragraph of the Directors' report (the lawsuit between the Anglo-American Company and the French Company).

Mr. JACKSON said he had intended to ask a question on the same subject. "The capture of the French cable" he regarded as one of the most scandalous incidents in Atlantic telegraphy, and it was the outcome, in his opinion, if not of what was fraudulent, of an intrigue towards which he believed the French people and the French courts would show no favour. He could not help expressing the opinion that there had been a supineness on the part of the "pool" directors in not bringing to an issue the litigation which had been so long pending, the existence of which he believed neutralised all the efforts of the associated Companies to share in the normal increase of the traffic.

The CHAIRMAN: Probably had I been standing in Mr. Jackson's place I might have used stronger language than he has, but I think I need not remind you, as you must know it, that the conduct of this affair is entirely in the hands of the Anglo - American Company. They have been working at it from the very beginning. The suit is in their name. We have, however, been constantly watching, and the other day, when I was in Paris, I took the liberty of talking to the lawyer who is conducting the case for them. I said I was interested in the case, though I had no right to interfere: but looking at it from our point of view, which enabled me to take a correct view of it, I said I thought that it was about the most scandalous case that ever came under my observation. I spoke very strongly, and knowing the excitable tendencies of the French people, when one speaks as I spoke, to resent such remarks, I almost congratulated myself at the end of the interview that I was not engaged in an affair of honour. However, Mr. Jackson, if you are going to the Anglo-American Company's meeting, which will be held shortly, you may, perhaps, be able to elicit the information which I am not in a position to give to you. I think I have spoken to you, Mr. Jackson, pretty plainly on this matter, but I differ from you in the conclusion you have come to. I do not think that that case is the cause of our paying 3½ per cent. instead of 5 per cent. Not at all. But I should like to see it removed, and I should like to have blotted out from the escutcheon of submarine telegraph companies the transaction which has given rise to the suit in question.

On the motion of Mr. JOHN NEWTON, seconded by Mr. JACKSON, a vote of thanks to the Chairman and Directors was then passed.

The CHAIRMAN: It is always a great satisfaction to me and my colleagues to be complimented by our shareholders. Time was when they were very severe upon us, but they are now just to us, when we have come to a time like this. We all feel that there is a want of a larger dividend. I am not one of those who say that you are getting all that you ought to get. I think in submarine telegraphy you ought to get more, as I have always said; but you may depend upon it that where there is introduced into a trade, however great and however growing, a new power in conducting the traffic—where the very people themselves who are interested have become such experts in coding and reducing the number of words required to carry on their business—you have little conception of the difficulty we have in getting out of them a fair return for the facilities which we provide for them. It is a very striking scientific question. While the trade is growing there is a growing knowledge of converting this electrical power more and more to their own purposes. We have all that to contend with. It is not a plain sailing business. We have also science to contend with, we have all the ingenuity of merchants to contend with, and we have the competition of one company with the other to contend with so as to hold our own, so that you see we do not lie on a bed of roses. I thank you very much on behalf of myself and colleagues for the vote of thanks which you have so kindly passed.

The proceedings then terminated.

---

## Anglo-American Telegraph Company.

The following is the report of the Directors of this Company, to be presented to the ordinary general half-yearly meeting of the proprietors, to be held at Winchester House, Old Broad-street, E.C., on Friday the 30th inst., at 2 o'clock:—

1. The total receipts from July 1 to December 31, 1800, including the balance of £2,793. 18s. 4d. brought forward from the last account, are

PATENT

SILICIUM BRONZE AND SILICIUM COPPER WIRE.

The best for overhead Telephone and Telegraph Lines,

AND ALL ELECTRICAL PURPOSES.

Hard Drawn High Conductivity Copper Wire.

ROLLED AND DRAWN PHOSPHOR BRONZE.

PHOSPHOR BRONZE — VULCAN — PHOSPHOR — DURO METAL

PHOSPHOR BRONZE BEARINGS, BUSHES, AND OTHER PARTS OF ELECTRICAL MACHINERY

SOLE PROPRIETORS of the British, Indian and Colonial Patents,

THE PHOSPHOR BRONZE COMPANY (Limited),

87, Sumner Street, Southwark, London, S.E.

WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

Digitized by Google

estimated at £161,9C6. 14s. 2d. This amount, however, is subject to revision, ~~as the~~ lawsuit between this Company and the Paris and New York Telegraph Company is still pending before the Council of State. The traffic receipts show an increase of £3,027 as compared with the corresponding period of last year.

2. The total expenses of the half-year, including repair of cables, &c., as shown by the revenue account, amount to £56,142. 6s. 11d.

3. Interim dividends of 15s. per cent. on the ordinary stock, and £1. 10s. per cent. on the Preferred Stock, were paid on November 1st last absorbing £52,5C0, leaving a balance of £53,344. 7s. 3d., out of which the Directors recommend the proprietors to declare final dividends of 15s. per cent. on the Ordinary Stock, and £1 10s. per cent. on the Preferred Stock, amounting to £52,500, making a total distribution for the year ended the 31st December, 1890, of £2. 17s. 6d. per cent. on the Ordinary Stock, and £5 15s. per cent. on the Preferred Stock, leaving £844. 7s. 3d. to be carried forward to the next account.

4. The Company's repairing s.s. "Minia" has been engaged during the past half-year in the repair of the Northern Placentia cable and was previously chartered to the Direct United States Cable Company. The vessel has been undergoing necessary repairs, and not being available when a serious fault appeared in the Brest-St. Pierre Cable, near Brest, the Directors took advantage of the Eastern Telegraph company's s.s. "Mirror" being in the neighbourhood to obtain her services, and the repair was promptly and satisfactorily effected by that ship.

5. The Company's cables and land lines are in good working order.

6. The Directors greatly regret to announce the resignation through failing health of their valued colleague, Viscount Monck, who has occupied the position of Chairman, with great advantage to the Company, since 1873. The Board unanimously elected the Marquis of Tweeddale as Chairman, and Mr. F. A. Bevan as Deputy-Chairman. The vacancy on the direction created by the retirement of Lord Monck has been filled by the appointment by the Board of Sir Albert J. Leppoc Cappel, K.C.I.E., formerly Director-General of Telegraphs in India.

7. In accordance with the Articles of Association, two Directors of the Company, the Marquis of Tweeddale and Cyrus W. Field, Esq., retire at this meeting, and, being eligible, offer themselves for re-election. Mr. Joshua Dean and Mr. John Gane, F.C.A., the auditors, retire, and offer themselves for re-election.

## NEW COMPANIES REGISTERED.

**NORTH-EASTERN TELEPHONE COMPANY (LIMITED.)**—This Company was registered on the 14th inst. with a capital of £4,600, in £1 shares, to carry on the business of a telephone company, and to adopt an unregistered agreement of 23rd ult. with the Primary Syndicate. The subscribers are:—J. V. Walton, Wilton, Durham, lead smelter; W. M. Angus, Newcastle-on-Tyne, merchant; G. Angus, Newcastle-on-Tyne, merchant; T. D. Challoner, Newcastle on-Tyne, chartered accountant; E. Fawcus, Newcastle-on-Tyne, merchant; J. Monks, Aden Cottage, Durham; E. S. Hindmarsh, Gateshead, merchant. The Directors of the Primary Syndicate (Limited) are appointed *ex-officio* Directors of this Company. Solicitor, Mr. H. W. Sample, St. Nicholas Chambers, Newcastle.

## CITY NOTES, &c.

**ANGLO-AMERICAN TELEGRAPH COMPANY.**—The Board of Directors of this Company have resolved to recommend to the proprietors at the next half-yearly general meeting of the Company, to be held on the 30th January next, the declaration of the following dividends:—(1) A balance dividend of 15s. per cent. upon the Ordinary Consolidated Stock for the year ending December 31, 1890; (2) a balance dividend of £1. 10s. per cent. upon the Preferred Stock for the year ending December 31, 1890, both payable on January 31st next, less income tax, to the stockholders registered on the books of the Company on the 13th inst. After paying the foregoing dividends there will be an estimated balance of £844 to be carried forward to the next account. The above dividends, together with those already paid, will amount to £2. 17s. 6d. per cent. on the Ordinary Consolidated Stock, and £5. 15s. per cent. on the Preferred Stock for the year 1890. The register of transfers will be closed from January 16th to the January 30th.

**ALLCHIN, LINNELL & CO. (LIMITED).**—A winding-up order has been made against this Company.

**BRAZILIAN SUBMARINE TELEGRAPH COMPANY.**—The receipts of this Company for the week ended January 16th amounted to £6,099. The Coupons of this Company's Five per Cent. Debentures (1884 issue), due January 31st, will be paid on and after that date at the Alliance Bank, Bartholomew-lane, London, E.C. Coupons must be left at the Bank three clear days for examination.

**CITY AND SOUTH LONDON RAILWAY COMPANY.**—The receipts of this Company for the week ended January 17th amounted to £758.

**COMMERCIAL CABLE COMPANY.**—This Company has opened a new office at 8, Foster-square, Bradford, and also at 37, Albert-square, Dundee.

**EASTERN TELEGRAPH COMPANY (LIMITED).**—This Company notify that the coupons on their Five per Cent. Debentures, due February 2nd next, will be paid on and after that date at the Banking House of Messrs. Glyn, Mills, Currie and Co., 67, Lombard-street, E.C. Coupons should be left at the bank three clear days for examination.

**EASTERN AND SOUTH AFRICAN TELEGRAPH COMPANY (LIMITED).**—This Company announce the payment by warrants on February 2nd next of interest for the half-year ending January 31st, on their Four per Cent. Mortgage Debentures. The Transfer Books will be closed from January 28th to February 2nd, both days inclusive.

**ELMORE'S AUSTRO-HUNGARIAN COMPANY.**—A meeting of this Company will be held at the Cannon-street Hotel, E.C., to-day, at 12 o'clock.

**MANGANESE BRONZE AND BRASS COMPANY (LIMITED).**—The Directors have declared an interim dividend of 8s. per share for the half-year ended December 31st last, payable on March 2nd next.

**MAXIM-WESTON ELECTRIC COMPANY.**—A meeting of this Company was held yesterday at Winchester House, E.C., but we are unable to provide a report, as our representative was informed that the proceedings were private, and that no reporters would be admitted.

**NEW COMPANY.**—The *Weiner Zeitung* announces that the Austro-Hungarian Banking Company has received the requisite sanction for the establishment of the General Austrian Electricity Company, with offices and works in Vienna.

**PERSONAL.**—Mr. H. A. Bell has been appointed Managing Director of Bell's Asbestos Company, Limited.

**STOCK EXCHANGE.**—Application has been made to the committee to appoint a settling day in, and to grant a quotation to, £320,000 Four per Cent. Mortgage Debenture Stock of the Eastern Extension, Australasia, and China Telegraph Company (Limited); and to allow Elmore's French Patent Copper Depositing Company (Limited), shares Nos. 1 to 66,750 to be quoted in the Official List.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY.**—The traffic receipts of this Company for the week ending January 16, 1891, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £4,935.

**WEST INDIA AND PANAMA TELEGRAPH COMPANY.**—The traffic receipts for the half-month ended Jan. 15th were £2,596, as compared with £3,C01 for the corresponding period of 1890, showing a decrease of £405.

**WHITE'S ASBESTOS (LIMITED).**—At an extraordinary general meeting of the shareholders of this Company, held on Thursday, a resolution was passed for winding up the Company voluntarily.


# THE NON-CONDUCTOR OF ELECTRICITY.

WAREHOUSE.

**VULCANISED FIBRE,**

PATENTED.

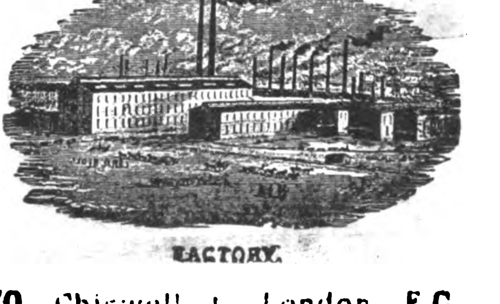
This new material is supplied in two qualities, Flexible and Hard.

The FLEXIBLE is a substitute for Leather, Rubber, Gutta Percha, &c., and is extensively used by Brass Founders, Axle Makers, Hydraulic, Sanitary, and other Engineers, Pump Makers, Carriage Builders, &c.

It makes the best Hot and Cold Water Packings, and for Axle Washers of all kinds it is unequalled.

The HARD is a substitute for Metals, Hard Wood, Ivory, Vulcanite, Ebonite, &c., and is a good Insulator.

Sold in sheets, 5ft. 6in. by 3ft. 6in., varying in thickness from 1-50in. to 1in.



FACTORY.

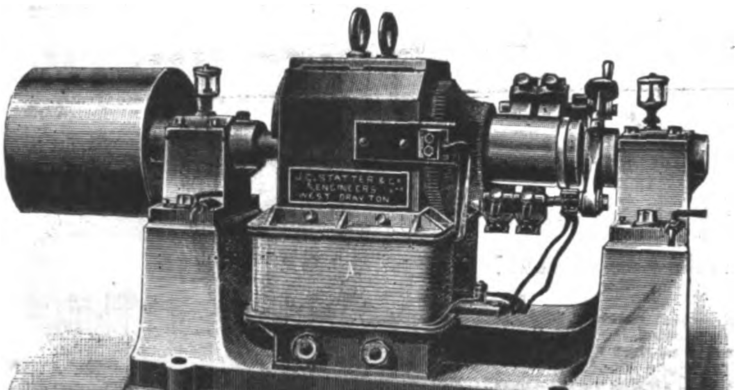
FLEXIBLE, 2/- per lb.; HARD, 2/3 per

**MOSSES & MITCHELL, 70, Chiswell-st., London, E.C.**

## COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name. | Previous Week's Price, Jan. 14. | | Price Wednesday, Jan. 21. | | Rate per Cent. Yielded. £ s. d. | Dividend Due. | Business Done During Week Ending Jan. 21. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **TELEGRAPHS.** | | | | | | | | |
| £1,381,380 | Stock | 15/0 | Anglo-American | 49 | 50 | 48⅞ | 49½ | 5 16 2 | Jan., Apr., July, Oct. | 49¾ | 49⅜ |
| £2,809,310 | Stock | 30/0 | Do. Preferred | 85½ | 86½ | 85 | 86 | 6 13 9 | ,, ,, | 86½ | 86 |
| £2,809,310 | Stock | .. | Do. Deferred | 13¼ | 13¾ | 13 | 13¼ | .. | ,, ,, | 13¼ | 13 |
| £250,000 | 100 | 4% | African Direct, Telegraph 4% Debentures | 98 | 101 | 98 | 101 | 3 19 3 | January and July .. | .. | .. |
| 130,000 | £10 | 3/0 | Brazilian Submarine | 11¼ | 11¾ | 11¼ | 11¾ | 6 7 6 | Mar., June, Oct., Dec. | 11⅝ | 11⅝ |
| £84,500 | £100 | 5% | Do. 5 per Cent. Bonds | 102 | 104 | 102 | 105 | 4 15 3 | January and July .. | 102¼ | .. |
| £75,000 | £100 | 5% | Do. 5 per Cent. Bonds (2nd Series, 1906) | 102 | 106 | 102 | 106 | 4 14 4 | June and December | .. | .. |
| $7,216,000 | $100 | 7% | Commercial Cable Capital Stock | 104 | 105 | 104 | 105 | 6 3 10 | April and October .. | .. | .. |
| 16,000 | 10 | 8/0 | Cuba Submarine | 11 | 12 | 11 | 12 | 7 1 8 | February and August | 11¾ | 11½ |
| 6,000 | 10 | 10% | Do. Preference 10% | 16½ | 17½ | 16½ | 17½ | 5 14 3 | ,, ,, | 17 | .. |
| 12,931 | 5 | 2/4½ | Direct Spanish (£4 paid) | 3¾ | 4½ | 3¾ | 4½ | 5 12 11 | April and October .. | .. | .. |
| 6,000 | 5 | 10% | Do. Preference 10% | 9 | 10 | 9 | 10 | 5 0 0 | ,, ,, | .. | .. |
| 60,710 | 20 | 3/6 | Direct United States ....xd | 10¼ | 10⅝ | 10¼ | 10⅝ | 6 15 0 | Jan., Apr., July, Oct. | 10⅝ | 10 5/16 |
| 400,000 | 10 | 2/6 | Eastern ....xd | 13¾ | 14½ | 14⅛ | 14⅜ | 4 10 5 | ,, ,, | 14½ | 14 |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference ....xd | 14¾ | 15¼ | 14¾ | 15¼ | 3 18 8 | ,, ,, | 15⅛ | .. |
| £1,200,000 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock | 104 | 107 | 105 | 108½ | 3 13 9 | May and November | 106¾ | 105½ |
| £200,000 | 100 | 5% | Do. 5 per Cent Debentures, 1899 | 108 | 111 | 108 | 111 | 4 10 1 | February & August | .. | .. |
| 250,000 | 10 | 2/6 | Eastern Extension ....xd | 14⅛ | 14⅜ | 14⅜ | 14⅝ | 4 15 9 | Jan., Apr., July, Oct. | 14½ | 14 3/16 |
| £320,000 | 100 | 6% | Do. 6 per Cent. Debentures, 1891 | 101 | 103 | 101 | 103 | 5 16 6 | February & August | .. | .. |
| .. | .. | .. | Do. 4 per Cent. Debentures Stock | .. | | 102 | 104 | 3 16 11 | .. | .. | .. |
| £91,800 | 100 | 5% | Do. 5 p. c. (Austin. Gov. Sub.) Debs. 1900 | 102 | 105 | 102 | 105 | 4 15 3 | January and July .. | 104½ | 102 |
| £145,300 | 100 | 5% | Eastern & S. African 5 per Cent. Mor. Deb., 1900 | 101 | 104 | 102 | 105 | 4 15 3 | ,, ,, | 104 | .. |
| 180,227 | 10 | 1/9 | Globe Telegraph and Trust | 8¾ | 9¼ | 9 | 9½ | 5 5 4 | Jan., Apr., July, Oct. | 9 5/16 | 9 |
| 180,042 | 10 | 6% | Do. 6 per Cent. Preference | 14¾ | 15 | 14¾ | 15 | 4 0 0 | ,, ,, | 15 | 14¾ |
| 150,000 | 10 | 5/0 | Great Northern | 16¼ | 16¾ | 16½ | 17 | 4 8 3 | Jan., April, and July | 16 15/16 | 16½ |
| £130,000 | 100 | 5% | Do. 5 per Cent. Debentures, 1883 | 105 | 108 | 105 | 108 | 4 12 7 | March & September | 106 | .. |
| 17,000 | 25 | 12/6 | Indo-European | 35 | 37 | 33 | 37 | 6 15 2 | May and November | .. | .. |
| 38,348 | 10 | 4/0 | London Platino-Brazilian | 6 | 7 | 6 | 7 | 5 14 4 | ,, ,, | .. | .. |
| £100,000 | 100 | 6% | Do. 6 per Cent. Debentures | 107 | 110 | 107 | 110 | 5 9 1 | March & September | .. | .. |
| 9,000 | 8 | 4/0 | Reuter's | 8½ | 9 | 8½ | 9 | 5 11 1 | April and October .. | 8⅝ | .. |
| 3,381 | £100 Cert. | 6% | Submarine Cables Trust 6% | 110 | 114 | 112 | 115 | 5 4 4 | ,, ,, | 113 | .. |
| 15,609 | 10 | 4/0 | West African Telegraph | 8 | 9 | 8 | 9 | 5 11 1 | January and July .. | .. | .. |
| £290,900 | 100 | 5% | Do. 5 per Cent. Debentures | 98 | 101 | 98 | 101 | 4 19 0 | March & September | 99¾ | 99½ |
| 30,000 | 10 | 3/0 | West Coast of America | 2 | 4 | 2 | 4 | .. | January and July .. | 3 | .. |
| £150,000 | 100 | 8% | Do. Debentures 8% 1902 | 97 | 102 | 95 | 100 | .. | June and December | 97½ | .. |
| 88,321 | 10 | .. | West India and Panama | 2¾ | 3 | 2⅝ | 2⅞ | .. | .. | 2 15/16 | 2 11/16 |
| 34,563 | 10 | 6/0 | Do. 1st Preference 6% | 11¼ | 11¾ | 11¼ | 11¾ | 5 2 2 | May and November | 11 9/16 | 11½ |
| 4,669 | 10 | £3 | Do. 6 p. c. 2nd Pref. | 11 | 12 | 11 | 12 | 5 0 0 | ,, ,, | .. | .. |
| 64,174 | 15 | 6/0 | Western and Brazilian | 10¾ | 11¼ | 11¼ | 11¾ | 5 2 3 | ,, ,, | 11½ | 10 15/16 |
| 27,873 | 7½ | 6/0 | Do. 5 per Cent. Cumulative Preferred | 6¼ | 6¾ | 6½ | 7 | .. | — | 6¾ | 6 11/16 |
| 27,873 | 7½ | 4/6 | Do. 5 per Cent. Deferred | 4¼ | 4¾ | 5 | 5½ | .. | .. | 5¼ | 4⅝ |
| £200,000 | 100 | 6% | Do. 6 per Cent. Debs., Series "A" 1910 | 103 | 106 | 103 | 106 | 5 13 2 | February & August | 105½ | 104 |
| £250,000 | 100 | 6% | Do. 6 per Cent. Mort. Debs., Series "B" 1910 | 103 | 106 | 103 | 106 | 5 13 2 | ,, ,, | .. | .. |
| $1,336,000 | $1,000 | 7% | Western Union 7 per Cent. 1st Mortgage | 120 | 125 | 120 | 125 | 5 12 0 | May and November | .. | .. |
| £175,100 | £100 | 6% | Do. 6 per Cent. Sterling Bonds | 99 | 103 | 99 | 103 | 5 16 0 | March & September | .. | .. |
| | | | **TELEPHONES.** | | | | | | | | |
| 224,850 | 14/0 | 0/4½ | Consolidated Telephone Const. & Maintenance. | 7/16 | 9/16 | 7/16 | 9/16 | .. | May and November | .. | .. |
| 220,000 | £1 | 3% | Oriental (11s. paid) | ⅛ | ⅜ | 5/16 | 5/16 | 5 5 9 | Yearly | .. | .. |
| 438,984 | 5 | 2/6 | National | 4⅜ | 4⅝ | 4¾ | 4⅞ | 5 18 11 | June and December | 4 11/16 | 4 5/16 |
| 15,000 | 10 | 6/0 | Do. 6 per Cent. Cumulative 1st Pref. | 12¼ | 12¾ | 12½ | 13 | .. | ,, ,, | 12⅝ | 12⅜ |
| 15,000 | 10 | 4/9¾ | Do. 6 per Cent. Cumulative 2nd Pref. (£8 pd) | 10 | 10½ | 10¼ | 10¾ | .. | ,, ,, | 10½ | 10½ |
| 209,750 | 1 | ½% | South of England, Ordinary | ⅛ | ⅜ | ⅛ | ⅜ | .. | — | .. | .. |
| 20,000 | 5 | 2/1 | Do. 6 per Cent. Cumulative Pf. (£3 10s. pd) | 2¾ | 3¼ | 2¾ | 3¼ | .. | .. | .. | .. |
| 58,000 | 5 | 5% | United River Plate | 3 | 4 | 3 | 4 | .. | January and July .. | .. | .. |
| £146,128 | Stock | 5% | Do. 5 per Cent. Debenture Stock | 90 | 95 | 90 | 95 | 5 5 3 | .. | .. | .. |
| £3,200 | 100 | 7% | Do. 7 per Cent. Debentures | .. | | .. | | .. | — | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | | | |
| 200,000 | 5 | .. | London Electric Supply | 2 | 2¼ | .. | | .. | — | .. | .. |
| 43,900 | 10 | .. | Metropolitan Electric Supply (£8 paid) | 7¾ | 8¼ | 7¾ | 8¼ | .. | — | 8¼ | .. |
| 42,853 | 5 | .. | Westminster Electric Supply (£3 paid) | 2½ | 3 | 3½ | 4 | .. | — | 3⅞ | .. |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | | | |
| 63,416 | 3 | .. | Brush Electrical Engineering | 2¼ | 2½ | 2¼ | 2½ | .. | .. | 2½ | 2½ |
| 63,416 | 2 | 0/10 | Do. 6 per Cent. Preference | 1½ | 2 | 1½ | 2 | 6 0 0 | June and December | 1⅞ | 1½ |
| 20,000 | 5 | 3/6 | Crompton and Co., 7 per Cent. Pref. Shares | 5 | 5½ | 5 | 5½ | 6 7 3 | January and July .. | .. | .. |
| 17,130 | 5 | .. | Edison and Swan United | .. | | .. | | .. | .. | .. | .. |
| 45,000 | 10 | 6% | Electric Construction | 7 | 7½ | 6¾ | 7¼ | 8 5 5 | .. | 7½ | 7⅛ |
| 70,000 | 2 | 10/0 | Elmore's Patent Copper Depositing | 4 | 4½ | 3¾ | 4¼ | .. | .. | 4½ | 3 15/16 |
| 20,000 | 5 | .. | Fowler-Waring Cables (£4 paid) | 2½ | 3½ | 2½ | 3½ | .. | .. | .. | .. |
| 41,600 | 10 | 10/0 | India Rubber, Gutta Percha & Telegraph Works | 18½ | 19½ | 18½ | 19½ | 5 2 7 | February & August | 19½ | 18¾ |
| £200,000 | 100 | 4½% | Do. 4½ per Cent. Debentures, 1896 | 102 | 104 | 103 | 105 | 4 5 9 | March & September | .. | .. |
| 11,334 | £10 | 10% | International Okonite Limited Ordinary ....xd | 9¼ | 9¾ | 9¼ | 9¾ | 10 4 7 | .. | .. | .. |
| 11,334 | £10 | 8% | Do. Preference ....xd | 9¼ | 9¾ | 9¼ | 9¾ | 8 4 1 | .. | .. | .. |
| 78,949 | 5 | 4/10 | Swan United (£3. 10s. paid) | 4½ | 5 | 4½ | 5 | 6 19 10 | May and November | 5 | 4¾ |
| 37,350 | 12 | 12/0 | Telegraph Construction and Maintenance | 44 | 46 | 44 | 45 | 5 9 7 | March and July..... | 46¼ | 44½ |
| £150,000 | 100 | 5% | Do. 5 per Cent. Bonds, red. 1894 | 101 | 103 | 101 | 103 | 4 17 1 | January and July .. | .. | .. |
| | | | **RAILWAYS.** | | | | | | | | |
| 50,000 | £10 | .. | City and South London Railway | .. | | 7 | 8 | .. | .. | 7¾ | 7½ |


# IMPROVEMENTS IN DYNAMOS.




## STATTER-BRUNTON DYNAMO.

**The latest design in the market, made with all the advantages of the latest scientific knowledge and the highest mechanical skill.**

The woodcut represents our B TYPE DYNAMO. A most efficient machine, working noiselessly, and without sparking or overheating; is highly finished and well proportioned. The output is so rated in our Catalogue that the machines may be worked very much in excess of their stated full output for short periods.

**STOCK SIZES UP TO 77 KILOWATTS.**
**MACHINES BUILT TO 500 KILOWATTS.**

**THE ELECTRICAL ENGINEERING CORPORATION, LIMITED,**
(STATTER'S) (UNITED.)

68, Victoria Street, London, S.W. WORKS:—ALLIANCE ENGINEERING WORKS, WEST DRAYTON, NEAR LONDON.

// THE ELECTRICIAN:
A WEEKLY ILLUSTRATED JOURNAL OF
ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.
No. 663.—Vol. XXVI. FRIDAY, JANUARY 30, 1891. Price Fourpence.

# NOTES.

Although the paper read by General Webber at the last meeting of the Institution of Electrical Engineers did not contain much matter of interest, it has certainly provided several subjects for discussion, and if the speakers will confine their remarks to some of the side issues raised, the debate may be of considerable value. We have not thought it necessary to reproduce the intricate diagram of the automatic switch, or the scarcely less complicated description of it. It is very unlikely that the Chelsea system will ever be largely imitated, and if something similar were to be attempted elsewhere the whole affair would probably be re-designed. There is a limit to automaticity in any mechanical arrangement, and this limit appears to have been considerably overstepped in the present case. It is difficult to imagine an engineer trusting to the accumulation of gas from a "master cell" to cause a series of complicated reversals and reconnections through the agency of magnets and local circuits. Dr. Fleming has thoughtfully pointed out that a device by which the services of a man can be dispensed with, may be valued by the capitalized sum of his wage. But this takes no account of risk, and when the safety of a station and the continuity of its supply are dependent upon automatic working, attended with such an amazing complication, it is obvious that engineers must be ever present to look after the whole of the automatic arrangements, indeed we have heard that a "master" block of wood is found to be very useful for holding up the switch until it is considered that the proper time has come for it to act.

Two appeals, each for £50,000, have been made simultaneously by University College and by King's College to meet the increasing demands of education, particularly in modern science and experimental research. These are supported by well-known names, to which Lord Salisbury's was subsequently added. Each college can point to excellent laboratories and valuable apparatus and appliances; but of late years technical education of the higher order has made such strides that these old-established foundations are in danger of being left behind, and of crystallising in that pitiable way to which all educational men and institutions are so liable. If University College and King's College are to hold their own in competing with the Central and the Finsbury Institutes of the City and Guilds of London in both science and engineering, neither the laboratory and traditions of Prof. Kennedy, nor the liberality of Lady Siemens and Messrs. Davey, Paxman, and Co. will suffice. These colleges, if they are to keep in the front rank, must have the personal influence of such teachers as those who are to be found in the rival lecture rooms. Given good men, the colleges will easily maintain their reputation, but the best men will not devote their whole time to the labour, and cut themselves off from all other professional work, unless they receive a reasonable renumeration; nor will they be attracted by the facilities for private research, which is the chief inducement in some cases, unless the laboratories be properly equipped. Now that the City and Guilds of London Institutes are so thoroughly successful, each in their own line, and Polytechnics are being proposed in different parts of London, we hope that the effort to maintain and develop the teaching of science and of engineering at Gower-street and the Strand will meet with the success it deserves.

The remarkable accession to the number of telephone subscribers consequent upon the reduction of the subscription is most encouraging to the policy which the National Telephone Company have now avowed their intention of pursuing. By attracting all the subscribers possible, and covering all the ground, they may confidently defy any competitor that has the temerity to enter the field against them. Now that their patents are virtually extinct they are in the position of some of the more powerful lines of railway, liable in theory to competition, but practically exempt. From the Post Office there comes no sound of warning; and it would seem that for another six years at least the great Telephone Companies will be free to make as much money as they can, and extend their operations as widely as they choose. We are confirmed in the opinion that the trunk lines which are being everywhere erected to link the systems together into a united whole, will not pay for their construction: but they will give a certain valuable prestige, and with good management may indirectly attract customers to the remunerative local sections.

In connection with this response on the part of the provincial towns to the Company's reduction of rates, the Chairman was probably right in the reason he assigned for not conceding a similar reduction to the far wider area of the Metropolis. But we think we could supply another and a more sufficient reason, namely, that cheapening the service in London would have no effect on the number of subscribers so long as the working remains what it is. Evidently provincial towns are far better

Digitized by Google

served; and if London had some of the Company's spare capital expended upon it, there is no reason to doubt that the improvement would be met by a similar generous inrush of subscribers.

PART 90 of the *Journal* of the Institution of Electrical Engineers is mainly occupied with the lengthy discussion arising in connection with the two papers on accumulator tests made at the Central Institution; but a few abstracts, and a list of the titles of some of the chief electrical papers which have appeared during the last five months are appended. For some years past the number of abstracts printed in the *Journal* has been steadily diminishing, those appearing in the volume just completed numbering little more than half those printed in the volume for 1887. This is to be regretted, as at the present day it is impossible for anyone to keep pace with the enormous mass of current literature, or even to avoid missing papers dealing with his own special branch of work. For this reason a well-chosen series of abstracts of those articles which have not appeared in the common technical papers, accompanied by a fairly full list of the titles of papers which have been printed in the chief English and Foreign Electrical Journals is invaluable; and the *Journal* of the Institution has in this respect set itself to fulfil a very important function. The list actually issued might, however, without much extra trouble have been made more complete; and especially in the case of foreign articles, if references were made, not only to the *Journal* in which the papers were originally printed, but also to the more accessible English journals in which translations have appeared.

THE proposal emanating from our monthly contemporary *Electrical Plant*, that a permanent electrical museum should be formed under the auspices of the Institution of Electrical Engineers, has much to commend it. Had such a museum been founded in the days of GILBERT of Colchester, and had it survived all vicissitudes until the present time, it would be impossible to overrate its value. When it is seen what support the proposal meets with it will be time enough to discuss details; but it is to be hoped that the advocates of this museum have some plan for making it more attractive, and consequently more useful than has hitherto been customary. A dusty, ill-arranged, badly-catalogued collection of miscellaneous electrical apparatus, stowed away in an indifferently lighted, almost inaccessible loft, would, no doubt, be a museum "within the meaning of the Act," but it would most certainly fail to attract. In an out-of-the-way corner of the Birmingham Exhibition of 1889 an old wooden frame was to be seen containing what appeared to be a brass drum and a medley of horseshoe magnets. Nor did reference to the catalogue throw much light on the mystery, which was nothing more or less than the first electro-plating machine ever constructed, and which, although dating as far back as A.D. 1844, was an excellent example of a dynamo with its equipotential armature coils connected in parallel. In a conspicuous position in the Edinburgh Exhibition of last year there was a fine collection of telegraph apparatus shown by the Post Office; the exhibit was both well arranged and well catalogued. A visitor to the Edinburgh Exhibition could scarcely fail to see the Post Office exhibit; while Woolrich's magneto-machine at Birmingham was a mere accidental discovery. It is unnecessary to say which method of exhibiting would tend to make a permanent electrical museum a genuine success.

WITH this issue we present to our readers a map, on the scale of 3½ inches to the mile, showing the streets in which electric supply mains were actually laid up to the beginning of the present month. The great activity of the supply companies of the metropolis is very apparent, though the number of miles of mains does not represent the volume of the business done in the different districts. We had at first hoped to represent the actual position of mains and feeders, but these are in many cases so numerous that it would not have been possible to show them clearly even on a map on a scale two or three times larger; and since few, if any, of the supply companies have as yet finally settled their feeders or systems of mains, it would be premature to deal with these details at present. The Ferranti mains of the London Electric Supply Company are not shown, as they are not used for supply of current to consumers. The four sets, belonging to this company, at present laid, cross the river at Charing Cross.

**Venice.**—Four 80 kilowatt alternators are to be installed for the lighting of Venice. These will supply 7,000 10 candle-power lamps.

**Tivoli.**—According to the *Elektrotechnischer Anzeiger*, the central station being built by the Società Romana di Gaz will be opened on May 1st.

**The Lighting of the City.**—The first portion of the electric lighting cable in the City will, be laid on Tuesday, the 3rd prox. The Lord Mayor, it is hoped, will be present on the occasion.

**Intra.**—A central station is to be built for the electric lighting of Intra, Italy. Power is to be derived from four 150 horse-power turbines, and the alternate current-transformers system will be used.

**Electric Traction at Gera.**—The Allgemeine Elektricitäts Gesellschaft are about to equip an electric tram line at Gera 10km. long. Some 10 cars will be provided, and the Sprague overhead system will be employed.

**Old Students' Association.**—On Saturday, January 24th, a most enjoyable evening was spent at Prof. Perry's house, 31, Brunswick-square, by the members of this association. In all there were about 200 persons present, most of whom were students and their friends.

**A Novel Application of the Duplex Method.**—Duplex working with ordinary Morse instruments has been tried as an experiment on the Bushire-Jask cable, says *Indian Engineering*. The experiment, which seems to have been fairly successful, is due to Mr. Possmann, electrician of the Persian Gulf section.

**The City Commissioners and the Overhead Wires Bill.**—The Commissioners at their last meeting resolved that a petition should be presented to provide, in regard to the London Overhead Wires Bill, against any alterations being made therein prejudicial to the jurisdiction of the local authority.

**Local Authorities and Telephone Wires.**—At a recent meeting of the Worksop Local Board the clerk was instructed to give the National Telephone Company one year's notice to remove the poles now fixed on the Board's roads and property, as no one was benefited by the telephone but private subscribers.

**The London Electric Supply Corporation.**—It is expected that the supply will be re-commenced by the middle of next month. It has been decided to earth the system at Deptford.

Digitized by Google

but the details of the insulation and the requirements of the Board of Trade and of the Post Office are not yet finally settled.

**Cardiff.**—Notices of opposition to the proposed electric lighting Order of the Corporation have been lodged by the Glamorganshire Canal Company, the Bute Docks Company, the Western Counties and South Wales Telephone Company, the Taff Vale Railway Company, and the Cardiff Gas Lighting and Coke Company.

**The Production of Copper in the United States in 1890.**—The production of copper in the United States in 1890 amounted to 124,380 tons, thus far exceeding any previous record, and being 20 per cent. greater than the output in 1889; it now amounts to more than 50 per cent. of the world's total output of this metal in 1889.

**County Councils and Technical Education.**—At a meeting of the Herts County Council on Monday it was decided by a large majority to expend £6,400, received from the beer and spirit tax, in the furtherance of technical education on an equitable basis throughout the county. An amendment proposing to devote the money to the reduction of local taxation was defeated by 32 votes to 17.

**The Clerk-Maxwell Scholarship.** — Candidates for the newly-founded Clerk-Maxwell Scholarship in Experimental Physics are requested to send their names to Prof. Thomson, 6, Scroope-terrace, Cambridge, before February 21st. Each candidate is requested to forward a statement of the original work which, in accordance with the conditions of the tenure of the Scholarship, he would undertake if elected.

**Electric Lighting and Traction in Madras.**—According to *Indian Engineering* a gentleman just arrived from England has submitted a scheme to the President of the Municipal Commission of Madras for lighting the city by electricity and placing electric tramcars in it. He is supposed to be powerfully backed at home, and one of the promoters is already on his way out to negotiate with the authorities concerned.

**The Pacific Cable.**—A Bill was introduced in the United States Senate on Monday sanctioning the incorporation of a Pacific Cable Company, with a capital of $5,000,000, to work a cable between San Francisco, Hawaii, Samoa, and Japan. The Bill provides that the majority of the directors shall be citizens of the United States, and authorises the Treasury to pay the company an annual subsidy of $200,000 for 15 years.

**Lightning Statistics.**—The following figures are taken from the official returns of the thunderstorms observed, and the damages caused by lightning in Belgium, during the years 1884–1888:—

| | 1884. | 1885. | 1886. | 1887. | 1888. |
|---|---|---|---|---|---|
| Persons killed ... | 16 ... | 13 ... | 5 ... | 7 ... | 15 |
| Houses set on fire | 29 ... | 28 ... | 54 ... | 17 ... | 19 |

**Electric Traction in Berlin.**—The Berlin Municipality has lately been approached by the promoters of electric traction, with a view to the extension of electric tramways throughout the city. The Municipality has decided that no concessions will be granted for the construction of high-level street electric railways, or for electric tramways requiring overhead conductors carried on posts, erected either on the horse-roads or footpaths.

**Personal.**—Mr. Drake has sufficiently recovered from his severe accident to enable him to be conveyed home from the Westminster Hospital, and it is hoped that he will in time thoroughly recover from the effects of his fall.——Friends of Major Flood-Page will be glad to learn that he is recovering from the severe indisposition which has confined him to his house for the past six or seven weeks. On inquiry yesterday afternoon we were informed that he was much better.

**The Lane-Fox Patents.**—We are informed that an arrangement has been concluded between the St. James and Pall Mall Electric Light Company and the Lane-Fox Electrical Company, by which the validity of the Lane-Fox distribution patent is specifically acknowledged: a licence is taken out and a royalty paid to the Lane-Fox Electrical Company. We further understand that the Lane-Fox Company is doing all it can to hurry forward the action it has brought against the Kensington and Knightsbridge Company.

**Liverpool.**—A deputation, representing the Liverpool Electric Supply Company, waited upon the Watch Committee at its last weekly meeting to ask permission to extend their area of supply, and to retain the 42 years' clause in the Provisional Order. The committee declined the application. The deputation also asked for an extension of the time allowed in the present area, and this request was likewise rejected. It is, however, expected that a compromise will be come to between the Corporation and the company, on the basis of a 35 years' duration of the company's powers.

**Correction.**—The following corrections should be made in Mr. Kennelly's Paper on Inductance, which appeared in our issues of January 2nd and 9th:—Page 268, 15 lines from end of page, for "tenth" read "hundredth"; p. 269, col. 1, line 10, for "9,778" read "9,978"; p. 306, col. 2, line 1, for "ampere, half" read "absolute unit of current (ten amperes), five times"; same line, for "393," read "3,930"; line 2, for "millihenrys" read "henrys"; line 3, for "per ampere" read "for ten amperes"; line 4, for "11·79" read "11,790"; lines 13 and 15, for "2/30" read "2/3"; line 18, for "0·393" read "3·93."

**Hull.**—At a meeting of the Electric Lighting Committee of the Hull Corporation last week an application was received from Woodhouse and Rawson United for permission to put down an installation on a piece of vacant ground, in Broadley-street, for the purpose of lighting a block of property by electricity. It was decided that intimation should be sent to the applicants to the effect that the committee were not in a position to entertain the matter. It was also decided that a circular should be sent to tradesmen and residents with a view to ascertaining whether they would be disposed to adopt the electric light, if it was introduced by the Local Authority.

**The New York Edison Company.**—A statement recently made by the Edison Electric Illuminating Company of New York to the New York Stock Exchange contains the following comparative statement of earnings:—

| | Years. 1888. | 1889. | 1890. |
|---|---|---|---|
| Gross ... | $226,301 ... | $327,678 ... | $488,595 |
| Operating expenses and taxes. | 110,066 ... | 203,647 ... | 259,517 |
| Net ... | 116,235 ... | 124,031 ... | 229,078 |

These earnings do not include any revenue from the large station in Pearl-street, now in course of erection, or from any considerable part of the additions and extensions recently made to the company's system throughout the city.

**Proposed Extension of the City and South London Railway to Peckham.**—A movement is on foot among some influential residents of Peckham and East Dulwich with the object of obtaining an extension to these districts of the above railway. A largely-signed memorial of inhabitants has been drawn up praying the local authorities to increase the railway accommodation of the district, which, it is complained, is at present far from satisfactory; and the Camberwell Vestry will shortly approach the Directors of the Railway Company with regard to the matter. Should that Company entertain the proposed scheme, it is suggested that their system should be extended from the Elephant and Castle, through the Walworth-road on to Camberwell-green, and thence down the Peckham-road to East Dulwich and Nunhead.

**The Electric Lighting of Railway Carriages.**—On Friday last week a special trial train fitted up with the electric light was run from Dublin to Drogheda, the contract for lighting all the mail trains on the system of the Great Northern Railway Company of Ireland by electricity having been entrusted to the Electrical Engineering Company of Ireland. Should the light prove successful, it will be extended to all trains. There are 18 accumulators provided for each composite carriage, and 5 c.p. lamps are provided. A Brush dynamo, worked by a Stockport gas engine, will be erected at the Amiens-street station to charge the accumulators.

**Telephonic Communication between London and Paris.**—According to a Reuter's telegram of the 24th inst., the French Minister of Commerce is engaged in drawing up the conditions for the working of the telephone service between London and Paris, and it gives the following as the essential points:—The charge for the use of the telephone would be 10fr. for a three-

Digitized by Google

minutes' conversation. This charge would at first be only experimental. The telephone will be available either night or day, and correspondents of the two nations will have the use of the instrument alternately. The telegram concludes with the announcement that "The British authorities on their part will adopt such measures as they may deem fit," which we presume means that the tariff for using the telephone on this side may differ from that given above.

**Bristol.**—The electric lighting committee of the Bristol Town Council have further considered Mr. Preece's report on the scheme for lighting the city. The committee have made arrangements by which a portion of the site for the installation can be entered upon by March 25th; but they have decided to ask Mr. Preece for additional advice as to the style of plant that should be laid down. They have also agreed to add £5,000 to the original estimate on account of the probability of work in respect of the foundations of the site in question being necessary. This will bring the total estimated cost to £60,000; and for this sum the committee believe that an adequate installation can be secured for brilliantly lighting the area contemplated.

**The Hanover-square School of Electrical Engineering.**—The manager of this School, Mr. L. Drugman, informs us that as the result of recent examinations the following students have now obtained the Vellum Certificate of the School:—(A) In Electric Lighting and Power Transmission: Messrs. A. C. D. Crommelin, B.A., J. Finlay, J. F. Irgens, H. Macfarlane, L. Marchetti, F. J. Moffett, B.A., R. J. F. Mostyn, J. W. Parr, P. F. W. Simon, P. J. S. Tiddeman, H. Treherne, L. W. Wild, C. B. Wigg. This examination was conducted by Mr. Gisbert Kapp, and consisted of a paper in Mechanical Engineering, a paper in Electrical Engineering, a *viva-voce*, and Practical Examination and Drawing. (B) In Telegraphy and Telephony, Mr. H. Treherne above-named. This examination was conducted by Mr. H. R. Kempe.

**High Pressure Transmission of Power Experiments.**—Some important experiments were carried out last week at Oerlikon by Mr. Brown with a view of demonstrating to officials of the German telegraph department and others the feasibility of high pressure transmission of power. As we have already announced it is proposed to electrically transmit 300 horse-power from Lauffen-on-Neckar to Frankfort-on-Maine, a distance of 100 miles, in connection with the Frankfort Exhibition, and the Government has been asked to supply the line for that purpose. An artificial line 4½ miles long was employed in these experiments, and pressures of 15,000, 20,000, and 33,000 volts were tried, step-up transformers being used at the transmitting end and step-down transformers at the receiving end. The experiments were carried out during a severe snowstorm.

**Temporary Decrease of Resistance of Badly-conducting Mixtures.**—With reference to the editorial note on p. 350 of our last issue, Mr. S. A. Varley calls our attention to his lightning protectors described at the British Association, 1870. He found that fifty cells would not pass an appreciable current through a mass of finely-divided black lead or wood charcoal, but with two or three hundred cells "the particles arranged themselves by electrical traction, making good electrical contact, and formed a bridge by which the electricity freely passed." On this principle he made lightning bridges, which were used on the Bristol and Exeter Railway, but which were condemned by the Post Office. Mr. Varley appears to be under the impression that his device "acted on similar principles to Prof. Hughes' microphone, which it anticipated, and which proved in practice to be a most efficient lightning protector." Our correspondent entirely misses the interesting part of M. Branly's experiments which are not accounted for by "electrical traction."

**A Severe Test of the Overhead System of Electric Traction.**—Judging by the accounts in the various American technical journals the overhead system of electric traction has stood the test of winter weather better than was anticipated. At Boston the conditions appear to have been particularly severe. Here, on Friday, December 26th, snow began to fall at 8.30 a.m., the temperature being very low, wind very high. By noon the temperature had risen, and remaining high during the afternoon the snow began to thaw. In the evening rain fell until midnight, when the temperature again fell. The system proved equal to the emergency. The only serious delay was on a section where the cars were run at such infrequent intervals as to allow the snow to accumulate on the track between trips, and of course when the snow melted and the rain fell, and the whole afterwards froze, the tracks became seriously obstructed. On all other sections of the systems regular running was maintained by the electric cars.

**The Streatham and Tulse Hill Institute.**—On Thursday evening, the 22nd instant, Mr. Henry Edmunds delivered a lecture before this Society on "The Applications of Electricity." The lecture hall was well filled with an appreciative audience. Various articles illustrating the domestic application of the current to such humble offices as heating irons and boiling water were shown, and several electric motors demonstrated the transmission of power. Mr. Edmunds also exhibited his phonoscope, which renders visible the changes in the diaphragm of a telephone; and also his electrical gyroscope, describing the possibilities of such an instrument. By the courtesy of the National Telephone Company the lecture hall was placed in communication with their service; and Mr. D'Oyley Carte having kindly allowed his stage telephones to be employed, the audience were enabled to hear the opera of the "Gondoliers" performed at the Savoy Theatre. But a more novel and important feature was a line which connected them to the Theatre Royal, Manchester, enabling them to hear the Pantomime which was then in progress.

**Overhead Wires and Snowstorms.**—According to Reuter's telegrams, a snowstorm, accompanied by strong winds, visited New York and its vicinity on Saturday night last. Although the fall of snow only amounted to six inches, the storm in its effect upon telegraph, telephone, and electric-light wires was the most destructive that has occurred since the great blizzard of 1888. New York was practically cut off from telegraphic communication with the rest of the country. The fallen poles and wires crossed the surface of the ground in all directions, and in some cases, where they had fallen across the tracks of the elevated railroad, almost stopped the traffic. The effect of the storm was specially felt by the various exchanges and mercantile houses, the breaking of telephone wires having almost brought business to a standstill In the city the telephone wires suffered most from the storm, the telegraph wires being chiefly underground. The Metropolitan Telephonic Company report that from 2,500 to 3,000 of their wires are broken. The Western Union Telegraph Company are at present unable to form an idea of their losses.

**Electric Lighting Memoranda.**—The following paragraph appears in the "Electric Lighting Memoranda" of the *Journal of Gas Lighting*:—"It was recently remarked in this column that since platinum has been so greatly in demand by electricians, the price of the metal has more than doubled; and something like a famine in regard to it has declared itself. Now it is reported that the same thing is about to happen with gutta-percha, which is growing so scarce that all sorts of inferior substitutes are being sold under the name; and consequently electricians are experiencing the greatest difficulty in keeping up the resistance of their insulated cables to the standard of a few years ago. Meanwhile, the value of copper is falling. These movements are favourable to the low-tension direct-supply companies now purchasing the heavy copper conductors in which so much of their capital is sunk, although the value of the mains already laid is correspondingly depreciated. The alternating current high-potential companies, on the other hand, will be more perplexed than ever if they cannot procure enough good *gutta-percha* to keep their output from leaking out of the mains."

**The Protection of the Electrical Industry in France.**—The proposed list of duties on electrical apparatus entering France, which we published in our issue of December 5, 1890, has not yet been approved of by the Customs Commission. Our Paris correspondent states that he has conversed with a number of people on the subject of the proposed duties, some of whom were pecuniarily interested in the matter, while others had no direct interest. It was generally admitted that the result of the imposition of such heavy duties would be to favour the French electrical industry, since even if the countries chiefly

Digitized by Google

affected indulged in reprisals they would be unable to effectually retaliate, the French exports of electrical apparatus being comparatively small. On the other it was pointed out that foreign competition would probably only become more direct, since several English, American, and German houses have announced their intention of establishing factories in France the moment the Bill passes the Chamber. If this is done the condition invariably imposed by the Paris municipality, whenever it grants an electric lighting concession, that all the plant shall be of French make will be complied with.

**A New Form of Meter Regulator.**—I have just been given by the superintendent of an electric light station in my territory a strange instance of the stopping of a meter, and of the explanation of its conduct, says Mr. Alfred Braddell in the *Electrical Engineer* of New York. On going to read the meter (a 20-light instrument) he found that the consumer had placed a mass of small boxes around the meter. As it was desirable not to disturb them, it was agreed that the meter should be allowed to run another month. Upon the expiration of this time, the coast being clear, the meter was examined, and it was found that it had only recorded five hours during the whole two months. A very close inspection was made, and it was discovered that a spider had spun its web around the fans so that they could not rotate under the action of the current. It appeared that the screw which holds the cover to the top of the instrument had not been put in, and, no doubt, the wily spider perceiving that he could secure a warm lodging free of rent, crept in through the opening thus provided, and without malice aforethought or otherwise, there took up his abode. The moral is that station superintendents as well as flies should beware of spiders.

**Electricity in Mines.**—At a meeting of the Federated Institution of Mining, held at Newcastle last week, a long discussion took place on Mr. Albion T. Snell's Paper on "The Distribution of Electrical Energy over Extended Areas in Mines," which was read at the Sheffield meeting in January, 1890 (see *The Electrician*, Vol. XXIV., p. 294). Messrs. Sydney F. Walker, A. L. Steavenson, M. H. Mills, Brown and Arnold Lupton took part in the discussion, the chief points raised being whether such an E.M.F. as 500 volts was either safe or advantageous in mines, whether electrical transmission gave greater useful effect than wire ropes or compressed air, and, finally, whether the using of continuous-current transformers would not nullify any advantages to be gained by use of high potential in the mains. Mr. Brown, of St. John's Colliery, Normanton, stated that they had been using an E.M.F. of 700 volts for three years without any accident, and that the efficiency of their electrical plant was far higher than the old system of compressed air. Mr. Snell pointed out that he only advocated the use of transformers in isolated instances, where small motors were to be put to work at inaccessible points, and where the advantage of using such motors would be so great as to entirely override any question of efficiency.

**The Junior Engineering Society.**—The sixth annual dinner of this society was held at the Holborn Restaurant on Friday last, when about sixty members and visitors assembled. The President, Prof. Silvanus Thompson, made some remarks upon the connection between engineering and science, and alluded to the ingenious inventions of those who had never enjoyed a regular mechanical training. In the absence of Sir John Fowler, Mr. F. E. Cooper responded for the Past Presidents and Vice-Presidents, and referred to Sir John Fowler's warm sympathy with the younger members of the engineering profession. Speaking of the visit of the members of the Junior Engineering Society to the Forth Bridge during the highly successful excursion of last summer, he remarked that from none of the numerous parties whom he had conducted over the works had he ever received such intelligent questions, or had so much pleasure in answering as on that occasion. Mr. J. C. Fell, replying for the honorary members in the absence of Mr. J. Macfarlane Gray, alluded to the great value of the society in promoting fellowship among its members, he congratulated them on their flourishing condition, and the thorough way in which they conducted their visits to engineering works and factories, and on the great increase of their numbers. Mr. A. J. Walter, in proposing the toast of the Junior Engineering Society, endorsed the great importance of the facilities which such a body offers for mutual intercourse and friendship, and the value of such *camaraderie* to those who were making a start in their profession, and the excellent opportunity afforded by their meetings for practice in public speaking and discussion.

**The Variations of the E.M.F. of Primary Cells.**—At a recent meeting of the Royal Society, a Paper by Messrs. G. J. Burch and V. H. Veley was read on "The Variations of Electromotive Force of Cells consisting of certain Metals, Platinum, and Nitric Acid." The following conclusions were drawn from the results of the experiments:—(1.) When the metals, copper, silver, bismuth, and mercury, are introduced into purified nitric acid of different degrees of concentration, and a couple made of platinum, the electromotive force of such a cell increases considerably from an initial value until it reaches a constant and—in most cases—a maximum value. The rise of electromotive force is attributed to the production of nitrous acid by the decomposition of the nitric acid, and the final value is considered to be due to the former acid only, while the initial value is due for the most part to the latter acid, though it is affected to a remarkable degree by the amount of impurity of nitrous acid, either initially present or produced by minute and unavoidable uncleanliness of the metallic strip and the containing vessel. (2.) If nitrous acid has been previously added to the nitric acid, then the maximum electromotive force is reached at once. (3.) If the conditions—namely, increase of temperature, of impurity, and of concentration of acid—are such as would favour a more rapid solution of the metal, and consequently a more rapid production of nitrous acid, then the rise of electromotive force is concomitantly more rapid. (4.) Conversely, if the conditions are unfavourable to the production of nitrous acid, the rise of electromotive force is less rapid. (5.) If any substance, such as urea, be added, which would tend to destroy the nitrous acid as fast as it may be formed, then the rise of electromotive force is extremely slow, being dependent upon the number of molecular impacts of the nitrous acid upon the surface of the metal.

**Metallo Chromes.**—The production of Nobili's rings, says Mr. George Hopkins in the *Scientific American*, is a very simple and pleasing electro-chemical experiment which may be readily tried by any one having one or two batteries or a small dynamo. To produce the rings, all that is required is a Bunsen or Grenet battery in good order, a strong solution of acetate of lead (sugar of lead), and a steel or nickel-plated brass plate. The lead solution is placed in a saucer, the steel or nickelled plate is placed at the bottom and connected by a wire with the zinc pole of the battery, and the end of the wire, which is connected with the carbon pole of the battery, is held near the steel plate without touching it. In a very short time a spot of colour will appear on the plate, and in a minute or so the spot will spread rapidly and form concentric rings of prismatic colours. A few trials will enable the operator to determine the time required for the production of the best effects. When the operation has proceeded far enough, the plate is removed from the solution, washed in clean water and dried. The beautiful colour effect is due to the decomposition of the light, by the exceedingly thin film of peroxide of lead deposited on the surface of the plate. It is quite permanent, and serves to protect the surface of the plate from oxidation. To secure the best results, the plate should be highly polished and the lead solution should be filtered. Since the discovery of this effect in 1826 by Nobili many modifications of the process have been devised, and some commercial applications have been made. It has been used to some extent in the ornamentation of small objects, such as buttons, articles of jewellery, &c., imparting to them an iridescence which cannot be imitated by any artificial colouring. Becquerel suggested a solution for this purpose, the formula of which is as follows: "Dissolve 200 grammes of caustic potash in 2 quarts of distilled water, add 150 grammes of litharge, boil the mixture for a half hour, and allow it to settle. Then pour off the clear liquor and dilute with its own bulk of water." This solution is adapted to other metals than those above mentioned, but the acetate of lead solution yields very satisfactory results and is sufficient for experimental demonstration.

Digitized by Google

## ELECTRO-MAGNETIC THEORY.--III.

BY OLIVER HEAVISIDE.

*(Continued from page 331.)*

§ 14. It will have been observed that I have said next to nothing upon the study of pure mathematics; this is a matter with which we are not concerned. But that I have somewhat dilated (and I do not think needlessly) upon the advantages attending the use of mathematical methods by the materialist to assist him in his study of the laws governing the material universe, by the proper co-ordination of known and the discovery of unknown (but not unknowable) phenomena.

It was discovered by mathematical reasoning that when an electric current is started in a wire, it begins entirely upon its skin, in fact upon the outside of its skin; and that, in consequence, sufficiently rapidly impressed fluctuations of the current keep to the skin of the wire, and do not sensibly penetrate to its interior.

Now very few (if any) unmathematical electricians can understand this fact; many of them neither understand it nor believe it. Even many who do believe it do so, I believe, simply because they are told so, and not because they can in the least feel positive about its truth of their own knowledge. As an eminent practician remarked, after prolonged scepticism, "When Sir W. Thomson says so, who can doubt it?" What a world of worldly wisdom lay in that remark!

Now I *do* admire this characteristically stubborn English way of being determined not to be imposed upon by any absurd theory that goes against all one's most cherished convictions, and which cannot be properly understood without mathematics. For without the mathematics, and with only the sure knowledge of Ohm's law and the old-fashioned notions concerning the function of a conducting wire to guide one, no one would think of such a theory. It is quite preposterous from this point of view. Nevertheless, it is true; and the view was not put forward as a hypothesis, but as a plain matter of fact.

The case in question is one in which we can be very sure of all the fundamental data of any importance, and the laws concerned. We can, for instance, by straightforward experiment, especially with properly constructed induction balances admitting of exact interpretation of results, readily satisfy ourselves that a high degree of accuracy must obtain not merely for Ohm's law, but also for Faraday's law of E.M.F. in circuits, and even in iron for Poisson's law of induced magnetisation, within certain limits. We have, therefore, all the conditions wanting for the successful application of mathematical reasoning of a precise character, and justification for the confidence that mathematicians can feel in the results theoretically deduced in a legitimate manner, however difficult it may be to give an easily intelligible account of their meaning to the unmathematical.

This, however, I will say for the sceptic who has the courage of his convictions, and writes openly against what is, to him, pure nonsense. He is doing, in his way, good service in the cause of truth and the advancement of scientific knowledge, by stimulating interest in the subject and causing people to inquire and read and think about these things, and form their own judgment if possible, and modify their old views if they should be found wanting. Nothing is more useful than open and free criticism, and the truly earnest and disinterested student of science always welcomes it.

§ 15. The following may assist the unmathematical reader to an understanding of the subject. It is not demonstrative, of course, but is merely descriptive. If, however, it be translated into mathematical language and properly worked out, it will be found to be demonstrative, and to lead to a complete theory of the functions of wires in general.

Start with a very long solenoid of fine wire in circuit with a source of electrical energy. Let the material inside the solenoid be merely air, that is to say, ether and air. If we examine the nature of the fluctuations of current in the coil in relation to the fluctuations of impressed force on it, we find that the current in the coil behaves as if it were a material fluid possessing inertia and moving against resistance. The fanatics of Ohm's law do not usually take into account the inertia. It is as if the current in the coil could not move without simultaneously setting into rotation a rigid material core filling the solenoid, and free to rotate on its axis.

If we take the air out of the solenoid and substitute any other non-conducting material for a core the same thing happens; only the inertia varies with the material, according to its magnetic inductivity.

But if we use a conducting core we get new phenomena, for we find that there is no longer a definite resistance and a definite inertia. There is now frictional resistance in the core, and this increases the effective resistance of the coil. At the same time the inertia is reduced.

On examining the theory of the matter (on the basis of Ohm's law and Faraday's law applied to the conducting core) we find that we can now account for things (in our analogy) by supposing that the rigid solid core first used is replaced by a viscous fluid core, like treacle. On starting a current in the coil it cannot now turn the core round bodily at once, but only its external portion. In time, however, if the source of current be steadily operating, the motion will penetrate throughout the viscous core, which will finally move as the former rigid core did. If, however, the current in the coil fluctuate in strength very rapidly, the corresponding fluctuations of motion in the core will be practically confined to its skin. The effective inertia is reduced because the core does not move as a rigid body; the effective resistance is increased by the viscosity generating heat.

Now, returning to the solenoid, we have perfect symmetry with respect to its axis, since the core is supposed to be exceedingly long, and uniformly lapped with wire. The situation of the source of energy, as regards the core itself, is plainly on its boundary, where the coil is placed; and it is therefore a matter of common-sense that in the communication of energy to the core either when the current is steady or when it varies, the transfer of energy takes place transversely, that is, from the boundary to the axis, in planes perpendicular to the axis, and therefore perpendicular to the current in the core itself. This is confirmed by the electro-magnetic equations.

But the electro-magnetic equations go further than this, and assert that the transference of energy in any isotropic electrical conductor always takes place across the lines of conduction current, and not merely in the case of a core uniformly lapped with wire, where it is nearly self-evident that it must be so. This is a very important result, being the post-finger pointing to a clear understanding of electro-magnetism. Passing to the case of a very long straight round wire supporting an electric current, we are bound to conclude that the transference of energy takes place transversely, not longitudinally: that is, across the wire instead of along it. The source of energy must, therefore, first supply the dielectric surrounding the wire before the substance of the wire itself can be influenced; that is, the dielectric must be the real primary agent in the electromagnetic phenomena connected with the electric current in the wire.

Beyond this transverse transference of energy, there does not, however, at first sight, appear to be much analogy between the case of the solenoid with a core and the straight wire in a dielectric. The source of energy in one case is virtually brought right up to the surface of the core in a uniform manner. But in the other case the source of energy—the battery, for instance—may be miles away at one end of the wire, and there is no immediately obvious uniform application of the source to the skin of the wire. But observe that in the former case the magnetic force is axial, and the electric current circular, whilst in the latter case the electric current (in the straight wire) is axial and the magnetic force circular. Now an examination of the electro-magnetic equations shows that the conditions of propagation of axial magnetic force and circular current are the same as those for axial current and circular magnetic force. We therefore further conclude that (with the exchanges made) the phenomena concerned in the core of the solenoid and in the long straight wire are of the same character.

Furthermore, if we go into detail, and consider the influence of the surroundings of the wire (which go to determine the value of the inductance of the circuit) we shall find that not only is the character of the phenomena the same, but that they

Digitized by Google

may be made similar in detail (so as to be represented by similar curves, for example).

The source of energy, therefore, is virtually transferred instantly from its real place to the whole skin of the wire over which it is uniformly spread, just as in the case of the conducting core within a solenoid.

§ 16. So far we can go by Ohm's law and Faraday's law of E.M.F., and, if need be, Poisson's law of induced magnetisation (or its modern equivalent practically). But it is quite impossible to stop here. Even if we had no knowledge of electrostatics and of the properties of condensers, we should, by the above course of inquiry be irresistibly led to a theory of transmission of electrical disturbances through a medium surrounding the wire, instead of through the wire. Maxwell's theory of dielectric displacement furnishes what is wanted to explain results which are in some respects rather unintelligible when deduced in the above manner without reference to electrostatic phenomena.

We learn from it that the battery or other source of energy acts upon the dielectric primarily, producing electric displacement and magnetic induction; that disturbances are propagated through the dielectric at the speed of light; that the manner of propagation is similar to that of displacements and motions in an incompressible elastic solid; that electrical conductors act, as regards the internal propagation, not as conductors but rather as obstructors, though they act as conductors in another sense, by guiding the electro-magnetic waves along definite paths in space, instead of allowing them to be immediately spread away to nothing by spherical enlargement at the speed of light; that when we deal with steady states, or only slowly varying states, involving immensely great wave length in the dielectric, the resulting magnetic phenomena are just such as would arise were the speed of propagation infinitely great instead of being finite; that if we make our oscillations faster, we shall begin to get signs of propagation in the manner of waves along wires, with, however, great distortion and attenuation by the resistance of the wires; that if we make them much faster we shall obtain a comparatively undistorted transmission of waves (as in long-distance telephony over copper wires of low resistance); and that if we make our oscillations very fast indeed, we shall have practically mere skin conduction of the waves along the wires at the speed of light, as in some of Lodge's lightning-conductor experiments, and more perfectly with Hertzian waves).

Now all these things have been worked out theoretically, and, as is now well known, most of them have been proved experimentally; and yet I hear someone say that Hertz's experiments don't prove anything in particular!

Lastly, from millions of vibrations per second, proceed to billions, and we come to light (and heat) radiation, which are, in Maxwell's theory, identified with electromagnetic disturbances. The great gap between Hertzian waves and waves of light has not yet been bridged, but I do not doubt that it will be done by the discovery of improved methods of generating and observing very short waves.

## INSTITUTION OF ELECTRICAL ENGINEERS.

PRESIDENTIAL ADDRESS OF PROF. WILLIAM CROOKES, F.R.S.

### Electricity in Transitu: from Plenum to Vacuum.

(*Concluded from p. 360.*)

*The Resistance of High Vacua.*

I must only lightly touch this phenomenon to-night; it is a subject of deep interest, and one to which I have lately devoted much time. Shortly I hope to publish a full account of results recently obtained.

The passage of an induction current at a high vacuum through a tube depends much upon the material of the tube or the substance enclosed within it. Given the same degree of exhaustion, and the same distance between the terminals inside the tube, the E.M.F. necessary to force the current through may vary from 3,000 volts to 20,000 volts, according to the particular material used.

Here is a very striking example that will serve to illustrate this phenomenon. Fig. 27 is a double tube joined by a narrow open channel and therefore in the same state of exhaustion throughout (P = 0·02 mm. or 26 M). Each tube is furnished with a pair of poles, A, B, and A′, B′. One tube contains the phosphorescent earth yttria, the other contains finely divided carbon. I first connect the yttria tube, C, to the coil, and place in parallel circuit with it a spark gauge. To begin with, this gauge is set to a gap of 1 mm. (An E.M.F. of 920 volts is necessary to strike across 1 mm. of air; therefore the difference of potential at the terminals inside the yttria tube is 920 volts, and this you perceive is not sufficient to force the current through the tube.) I now gradually open the gauge until the potential of the inner terminals has risen to a point high enough to allow the spark to pass through the tube, making the yttria phosphorescent.

The gap is at 7 mm. equal to an E.M.F. of 6,440 volts. I next attach the coil wires to the tube D containing the carbon, and the exhaustion in the tubes being the same as before, I repeat the experiment; you now see that the gap has to be opened to 30 mm., equivalent to an E.M.F. of 27,600 volts, before the current will pass through the tube. The fact of whether the vacuum tube contains yttria or carbon makes a difference of 21,160 volts in the E.M.F. required to cause a discharge between the terminals.

One other experiment I would like to show in further illustration of this resistance. The idea suggested itself that possibly differences in the material or conductivity of the particular bulbs might influence the results you have just seen.

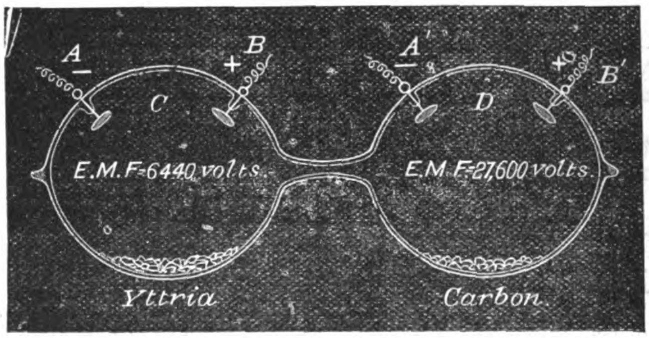



Fig. 27.—Pressure = ·02mm = ·25 M.

Here (Fig. 28) is a long cylindrical tube of phosphorescent Bohemian glass containing a pair of terminals, A, B; it also contains a shorter cylinder of glass, C, C, brightly silvered inside. The internal pressure is 0·00068 mm., or 0·9 M. The silver cylinder is now at one end of the tube out of the way of the terminals, which, therefore, have phosphorescent glass around them. I turn on the coil and find that the E.M.F. necessary to force the current through, now that the terminals are in a phosphorescent chamber, is 1,380 volts. I slide the cylinder down to the end of the tube so as to enclose the terminals in a metallic silver chamber, and you see the E.M.F. necessary to pass the current rises to 6,440 volts. Metallic silver does not phosphoresce, whilst Bohemian glass phosphoresces very well. It appears that the greater the phosphorescing power of the substance surrounding the poles so much the easier does the induction spark pass. Surround the poles with Bohemian glass or yttria—two phosphorescent non-conductors of electricity—and the induction spark passes easily; immediately I surround the terminals with a non-phosphorescent conductor the current refuses to pass.

*What Occasions Phosphorescence?*

I should like to interest you in a question that has exercised my mind for some time past. What is it that occasions the phosphorescence of yttria and other bodies *in vacuo* under molecular bombardment?

So far I have found this phosphorescence to be an attribute of non-conductors only. We know that in the act of phosphoresence the molecules of yttria are in a state of intense vibration. Each molecule may be viewed as the radiating

Digitized by Google

centre of the entire bundle of rays, which, when decomposed by the prism, displays a discontinuous spectrum. We may also suppose that the residual atoms of gas charged with negative electricity give off their electricity on coming in collision with a phosphorescent body and on their return take up a fresh charge.

*The Electrolysis Hypothesis.*

There is a certain amount of evidence in favour of an electrolytic hypothesis of the passage of electricity through rarefied gases. This has been ably advocated by Prof. Schuster in the Bakerian Lecture before the Royal Society, March 20, 1890.*

A molecule of hydrogen gas, for instance, may be made up of one group of atoms of hydrogen having an equivalent of negative electricity inherent in it, and one group of atoms having an equivalent of positive electricity bound up with it. These atoms are also charged with *additional* equivalents of positive or negative electricity, which they carry about as a ship carries its cargo. We are not concerned with the inherent electricity—of which we are ignorant—but with the extra or "cargo" charge. Let us imagine a molecule of hydrogen near the face of the negative pole in a vacuum tube. I turn on the current, and the atoms of the hydrogen molecule are dragged apart. The positive atom is attracted to the negative pole, where the violence of impact, or the discharge of electricity, renders it apparent with evolution of light. The internal luminous layer, which is closely adjacent to the negative electrode, is due, therefore, to the positive atoms rushing to the negative pole, and not like the glow round the edge of the dark space, to the negative atoms projected from it. The negative atom, on the other hand, is driven violently from the negative pole, in virtue of the mutual repulsion existing between any two bodies similarly electrified, with a velocity varying with the intensity of the electrification and the degree of the vacuum; the more perfect the vacuum the greater the velocity, the atoms flying outwards in straight lines until they meet with an obstacle. Such an obstacle may be a procession of positively charged atoms from the positive pole; in this case the two kinds of atoms mutually discharge each other's cargoes with a display of light. This phenomenon occurs at the margin of the dark space when the vacuum is only moderate. Or the obstacle may be produced by the vacuum being so high that the atoms of gas present are too few to form a continuous procession. (*Why* a high vacuum should be non-conductive does not clearly appear, but the fact itself is beyond doubt; it is probably connected with the inability of electrified atoms to leave the poles.) Or again, the obstacle may be a phosphorescent body like yttria. In this case the negatively charged atoms deliver up their charge of electricity to the yttria, which is so constituted—perhaps after the manner of a Hertz resonator—that its atoms charge and discharge, vibrating about 550 billion times in a second, and producing waves in the ether of the length, approximately, of 5·74 ten-millionths of a millimetre, and occasioning in the eye the effect of citron light.

We are not under the necessity of supposing that this number of hydrogen atoms are driven against the yttria in the second, although even at a high vacuum there are quite enough atoms left in the bulb to keep up such a supply. All that is needed is that a succession of shocks, not necessarily rhythmical, may strike the yttria at frequencies which will set up such a number of vibrations, just as a series of slow impacts on a gong causes it to emit sound waves of much greater frequency.

In a low vacuum only very few atoms can run the gauntlet among the crowd of inrushing atoms, and those few which succeed in reaching the yttria arrive with much reduced velocity, and so faint is the phosphorescence they set up that it is completely obscured* by the brighter phosphorescence of the residual gas. As the vacuum becomes higher, more and more atoms find their way across, and their speed being at the same time accelerated, the phosphorescence becomes intensified.

At a good vacuum most of the atoms hit the yttria, their velocity is increased, and the rhythmical excitation reaches its maximum.

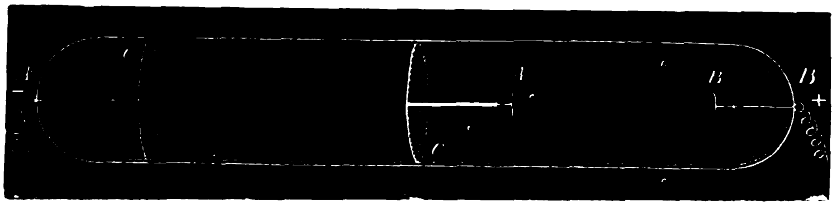


Fig. 28.—Pressure ·00068mm. = ·9 M.
Silvered Cylinders away from Poles. E.M.F. = 1380 volts.
Silvered Cylinders round Poles. E.M.F. = 6440 volts.

*The Dark Space in Mercury Vapour.*

In applying the electrolytic hypothesis, I have used for illustration's sake the gaseous residue of hydrogen, which is known as a diatomic gas. I have found, however, the phenomena of the dark space, &c., to occur in the vapour of mercury, which is a monatomic gas. This important result induced me to patiently investigate this subject, and the result of one experiment is before you (Fig. 29). The tube is furnished with aluminium terminals, and is so arranged that the induction spark can be kept passing during exhaustion to drive off occluded gases. When at the highest attainable vacuum, the tube is filled with pure mercury by simply raising a reservoir. On applying heat the entire contents of the tube are boiled away and pass down the fall tubes of the pump, exhaustion going on at the same time. When the whole of the mercury has thus been boiled away *in vacuo*, except a little condensed at the upper part of the tube, the results on passing the spark are as follows:—When the tube is cold the induction current refuses to pass; on gently

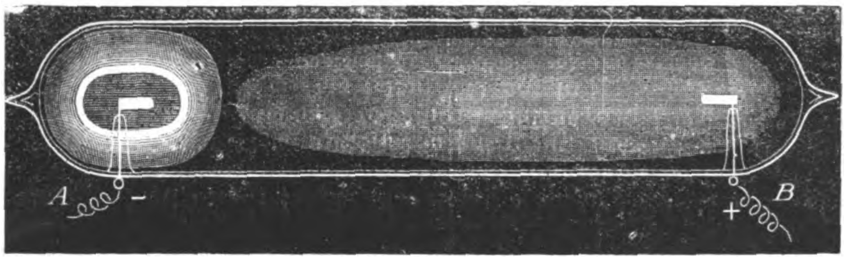



Fig. 29.

* *Roy. Soc. Proc.*, xlvii., 526.

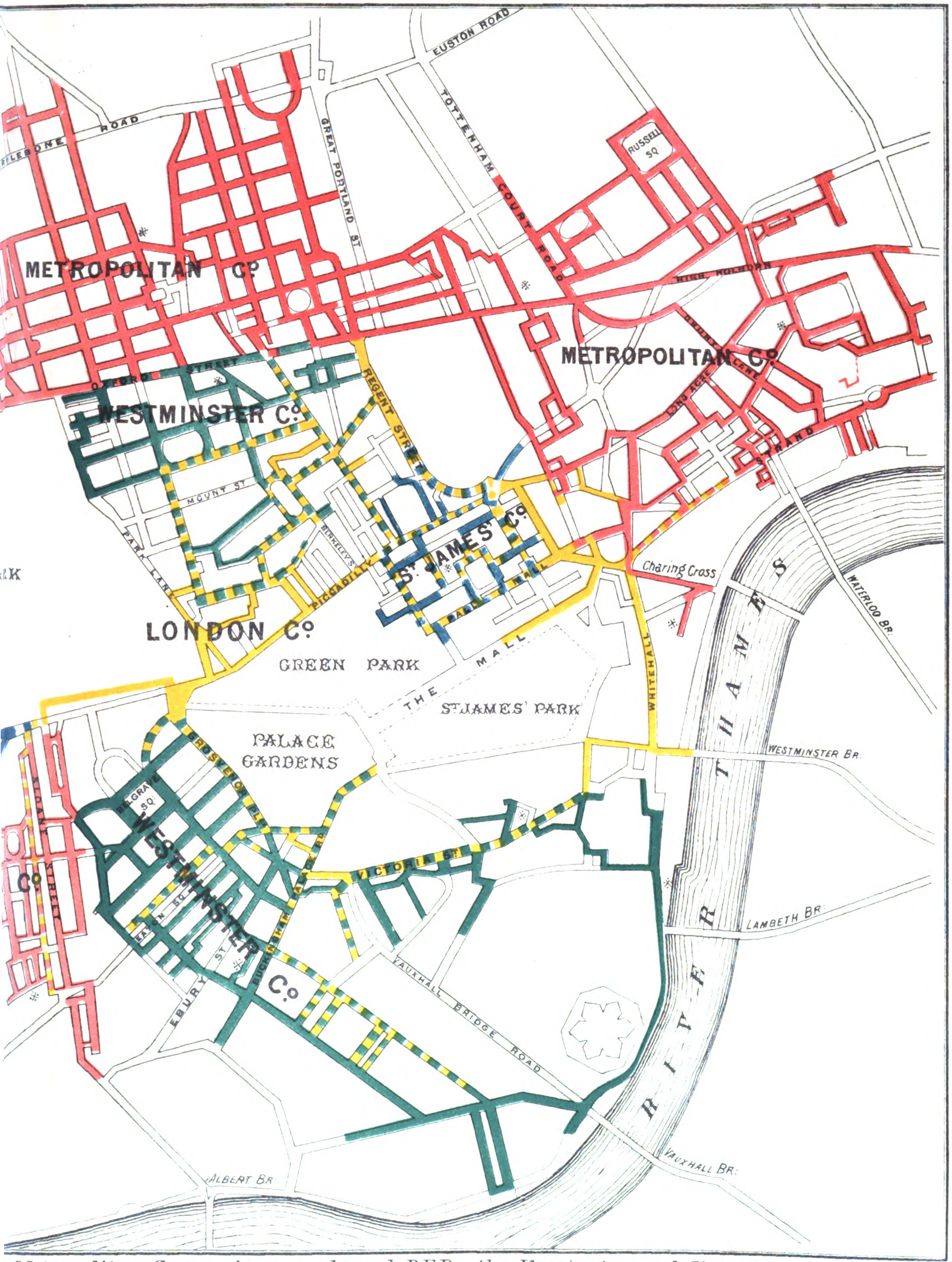
* This faint phosphorescence at a low vacuum can be rendered visible by the electrical phosphoroscope described in my lecture at the Royal Institution in 1887.

Digitized by Google

Digitized by Google

*NOTE.—To avoid a confusing number of colours, the Notting Hill, the Chelsea, and the the St. James's Companies are coloured BLUE; the House to House and the West is coloured YELLOW. Where the latter Company works in competition wit*

Digitized by Google




*Metropolitan Companies are coloured RED; the Kensington and Knightsbridge and*
*tminster Companies are coloured GREEN; and the London Electric Supply Company*
***h other Companies, the colours of the competing Companies are shown DOTTED.***

Digitized by Google

Digitized by Google

heating with a gas-burner the current passes and the dark space is distinctly visible. Continuing the heat so as to volatilise the drops of mercury condensed on the sides, the whole tube becomes filled with a green phosphorescent light, the dark space gets smaller and smaller, and ultimately the negative pole becomes covered with a luminous glow. On allowing the tube to cool the same phenomena ensue in inverse order. The luminous halo expands, showing the dark space between it and the pole, and this dark space gradually grows larger as the tube becomes cooler. The mercury again condenses on the side of the tube, the green phosphorescence grows paler and paler, until at last the induction spark from the large coil refuses to pass.

therefore say that the atoms in a molecule of free hydrogen act in chemistry as two separate groups, each of a minimum relative weight of I, whilst those in a molecule of free mercury act as one undivided group of the relative weight 200. But to what number of atoms the I and 200 correspond respectively no chemist knows.

To show how intimately chemistry and electricity interlock, I may here remark that one of the latest theories in chemistry renders such a division of the molecule into groups of electro-positive and electro-negative atoms necessary for a consistent explanation of the genesis of the elements. This is so important that I may be excused for digressing a little into this development of theoretical chemistry.

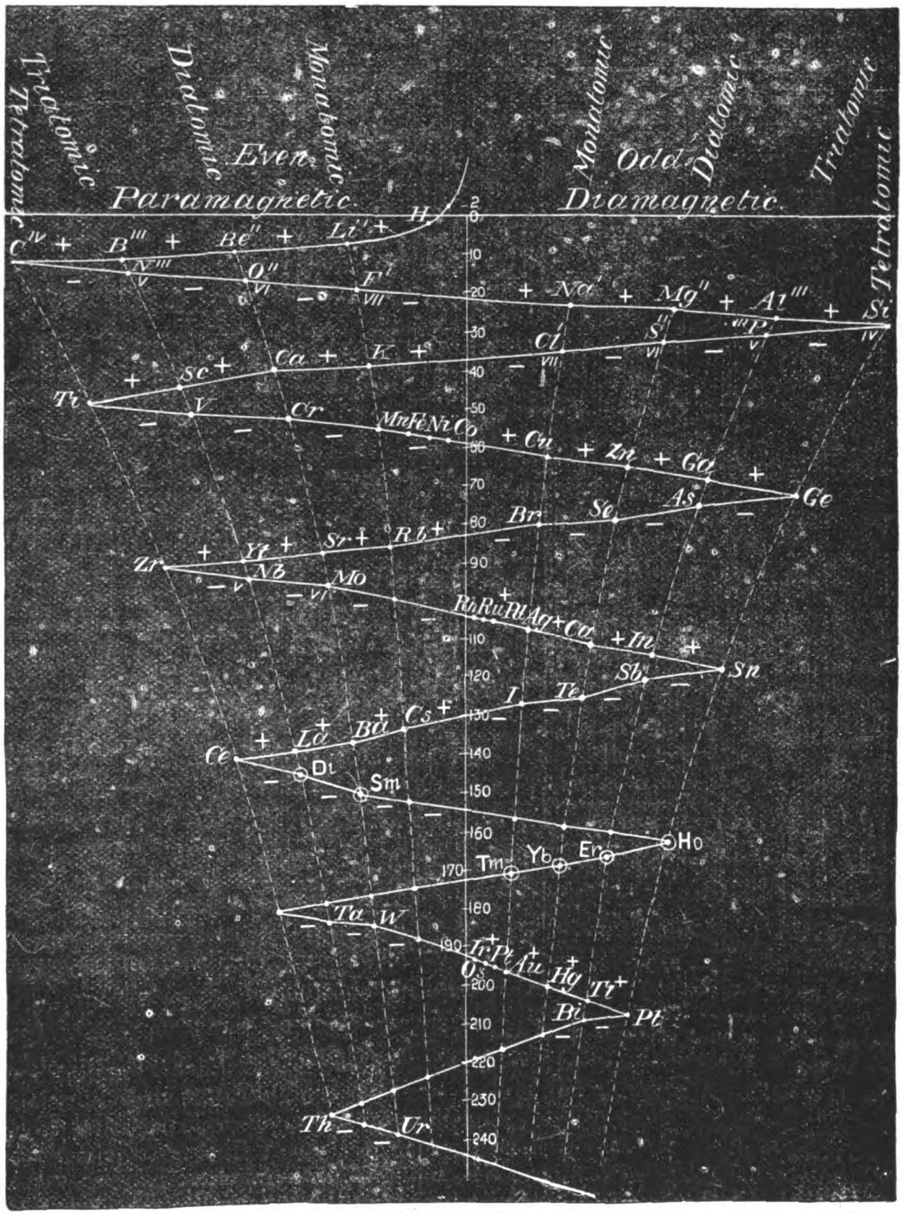



FIG. 30.—Mendeljeef's diagram of the periodic law of elements.

At first sight this result appears fatal to the electrolytic hypothesis, for if the molecule of mercury contains only one atom, how can we talk of its separation into positive and negative atoms by the electric stress? It must be remembered, however, that we are as yet ignorant of the absolute mass of the atom of any element. All that can be said is that a molecule of free hydrogen becomes halved in combining chemically with certain other elements, whilst a molecule of free mercury does not suffer division on yielding any known compound of mercury; the physical atoms in the one behave as two separate groups, and those in the other as one undivided group. It has been agreed by chemists, for simplicity's sake and for facilitating chemical calculations, to reduce the units to the lowest term, consistent with the avoidance of fractions; we

*Genesis of the Elements.*

It is now generally acknowledged that there are several ranks in the elemental hierarchy, and that besides the well-defined groups of chemical elements, there are underlying sub-groups. To these sub-groups has been given the name of meta-elements. The original genesis of atoms assumes the action of two forms of energy working in time and space —one operating uniformly in accordance with a continuous fall of temperature, and the other having periodic cycles of ebb and swell, and intimately connected with the energy of electricity (Fig. 30). The centre of this creative force in its journey through space scattered seeds or sub-atoms that ultimately coalesced into the groupings known as chemical elements. The law which governs the motions of multitudes of men and

Digitized by Google

women in a busy thoroughfare I have applied to the atoms of gas in a vacuum tube. At this genetic stage the new-born particles vibrating in all directions and with all velocities, the faster-moving ones would still overtake the laggards, the slower would obstruct the quicker, and we should have groups formed in different parts of space. The constituents of each group, whose form of energy governing atomic weight was not in accord with the mean rate of the bulk of the components of that group, would work to the outside and be thrown off to find other groups with which they were more in harmony. In time a condition of stability would be established, and we should have our present series of chemical elements, each with a definite atomic weight—definite on account of its being the average weight of an enormous number of sub-atoms or meta-elements, each very near to the mean. The atomic weight of mercury, for instance, is called 200, but the atom of mercury, as we know it, is assumed to be made up of an enormous number of sub atoms, each of which may vary slightly round the mean number 200 as a centre.

We are sometimes asked why, if the elements have been evolved, we never see one of them transformed, or in process of transformation, into another? The question is as futile as the cavil that in the organic world we never see a horse metamorphosed into a cow. Before copper, *e g.*, can be transmuted into gold it would have to be carried back to a simpler and more primitive state of matter, and then, so to speak, shunted on the track which leads to gold.

This atomic scheme postulates a to and fro motion of a form of energy governing the electrical state of the atom. It is found that those elements generated as they approach the central position are electro-positive, and those on the retreat from this position are electro negative. Moreover the degree of positiveness or negativeness depends on the distance of the element from the central line: hence calling the atom in the mean position electrically neutral, those sub-atoms which are on one side of the mean will be charged with positive electricity, and those on the other side of the mean position will be charged with negative electricity, the whole atom being neutral.

This is not a mere hypothesis, but may take the rank of a theory. It has been experimentally verified as far as possible with so baffling an enigma. Long-continued research in the laboratory has shown that in matter which has responded to every test of an element, there are minute shades of difference which have admitted of selection and resolution into meta-elements, having exactly the properties required by theory. The earth yttria, which has been of such value in these electrical researches as a test of negatively excited atoms, is of no less interest in chemistry, having been the first body in which the existence of this sub-group of meta-elements was demonstrated.

*Conclusion.*

I frankly admit I have by no means exhausted the subject which daily and nightly fills my thoughts. I have ardently sought for facts on which to base my theory. I have struggled with problems which must be conquered before we can arrive at exact conclusions—conclusions which, so far as inorganic nature is concerned, can only be reached by the harmonious interfusion—not confusion—of our present twin sciences, electricity and chemistry. Of this interfusion I have just endeavoured to give you a foretaste. In elaborating the higher physics, the study of electrical phenomena must take a large, perhaps the largest, share. We have invaded regions once unknown, but a formidable amount of hard work remains to be completed. As we proceed we may look to electricity not only to aid, as it already does, our sense of hearing, but to sharpen and develop other powers of perception. Science has emerged from its childish days. It has shed many delusions and impostures. It has discarded magic, alchemy, and astrology. And certain pseudo-applications of electricity, with which the present institution is little concerned, in their turn will pass into oblivion. There is no occasion to be disheartened at the apparent slow pace of elemental discovery. The desponding declare that if Roger Bacon could re-visit "the glimpses of the moon" he would shake his head to think we have got no further, that we are still in a haze as to the evolution of atoms. As for myself I hold the firm conviction that unflagging research will be rewarded by an insight into natural mysteries such as now can scarcely be conceived. Difficulties, said a keen old statesman, are things to be overcome, and to my thinking science should disdain the notion of finality. There is no stopping half-way, and we are resistlessly driven to ceaseless inquiry by the spirit "that impels all thinking things, all objects of all thought, and rolls through all things."

## OVERHEAD WIRES IN LONDON.

As considerable misapprehension existed last year as to what was and what was not contemplated by the London County Council in their Bill of that date dealing with overhead wires in the metropolis, we print this week some of the more important clauses of "The London Overhead Wires Act, 1891." The Bill is an eminently reasonable one; interference with property rights is carefully guarded against, and the intrusion of the "uniformed inspector" is made as gentle an attack upon the Englishman's castle as can well be if overhead wires are to be submitted to any supervision at all.

Clauses 1 and 2 relate to the title of the Bill and to definitions of expressions used therein.

**Removal of wires into subway.**

3. Where the Council have a subway in any street it shall be lawful for the Council at any time to require the Company by notice in writing to remove into such subway any then existing wire of the Company over the street which can conveniently be placed in such subway. If any question shall arise between the Council and the Company as to whether such subway is, in fact, convenient for the reception of such wire, or whether, having regard to the purposes for which such wire is used, it can, under the circumstances, be conveniently placed in such subway, the matter shall be settled by an arbitrator.

**Charge for use of subway.**

4. It shall be lawful for the Council to make on the Company using any subway of the Council a charge by way of rent for such use and contribution towards the costs of maintenance and supervision according to a scale to be determined by such bye-laws as hereafter provided.

**Maintenance of wires in subway.**

5. Every wire placed in a subway shall be maintained and kept in proper condition and repair by and at the expense of the Company to whom it *belongs*, under the direction and supervision of the officer to be appointed for that purpose by the Council. If the Company fail at any time to keep any such wire in proper condition and repair, it shall be lawful for the Council to place the same in proper condition and repair and to execute any works which may be necessary for that purpose, and the amount of any costs and expenses to which the Council may be put in connection with any such work shall be repaid on demand to the Council by the Company to whom the wires belongs, and in default of such payment may be recovered by the Council in a summary way. Every subway shall be maintained and kept in proper condition and repair by the Council, with efficient means of ventilation, and free from water and other obstructions in the way of the Company.

**New overhead wires not to be placed except in accordance with bye-laws.**

6. From and after the passing of this Act the Company shall, within one month after they shall have placed any wire overhead, give notice in writing to the Council and the Local Authority, specifying the locality and position in which the wire has been placed; and after bye-laws in relation to wires shall have been made under powers of this Act it shall not be lawful to place any wire overhead otherwise than subject to and in accordance with such bye-laws.

Clause 7 deals with the question of connections of wires in subways with other wires outside.

**Charges for Supervision of Wires.**

8. The Local Authority may charge every Company and person owning any wire placed or retained overhead after the passing of this Act such reasonable fees in respect of the identification and such reasonable annual charges in respect of supervision of wires as shall be fixed by the bye-laws hereinafter provided.

**Rights over private property not to be acquired except by agreement.**

9. The Company shall not otherwise than by agreement with the owner of and persons interested therein by carrying a wire over any land or building, or supporting such wire thereon or attaching the same thereto, acquire any right which shall in any way interfere with any right of such owner or other person, and if at any time by reason of any alteration, rebuilding, or otherwise, it becomes necessary for any such owner or person to require the Company to alter or remove any such wire the Company shall alter or remove the same accordingly on being required so to do by notice in writing by such owner or person. And in the event of the Company

Digitized by Google

refusing or neglecting for the space of one month after such requisition to alter or remove the same, it shall be lawful for any inspector, officer, or workman duly appointed by the Council to remove or alter the same, and to enter upon the land or building for that purpose, and the costs and expenses of and incidental to such removal shall be repaid by the Company to the Council on demand, and in default of payment may be recovered in a summary way. As regards the City of London this section shall be read and have effect as if the Commissioners of Sewers were named therein instead of the Council.

Clause 10 details the matters on which bye-laws may be made, such as the identification of overhead wires; the regulation of wires; the strength of the materials to be employed in placing, maintaining, and supporting wires; the removal of wires erected or placed otherwise than in accordance with such bye-laws and of disused wires; the determination of a scale of fees and charges to be paid by way of rent for the use of any subway, and in respect of the identification and supervision of wires, and the terms and conditions to which the Company and persons employed by them and using the subways shall be subject.

No bye-law is to have any effect until approved by the Board of Trade, who may also exempt any then existing wire from the operation of any bye-law for such period as they think proper not exceeding five years from the confirmation thereof.

**Enforcement of bye-laws by Local Authority.** 11. Bye-laws under this Act shall, subject to the provisions of this Act be enforced and administered by the Local Authority except in so far as they shall relate to any subway of the Council, in which case they shall be enforced and administered by the Council.

Clause 12 provides for uniformity in enforcement of bye-laws.

**Inspectors of overhead wires.** 13—1. It shall be lawful for the Council or the Local Authority, as the case may be, to appoint and employ an inspector or inspectors of wires and such other officers and workmen as they may find requisite for the purposes of this Act.

2. *Any such inspector being in uniform, and duly authorised in writing by the Council or Local Authority in that behalf, may, after notice previously given, enter at a reasonable time to be named by the occupier, or if there be no occupier by the owner, on any lands, houses, and premises for the purpose of inspecting any wire supported thereon or attached thereto, or of removing or altering such wire under the powers of this Act; and if the occupier fails to name a time for such entry within four days after request, nor in any case of emergency, such inspector may enter without further notice.*

**Removal of existing overhead wires.** 14. If at any time, on the report of any of their inspectors, it shall appear to the Local Authority that any wire is in such a condition that danger to the public using the streets may be apprehended, the Local Authority may serve notice in writing on the Company, requiring them to remove, renew, or alter the same, and to place such wire in such position as the Local Authority may reasonably determine; and in the event of such requisition not being complied with within such time as shall be therein specified, it shall be lawful for the Local Authority to apply to a Court of Summary Jurisdiction to issue a summons calling on the Company to show cause why the wire should not be dealt with in accordance with such requisition, and such Court may make an order authorising the Local Authority or any of their inspectors or officers, to remove or alter any such wire, and to charge the expenses of such removal or alteration on the Company, to whom the wire belongs, as may be prescribed in such order. And such expenses may be recovered under the provisions of the Summary Jurisdiction Acts. Provided that the Local Authority may at any time, after bye-laws shall have been made under the provisions of this Act, proceed under this section without any such notice or requisition in the case of any wire not being in accordance with such bye-laws, and at any time after such bye-laws are made it shall be lawful for the Council or Local Authority to remove any such wire if they are unable to ascertain the owner thereof.

Clauses 15 to 20 relate to liability for accidents, arbitration, recovery of penalties, &c., &c.

**Wires not to be inconsistent with regulations of Board of Trade.** 21. The Company shall not under the powers of this Act or any bye-law made under this Act be required to place any wire in any manner which shall be inconsistent with any regulation or condition for securing the safety of the public or for the protection of the electric lines and works of the Postmaster-General made, prescribed or imposed by the Board of Trade under the "Electric Lighting Acts 1882 and 1888" or any Provisional Order made under those Acts and confirmed by Parliament.

**Electric currents not to be interfered with.** 22. The Council or Local Authority shall not under the powers of this Act require or permit the Company to place or use any wire in such position or manner as may have the effect of disturbing or interfering by induction or otherwise with the action of any electric currents from time to time used or intended to be used for the purpose of telegraphic, telephonic, or electric signalling communication. But the Council may alter or rearrange any pipes or wires in any subway in order to prevent any such disturbance or interference by induction or otherwise as aforesaid, and the cost of such alteration or rearrangement shall be defrayed or repaid to the Council by the Company the introduction of whose wires into such subway shall have led to the alteration or re-arrangement.

**As to authorised electric lighting undertakers and wires.** 23. Nothing in this Act or any bye-law or regulation made in pursuance thereof shall apply or extend to any Undertakers acting under Special Act Provisional Order or licence under "The Electric Lighting Acts 1882 and 1888," or to any wires of such Undertakers, except such bye-laws and regulations as are made in pursuance of this Act with respect to the position and manner in which wires shall be placed in subways; the manner in which any repairs to or alterations in any such wires may be made; the control and regulation of persons resorting to any subway, and all persons fixing or altering any wire therein; and then only if and when such Undertakers desire or are required to lay in any subway any wires under the terms of their Special Act or Provisional Order or licence under the provisions of "The Electric Lighting Acts, 1882 and 1888."

**Not to authorise placing unauthorised wires overhead or in subways.** 24. Nothing in this Act contained shall be deemed to authorise the Council to confer any powers of placing wires for electric lighting purposes overhead on any company, body, or person not authorised to place such wires by a Special Act Provisional Order or licence under the provisions of "The Electric Lighting Acts 1882 and 1888" or empower the Council to require or enable any company, body, or person owning or using overhead wires for electric lighting purposes to place such wires in any subway unless such company, body, or person is authorised to supply electricity by Special Act, Provisional Order, or licence under the provisions of "The Electric Lighting Acts, 1882 and 1888."

The remaining clauses of the Bill, five in number, relate to the exemption of Government and Crown property from powers as to overhead wires, and the saving rights of the Postmaster-General.

## MEETINGS OF SCIENTIFIC SOCIETIES, &c.

**FRIDAY, January 30th.**

INSTITUTION OF MECHANICAL ENGINEERS.

*7.30 p.m.* Annual General Meeting.

INSTITUTION OF CIVIL ENGINEERS.

*7.30 p.m.* Students' Meeting. Paper to be read: "The Counterbalancing of Locomotive Engines," by EDMUND L. HILL, S.I.C.E.

ELECTRO-HARMONIC SOCIETY.

*8 p.m.* Smoking Concert at St. James' Hall Restaurant.

ROYAL INSTITUTION.

*9 p.m.* Evening Discourse: "The Rejuvenescence of Crystals," by Prof. J. W. JUDD, F.R.S.

**MONDAY, February 2nd.**

ROYAL INSTITUTION.

*5 p.m.* General Monthly Meeting.

SOCIETY OF ENGINEERS.

*7.30 p.m.* Ordinary Meeting. Presentation of Premiums. Presidential Address.

SOCIETY OF ARTS.

*8 p.m.* Cantor Lecture II. 2. "The Construction and Capabilities of Musical Instruments," by A. J. HIPKINS F.S.A.

**TUESDAY, February 3rd.**

ROYAL INSTITUTION.

*3 p.m.* Afternoon Lecture: "The Structure and Functions of the Nervous System," by Prof. VICTOR HORSLEY, F.R.S.

INSTITUTION OF CIVIL ENGINEERS.

*8 p.m.* Ordinary Meeting. Paper to be read with a view to discussion: "Electric Mining Machinery," by LLEWELYN B., and CLAUDE W. ATKINSON, A.M.I.C.E.; also ballot for members, and—at 9 p.m.—Reception by the President and Council.

**WEDNESDAY. February 4th.**

SOCIETY OF ARTS.

*8 p.m.* Ordinary Meeting. "Decimal Coinage, Weights and Measures," by J. EMERSON DOWSON.

**THURSDAY, February 5th.**

INSTITUTION OF CIVIL ENGINEERS.

*2 p.m.* Students' Visit. The Refrigerating Machinery at the Victoria Dock.

**FRIDAY, February 6th.**

ROYAL INSTITUTION.

*9 p.m.* Evening Discourse. "Some Applications of Photography," by Lord RAYLEIGH, F.R.S.

*** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

Digitized by Google

# The Electrician.

**Published every Friday, Price Fourpence; Post Free, Fourpence Halfpenny**
**Editorial, Publishing, and Printing Offices:**
**SALISBURY COURT, FLEET ST., LONDON, E.C.**
*Telephone No. 2714. Telegrams:* "ELECTRICIAN NEWSPAPER, LONDON."

*All Letters relating to Subscriptions, Advertisements and other business matters should be addressed to the Publisher, "THE ELECTRICIAN," Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to "THE ELECTRICIAN" Printing and Publishing Company, Limited, and be crossed "Coutts and Co." All other letters to be addressed to the Editor.*

*All letters intended for insertion in "THE ELECTRICIAN," or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

*"THE ELECTRICIAN" is published every Friday morning, in time for the morning mails. Subscribers should receive their copies by the first post on Friday morning.*

*"THE ELECTRICIAN" is on sale at the railway bookstalls throughout the Kingdom on Friday morning, and can be obtained of all Booksellers and Newsvendors; or direct from the Publishing Offices as above.*

*New Volumes of "THE ELECTRICIAN" commence in May and November.*

## SUBSCRIPTION RATES.

The rates for Subscriptions to "THE ELECTRICIAN" are as follows:—

| | 3 months. s. d. | 6 months. s. d. | 12 months. s. d. |
|---|---|---|---|
| For the United Kingdom | 5 0 | 10 0 | 19 6 |
| For Foreign Parts and Colonies:— Within Postal Union | 6 6 | 12 6 | 24 0 |
| Aden Borneo, Ceylon, China, India, Japan, Java, Labuan, Mozambique, New Caledonia, Persia, Philippine Islands, Siam, Transvaal, and Zanzibar | 7 6 | 14 6 | 28 0 |



## TO ADVERTISERS.

*"THE ELECTRICIAN" offers exceptional advantages to Advertisers.* **It has by far the largest circulation of any English Electrical paper, and circulates all over the World.**

*Particulars relating to Advertisements will be promptly forwarded on application to the Offices as above.*

TRADE ADVERTISEMENTS *intended for the current issue must reach the Offices not later than First Post on Thursday morning. Renewals of expiring advertisement orders and alterations to standing advertisements should be in the Publisher's hands by Wednesday at latest. No alteration can be made in Wrapper advertisements after Wednesday evening.*

SMALL PREPAID ADVERTISEMENTS *(for Rates see page xvii.) are accepted up to 4 p.m. on Thursday.*

## TECHNICAL PRINTING.

"THE ELECTRICIAN" PRINTING AND PUBLISHING COMPANY (LIMITED) *inform Electricians, Electric Light Engineers, &c., that they make a specialty of Technical Printing, and have a large Staff thoroughly acquainted with Electro-Technology. They can, therefore, promise Accuracy and Despatch in the Printing of Electro-Technical Literature, &c.*

## "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. (Royal 8vo.)

*Early in each year is issued "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. The DIRECTORY was established in 1883, and the 1890 Edition consisted of about 850 pages of printed matter. The names and addresses of all persons engaged in the Electrical Industries at home and abroad may be relied upon as accurate. Useful Tables and Electrical Formulæ, and information specially compiled for this work are given, together with popularly-written Biographical Notices of the leading Electricians, Electrical Engineers, &c., accompanied in many cases by Portraits.*

*The 1891 Edition is now actively preparing, and Subscription and Advertisement Orders, New Names, Corrections, &c., can be received.*

## ELECTRICAL BOOKS AND PUBLICATIONS.

***All Books, Newspapers, and other publications, dealing with Electrical and kindred subjects, can be ordered direct of "THE ELECTRICIAN" Printing and Publishing Company, who are proprietors of the well-known "ELECTRICIAN" Series of Standard Electrical Works, and are agents for all the leading publishing houses at home and abroad.***


## CONTENTS OF THE CURRENT NUMBER.


NOTES ... 383
Electromagnetic Theory. III. By Oliver Heaviside. Continued ... 388
Institution of Electrical Engineers—
Presidential Address of Prof. William Crookes, F.R.S.—"Electricity in Transitu: from Plenum to Vacuum. Illustrated. Concluded ... 389
Overhead Wires in London ... 392
Meetings of Scientific Societies. 393
THE COUPLING OF ALTERNATORS ... 394
The Historical Development of the Induction Coil and Transformer. By Dr. J. A. Fleming, M.A. Illustrated ... 396
The Elmore Process ... 393
Electric Lighting at the General Post Office ... 398
"The Distribution of Electricity, with Especial Reference to the Chelsea System." By Major-General C. E. Webber. Illustrated ... 399
The Liverpool Electric Supply Stations. By A. Bromley Holmes, M.I.C.E. ... 401
The Electrical Trades' Section of the London Chamber of Commerce ... 402
American Notes ... 405
Australasian Notes ... 405
CORRESPONDENCE—
Lapse of the Telephone Patent—Otis K. Stuart ... 405
Electric & Magnetic Theories—J. T. Sprague ... 406
Boult's Wire Tables—W. S. Boult ... 406
Legal Intelligence ... 407
Trade Notes and Notices ... 407
COMPANIES' MEETINGS, &c.—
Elmore's Foreign and Colonial Patent Copper Depositing Company (Limited) ... 407
Elmores' Austro-Humgarian Patent Copper Depositing Company (Limited) ... 408
New Companies Registered ... 409
City Notes, &c. ... 409
Companies' Share List ... 410


## NOTICE.

**With this Number is issued a Coloured Map showing the Electric Mains laid in the London streets up to January 1, 1891.**


## STEEL-PLATE PORTRAITS

*Of W. H. Preece, F.R.S.; Michael Faraday; Sir John Pender, K.C.M.G.; Sir William Thomson, F.R.S. (Past-President of the Institution of Electrical Engineers); C. H. B. Patey, C.B. (Late Secretary of Telegraphs, G.P.O.); Dr. John Hopkinson, F.R.S. (Past-President of the Institution of Electrical Engineers); Dr. Oliver J. Lodge, F.R.S., and Prof. William Crookes, F.R.S. (President of the Institution of Electrical Engineers), have been issued as Supplements to "THE ELECTRICIAN." A few Copies of these admirably-executed Steel Engravings can be supplied, price 1s. each, post free on roller, 1s. 2d. Or framed in neat Black Pillar or Brown Ornamental Frames, price, post free, 4s. 6d.*


## THE COUPLING OF ALTERNATORS.

Much vagueness still exists with regard to the action of alternate-current machines when run in series or parallel on the same circuit, although the generally accepted theory, that of Dr. HOPKINSON, was published as long ago as 1884. That alternators will not run in series, but can be made to run in parallel, has been frequently established by experiments on a large scale, but unexplained cases exist in which it has been found practically impossible to connect them so as to aid each other in feeding a pair of mains, while even where no difficulty occurs in coupling the machines in parallel, the device, in spite of its convenience, is rarely if ever used in practice. The usual plan is that adopted at the Manchester-square Station, where each machine is coupled on to its own system of mains, and the circuits are re-arranged if the loads alter considerably.

The theory which Dr. HOPKINSON put forward in 1884 depended upon the effects of difference of phase. The importance of this quantity in connection with alternating currents is hardly yet fully recognised. It is indeed remarkable what a very slight lag between the amperes and the volts given out by an alternator working at ordinary frequency will reduce

its output to zero just as effectually as if the current were switched off altogether. A 50 horse-power alternator, yielding a current at 100 periods per second, will have its electrical output reduced 20 per cent. if only one-thousandth of a second is made to intervene between the moments at which the volts and amperes attain their greatest values. This means that the engine driving the dynamo, whenever this lag occurs, has over 10 horse-power available to increase the speed of the machine considered merely as a revolving mass. If the current lag has been caused by the dynamo momentarily slowing down, the engine will quickly remedy the defect and the lag will tend to diminish. Otherwise the phase difference will go on increasing and the engine will race. Two independently driven alternators coupled up to the same circuit must tend either towards coincidence of phase, or towards opposition. In the former case they would be suitable for series working, since their volts would add up, while in the latter case they could advantageously be joined in parallel since, just as with accumulators connected in parallel, the currents would add as regards an external circuit, and oppose as regards local circuits. Dr. Hopkinson showed that the self-induction of the circuit, by causing the current to lag behind the resultant electromotive forces due to the two machines, causes the leading dynamo to give out less power than the other, and the engine driving the former machine tends, in consequence, to run faster, so that any difference in phase between the electromotive forces is increased by the effect of self-induction until the state of opposition needed for parallel working is reached.

As, however, was pointed out by Dr. Hopkinson at the time, although the tendency of self-induction is to render parallel working stable, it may not be sufficiently strong to ensure its success. Whether it is so or not must depend upon the mechanical conditions of driving. It is unfortunate that the descriptions which have been given of various successful or unsuccessful attempts at parallel working have rarely contained full particulars of the manner in which the engines have been governed, and of the methods used to couple them with the dynamos. We do not at the moment recall any instance in which parallel working has been successfully accomplished in this country with direct driven machines, and it is possible, since so much must depend upon the flexibility of the driving mechanism, that the explanation of parallel working is to be sought as much in the engines as in the dynamos. The direct driving engines used in this country are not usually provided with sensitive governors. A run-away governor acting on the throttle valve is generally considered sufficient, but the engines used by Ganz and Co., at Leghorn, described in *The Electrician*, Vol. XXV., page 380, which drive the dynamos direct at 250 revolutions per minute, are provided with extremely sensitive governors of the Armington and Sims type. It is desirable that fuller attention should be given to this matter, and also that experiments should be tried with the object of increasing the effect of self-induction in controlling the phase of the two dynamos. Several devices with this latter object in view have been proposed by Mr. Swinburne, most of them being based on the tendency of the currents in the two coils of a transformer to keep in opposite phase. We have not heard, however, that these methods have received much attention experimentally.

Mr. Mordey, who is dissatisfied with the explanation of Dr. Hopkinson, has urged the importance of alternators having a "stiff field" if intended for parallel working. This is not incompatible with the armature having a large self-induction in comparison with its resistance, nor is the presence or absence of iron in the armature of any serious importance when the magnetic circuit of the field magnets is very good, as is the case in machines of recent date. Indeed, Mr. Mordey's alternator, although its field is "stiff," and its coils are free from iron, yet possesses in its armature more than six times as much self-induction in proportion to its resistance as is required by the formula which Dr. Hopkinson has given for the best parallel working conditions. The successful coupling of Mordey machines in parallel is thus no evidence against the old theory; while it is interesting to note that if the theory is correct it should be possible to get alternators to run in series as well as in parallel. Mr. Paul Boucherot, in a recent number of *L'Electricien*, has pointed out that, if a condenser of suitable capacity is placed in series or shunt to the external circuit, the current may be made to attain its maximum value before that of the electromotive forces instead of afterwards, and that the same arguments urged by Dr. Hopkinson to show that parallel working is possible with self-induction in circuit can also be used to show that series working is possible with the aid of condensers. Of the practical value of this idea little can be said at present. Before it can be even tried it is necessary to get condensers capable of withstanding high alternating potentials. We may remind our readers that some valuable and much-needed information in connection with this subject was contributed by Mr. Swinburne in a Paper read recently before the Physical Society. The successful accomplishment of series working by use of condensers would, however, establish the truth of the Hopkinson theory beyond all question.

There is one point in the theory, however, which it seems possible to doubt. The logic of the argument no one can gainsay; but mathematics, however perfect as a process of deduction, can only evolve worthless results from assumptions which are untrue. In the Hopkinson theory it is assumed that the periodic state has been attained before the influence of self-induction is investigated. The effect of putting alternating volts on to a circuit possessing self-induction is ultimately to produce a current which varies in the same way as the volts, but for the first two or three periods this is far from being the case. Extra currents are produced, represented mathematically by exponential functions of the time, whose value is considerable at first and rapidly diminishes as time goes on. The same effect is produced whenever any change is produced in the mean value of the volts or amperes in circuit. We have already pointed out that the actual time corresponding with the difference in phase is exceedingly small, so small, indeed, that the extra non-periodic currents produced whenever any change in phase occurs have not had time to die away. These extra currents are of supreme importance at the instant any change takes place, and their value is appreciable until two or three periods have elapsed. What their influence is on the question it is not very easy to foretell, but as the Hopkinson theory ignores them altogether, it seems desirable that their actions should be investigated, especially in view of the fact that there seems to be a general impression among engineers that the armature resistance is a very important factor in the problem.

Before Mr. Mordey's experiments there was some doubt in the minds of many engineers whether any alternators could be coupled satisfactorily for ordinary use. What he did was acknowledged to be a confirmation of Dr. Hopkinson's theory; how he did it was not clear, but several engineers went home and repeated all the experiments, and said that there was no mystery about it. Most of them now claim "our alternators run in parallel." But there is now nothing extraordinary about this, and the mystery has been shifted to the failure of alternators to run in parallel.

Digitized by Google

## THE HISTORICAL DEVELOPMENT OF THE INDUCTION COIL AND TRANSFORMER.*

BY DR. J. A. FLEMING, M.A.

The induction coil and the transformer are no exceptions to the general law that improvements in experimental appliances advance along definite lines by a process of evolution in which rudimentary forms are successively replaced by more and more completely developed machines. We are able by careful scrutiny of existing and pre-existing modifications to detect the ideas which have at every step impelled invention forward, and also to examine the prototypes in their relation to the final and fully developed idea. Most readers would probably consider that the proto-typical form of all modern induction coils and transformers was the iron ring with which Faraday made the initial discovery in electro-magnetic induction,† and in one sense this is of course correct, but a careful examination of the early stages of the development of the induction coil as we now possess it seems to show that it is descended in the direct line not from Faraday's ring so much as from Henry's flat spirals, and that it is these latter which are the chiefs of the clan and true ancestors of our modern coil.

Henry's claim to be an independent discoverer of the fundamental fact of electro-magnetic induction is not now disputed. In the July number of *Silliman's American Journal of Science* for 1832, Joseph Henry, then a young teacher in the Albany Academy, gave an account of the manner in which he had independently, and before receiving an account of Faraday's work performed in the previous autumn, elicited from his own great electro-magnet an induced current by wrapping round the soft iron armature certain coils of insulated wire.‡ In the same Paper in which he thus discloses his anticipated discovery he rendered an account of that in which he had in turn anticipated his illustrious rival by the discovery of the fact of the *self-induction* of a spiral conductor, and denoted the phenomenon by the name by which it has since been known. Simply confining himself to the bare statement of the new fact that if the poles of a small battery are joined by a wire a foot long no spark will be found on breaking the circuit, whereas if the wire be thirty or forty feet long, and particularly if it be coiled into a spiral, it gives a bright spark when so employed, Henry noted the discovery and correctly attributed the phenomenon to the induction of the circuit upon itself. Finding, however, that Faraday was following on the same line of discovery he published in the *Journal of the Franklin Institute*, in March, 1835 (Vol. XV., pp. 169-170), a brief epitome of the facts he had collected, and made mention, for the first time, of the use of the spirals of flat copper tape or ribbon, insulated and closely wound together, with which he subsequently conducted his brilliant train of discoveries on the mutual induction of circuits.

A few months later, in the July number of *Silliman's American Journal of Science*, 1835 (Vol. XXVIII., pp. 329-331), he followed this up with a more explicit account of his investigations on the action of a spiral conductor, especially a flat tape spiral, in increasing the spark and the shock from a single cell of a galvanic battery. Using a very large single cell of very low internal resistance known as "Dr. Hare's Calorimotor," he sent the current from this through a spiral conductor formed of copper ribbon about one inch wide and from sixty to one hundred feet long, well covered with silk, and the several spires closely wound on each other. One end of the conductor being attached to one pole of the battery and the other being brought in contact with or rubbed along the rough edge of a plate of metal attached to the other end, he obtained vivid sparks at the place of contact. Moreover he noted that if copper cylinders two inches in diameter and about five inches long, were attached as handles to the ends of the spiral by supplementary wires, and if these cylinders were grasped by moistened hands, a series of sharp shocks was experienced when the end of the spiral conductor was as before drawn along the rough edge of one plate of the calorimotor. This preliminary investigation on the production of a spark and a shock from a single cell of a battery led him to make a thorough investigation of the phenomenon, and in which he most fully explored the whole of the facts. The experiments he recounted in the *Transactions of the American Philosophical Society* for February, 1835, (Vol. V., pp. 223-231); and in *Silliman's American Journal of Science* for July, 1835, covering in these pages a recital of the independent investigations he made in going over the same ground as that occupied by Faraday in his Ninth series of "Electrical Researches" *On the Influences by Induction of an Electric Current on Itself*, sent to the Royal Society in December, 1834, and read in January, 1835. Henry's removal from Albany Academy to Princetown College created an interruption in his researches, but the news of them travelled to England, and in turn created a further wave of discovery. The subject was taken up by William Sturgeon, the inventor of the electro magnet. Sturgeon met one day a Mr. Peaboddy, lately from the United States, in the Adelaide Gallery of Practical Science*, and this gentleman informed him of Henry's experiments on the production of a shock and spark from a single pair of plates in a galvanic cell. Sturgeon was at that time just engaged in launching a new venture, in the shape of his *Annals of Electricity*, a monthly journal devoted especially to electrical science; and in the first volume of this publication, he led off with a paper "On the Electric Shock from a Single Pair of Plates," in which he gave an account of Henry's work and of his own repetition of the experiments (*Sturgeon's Annals*, Vol. I., p. 67). This was published in October, 1836. W. Sturgeon did not appear at this time to have been acquainted with Faraday's Ninth series of Electrical Researches; but after repeating most of Henry's experiments, and adding some of his own, he arrived at the conclusion that the action of the spiral conductor in creating a shock was due to the *collapse* of the magnetic lines of force

* This series of articles forms part of the second volume on "The Alternate Current Transformer in Theory and Practice." All rights are reserved.

† See "The Alternate Current Transformer," Vol I., p. 2.

‡ See "Collected Scientific Writings of Professor Joseph Henry," Vol. I., p. 73; also, *Silliman's American Journal of Science*, July, 1832, Vol. XXII., pp. 403-408; also, Prof. E. N. Dickerson's "Sketch of the Life of Joseph Henry," p. 12.

* The building, which was formerly the Adelaide Gallery of Practical Science, now survives as Gatti's restaurant in the Strand. It has many interesting electrical reminiscences connected with it. In the Adelaide Gallery Wheatstone performed his classical experiments on the "Velocity of Electricity" in 1834 (*see* "Wheatstone's Scientific Papers," p. 90). In it also Faraday performed the experiments on the Electrical Fish or Gymnotus, and established the real electrical nature of its shock in 1838 (*see* "Electrical Researches," Vol. II., p. 3).

The following extract from EDWARD WALFORD'S "Old and New London" may be of interest.

"Adjoining the Lowther Arcade, with its entrance in Adelaide-street, is the Adelaide Gallery, originally intended as a place of amusement and instruction combined. It was first opened in the year 1830, and named after Queen Adelaide, the consort of William IV. Its varied fortunes from the day when it was opened as a temple of science down to its tranformation into a casino, are thus cleverly sketched by the late Mr. Albert Smith in his little book on 'London Life and Character':—'Some time back—dates are very dry things, so we need not care about the precise year—there existed in the neighbourhood of the Lowther Arcade an establishment called the Adelaide Gallery. It was at first devoted to the diffusion of knowledge. Clever professors were there, teaching elaborate sciences in lectures of twenty minutes each; fearful engines revolved and hissed and quivered, as the fettered steam that formed their entrails grumbled sullenly in its bondage; mice led gasping sub-aqueous lives in diving bells; clock-work steamers ticked round and round a basin perpetually to prove the efficacy of invisible paddle-wheels; and on all sides were clever machines which stray visitors were puzzled to class either as coffee-mills, water wheels, roasting jacks, or musical instruments. There were artful snares laid for giving galvanic shocks to the unwary, steam guns that turned bullets into lead sixpences against the target; and dark microscopic rooms for shaking the principles of teetotallers, by showing the wriggling abominations in a drop of the water which they were supposed daily to gulp down. Then came a transition stage in the existence of the Adelaide Gallery, at first stealthily brought about. The oxy-hydrogen light was slily applied to the comic magic lantern, and laughing gas was made instead of carbonic acid. By degrees music stole in, then wizards, and lastly talented vocal foreigners from Ethiopia and the Pyrenees. Science was driven to her wit's end for a livelihood, but she still endeavoured to appear respectable. . . . And at last all the steam-engines and waterworks were cleared away, and the Adelaide Gallery was devoted entirely to the goddess of the "twinkling feet," and called a casino. It was altered into the Marionette Theatre in 1852, and is now one of the refreshment rooms of Messrs. Gatti."

Digitized by Google

when the current in the coil was interrupted, and that this gave rise to a momentary self-induced current in the coil set in motion by a greater electromotive force than that of the exciting cell. Subsequently he became acquainted with Faraday's prior work on self-induction, and in a critical paper (Sturgeon's *Annals of Electricity*, Vol. I., p. 192) he discusses Faraday's results, and with great skill experiments with a number of coils with and without iron cores, with the object of finding out how much of the "shock" was due to the iron, and how much to the wire coils. On page 283, Vol. I., of the *Annals* there is a full reprint of Henry's Paper read before the American Philosophical Society in February, 1835.

The next important fact seems to have been added by Prof. C. G. Page, of Washington, in the United States, who published an account in *Silliman's American Journal of Science* for October, 1836 (Vol. XXXI., p. 137), of his researches on the self-induction of spiral conductors. Sturgeon abstracted an account of Page's work in his *Annals* (Vol. I., p. 290), and made it available for English readers. Prof. C. G. Page constructed in 1835 a spiral copper strip coil, of which the strip was one inch wide and 220ft. long, carefully insulated, and having terminal wires

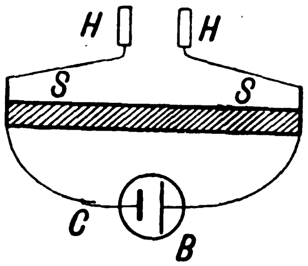



Fig. 1.—Henry's Coil.

soldered at intervals of 55ft. This strip was rolled up into a flat spiral, and mercury cups attached to the six terminal wires.

A single cell of a Hare's calorimotor, or large copper-zinc cell, was then attached to an adjacent pair of terminals, and it was found that on breaking the battery contact sparks and shocks could be procured by touching any of the other terminals in pairs.

The difference between Henry's and Page's arrangements may be indicated by a diagram, in which for clearness the copper strip is represented as unrolled.

Let S S (Fig. 1) be Henry's copper strip coil unrolled, and let B be a galvanic cell, and H H the handles for taking the inductive shock, when the battery circuit is broken at C. In Henry's experiments the arrangement of the coil was such that the self-induction of the whole of it was employed in producing the shock when a person held the handles H H.

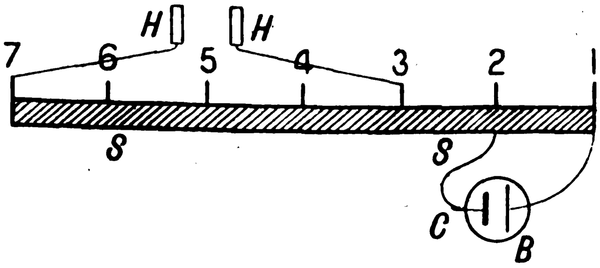



Fig. 2.—Page's Coil.

In Page's arrangement the strip with its six or seven contacts is represented by S S (Fig. 2), and the cell or battery was applied to the terminals 1 and 2. Page found that severe shocks could be obtained by taking hold of metal handles attached to the terminals 7 and 3, or 6 and 5, or 7 and 6, when the battery circuit was broken at C. By making the break and make of contact by rapidly revolving spur wheel he got a succession of sparks from a portion of the strip not included between the battery terminals. In place of a spur wheel he also made and broke contact rapidly by dragging one end of the battery wire over a file or rasp in contact with the plate of the battery.

On page 294 of Vol. I. of the *Annals* Sturgeon explained Page's experiment correctly as due to the induction of one part of the coil on the other. Page really made the first experiment in *auto-induction*, and showed that different parts of the same conductor might act as primary and secondary circuits to each other if in contiguity.

We then come to an important contribution by the Rev. N. J. Callan, of Maynooth College. This investigator followed up with great interest and success the researches of Faraday, Henry, Page, and W. Sturgeon, and on page 295 of Sturgeon's *Annals of Electricity*, Vol. I, we have a Paper by him, written in 1836, "On the best method of making an electro-magnet" "for electrical purposes, and on the vast superiority of the" "electric power of the electro-magnet over the electric power of" "the common magneto-electric machine."

In this Paper Callan describes the construction of an electromagnet with *two separate insulated wires, one thick and the other thin*, wound on the iron core together. He first coiled on a long and thick horseshoe-shaped bar of iron a very *thick copper wire* covered with silk or cotton, and securely over this a very long *thin iron wire*, also insulated with cotton, and one end, viz., the inner end, of the iron wire was joined to the outer end of the copper circuit. In his first magnet the copper wire consisted of a wire 50ft. long and one-twelfth of an inch in diameter, and the iron wire was 1,300ft. long and one-fortieth of an inch in diameter.

He sent a current from a battery of one or two pairs of plates through the thick copper wire, and attached metallic handles to the ends of the iron wire for the purpose of taking a shock, and then on making and breaking the circuit of the battery rapidly he got severe shocks from the iron wire circuit. Here we have the first description that exists of an induction coil with a short thick and a long thin wire upon it; but the peculiarity of it is that the end of the secondary or thin wire is joined to the end of the thick wire, so that they form one circuit wound all in the same direction upon the magnet. Callan's experiment was, therefore, an extension of Page's, and this last, again, was an improvement on Henry's apparatus. Callan followed up this Paper by another dated June 14, 1836, published in Sturgeon's *Annals*, Vol. I., p. 376, being "A description of the most powerful electro-magnet yet constructed." He had forged an iron bar 2½ inches in diameter, 13 feet long, and bent into a horseshoe. It weighed 15 stone. Four hundred and ninety feet of insulated copper wire, one-sixth of an inch in diameter, were wound on it in one layer, and over this a thin insulated copper wire 10,000 feet long and one-fortieth of an inch in diameter; and one end of the thin wire was soldered to one end of the thick wire, so that the whole length of the two wires formed a single circuit, wound all in the same direction on the big horseshoe. The current from 20 large Callan cells (iron cells), or from a Wollaston battery of 280 pairs of plates, was passed through the thick copper wire circuit alone, and rapidly interrupted by an apparatus Callan called a repeater. Wires were soldered to the extremities of the fine wire circuit to receive the induced current. Provided with this formidable apparatus, the inventor proceeded to perform striking experiments with the induced currents. "When by means of an *electro-magnetic repeater* a rapid succession of secondary currents was induced in the fine wire, and passed between charcoal points attached to the ends of the secondary circuit, they were slightly ignited." The shock, as can be imagined, was exceedingly severe, and the ardent experimentalist proceeded to pass from this germinal experiment in the production of an arc light by means of a transformer to an experiment in *electrocution*. For he adds: "Although the" "igniting power of the electric current produced in the long" "coil of thin wire was very feeble, its intensity was exceedingly" "great. When it (the secondary current) was passed through" "the body of a large fowl instant death was produced." This magnet, or one like it, was sent by Callan to Mr. Sturgeon, and by him exhibited to the London Electrical Society at a meeting held on August 5, 1837, and members and visitors enjoyed powerful shocks from the secondary wire of this electromagnetic apparatus.

Digitized by Google

## THE ELMORE PROCESS.

On Tuesday last, a large party of visitors was invited by the Directors of Elmore's Patent Copper Depositing Company, to inspect their works at Haigh Park, Hunslet, near Leeds. The site chosen for the works is about three miles from Leeds, and is admirably situated, being bounded on one side by a canal and on the other by the Midland Railway Company's line. Two Elmore Companies are located at Hunslet, namely the Depositing Company and the Wire Company, and the land owned by them has an area of no less than 120 acres. The works of the Depositing Company occupy six acres, and are in a fairly complete state; the Wire Company's works are as yet only slightly advanced, but there is evidence enough that a very large concern will eventually be established here.

On arrival at the works the visitors were taken to the generating room, where three high-speed Willans engines are in position, driving one Elwell Parker and three Mather and Platt dynamos, each of which has an output of 37½ kilowatts (50 volts × 750 amperes). The melting shed was next inspected, where the rough Chili bars are melted into a convenient form for handling and placing in the depositing tanks. The method employed is as follows:—The molten metal is poured into a well of water, and becoming granulated in the process, it can be handled as easily as coal or coke, and shovelled into the tanks where required. The depositing sheds were then visited. Here the Elmore process was to be seen in its various stages. At present there are 60 tanks available, each being about 11ft. long by about 3 deep and 2ft. 6in. across. These 60 tanks are all placed in series, and consume on an average a total of some 60 E.H.P. (·9 volt × 750 amperes per tank). The plant at present in operation is capable of dealing with 20 tons of deposited copper per week. The ingenious device of a revolving mandrel and burnisher, employed by Mr. Elmore to secure a dense, fibrous, and cohesive deposit is too well known to require detailed description in the present brief account, and it need only be remarked that the mandrel revolves 20 times a minute, and the continuously moving agate burnisher presses upon it with a weight of about 3lbs. It may be interesting to note that about ½oz. of gold and some 3oz. of silver are recovered in the vats per ton of copper deposited. The visitors were next conducted through the machine shop, where the operation of removing the copper tubes from the mandrels was witnessed, and through the testing-room, extension works, and the buildings in progress for the manufacture of copper strip for wire drawers.

The wire works when completed will have a capacity of 200 tons per week. The whole of the proposed weekly output of these works is, we were given to understand, already bespoken by a powerful group of wire drawers. These works will contain 720 depositing tanks, and the total power required will amount to 2,600 horse-power.

Whatever difference of opinion there may be as to the exact commercial value of the Elmore process, a visit to the works leaves no doubt on our minds that the companies concerned are energetically engaged in building up a most extensive business at Hunslet, and we hope in an early issue to give a complete illustrated description of the works and the process as carried out on a large scale.

## ELECTRIC LIGHTING AT THE GENERAL POST OFFICE.

The two main buildings of the General Post Office devoted to the Postal Branch and to the Telegraph Department have recently been provided with a very complete plant for electric lighting. The lighting commenced in November last and was pushed forward rapidly in order to provide for the great pressure at Christmas. The work is not yet complete, and extensions are being carried out. In the basement of the Postal building is a boiler-room of ample size with a still more commodious dynamo-room adjoining. Three Davey-Paxman locomotive boilers are provided, of which two are used at a time, one being in reserve. The boilers are entirely covered with lagging composition, and the gases pass through downtakes into a large shaft which provides an excellent draught. Opposite the boilers is a coal bunker, from which the coal is shot direct from the street. Water softening apparatus and filter press is provided, since the feed water is taken from the New River Company. In this respect the boilers are at a disadvantage compared with those which work the powerful engines in the Telegraph building for the pneumatic service; these are supplied from a well on the premises, the water from which is exceptionally well suited for steaming. The usual feed water heater, injectors, and feed pumps are provided, together with a tank containing enough water for six hours' supply.

Four continuous-current Elwell-Parker dynamos at present are fixed on massive concrete foundations some 6ft. deep. These dynamos are set in Willans' combination bed-plates, and are coupled to Willans' central valve compound engines. They are extremely compact, more so, indeed, than seems to be necessary, considering the size of the engine-room; and the advantages of the Willans' combination, which are so important in ship work, do not appear in such a case as this to outweigh the importantance of easy access to the brushes and armature and the ready removal of the latter in the case of need.

The engines run under 120lb. of steam, and exhaust into a stack pipe. At present three are used, and one is in reserve. It is intended to add two more engines of the H. H. and two of the G. G. size. Each is capable of delivering 460 amperes at 110 volts. The fields are compound-wound, the shunts being inside the main windings, which consist of four conductors in parallel. The commutators are of ample size, about 9in. diameter by 8½in. long, and have only 48 sections. The main conductors are of high-class Silvertown make, and are led into a chase in the concrete; they are supported by ring-insulators resting on hooks.

The lighting is divided between two machines for the Postal building, while one supplies the telegraph department. The former supplies about 1,000 glow lamps and 36 arc lamps, the pressure being 105 volts. There are about 600 lamps in the telegraph building at 100 volts. The arc lamps are of the Brockie-Pell make, and are run two in series with Brockie-Pell resistance and choking coil. These lamps take about 10 amperes, and run with their usual perfect steadiness. Two are fixed under the portico of the postal building, and on the occasion of our visit nine arcs gave very satisfactory illumination in the large hall of the Inland branch, where six others are used during the busiest hours. The conductors from the dynamos are led up to a large switch-board in the dynamo-room, each conductor coming to the centre of an 8-way switch designed and made in the Post Office workshops. These switches are of the hatchet type, the blade being at right angles to the handle, but working in a plane at right angles to the switchboard. The spring contacts are grouped in a circle on the central plate, forming the end of the conductor, while the eight switches are arranged concentrically around it.

By this switch-board any circuit can be put on to any dynamo. The whole of the circuits are duplicated, and the main cables of 61/12 wire on leaving the dynamo-room, run to other distributing switch-boards in different parts of the building. Here again any branch circuit can be put on any dynamo, or any circuit may be broken.

Cardew voltmeters are used in the engine-room, and Dolivo ammeters. These instruments consist of a solenoid formed of discs, like the old Gaulard-Gibbs transformers, and contain a core of fine iron wire, which moves the needle. Double pole Edison cut-outs are used with rather more profusion than we were prepared for, but in so large a building it would no doubt be difficult to arrange separate lamp-currents from minor distributing boards. The arc lamps are not arranged for lowering, but trestles are used for trimming. The lamp-holders are of the screw socket type, and the fittings are of a plain, substantial character.

It is hardly necessary to say that the electric lighting is immensely appreciated by the *employés*, as many of the rooms were unbearably hot during the long night work with gas. The plant has been inspected by many deputations from provincial and other local authorities, and may be considered a model of its kind.

Digitized by Google

## "THE DISTRIBUTION OF ELECTRICITY, WITH ESPECIAL REFERENCE TO THE CHELSEA SYSTEM." *

BY MAJOR-GENERAL C. E. WEBBER.

In September, 1889, I read a Paper before the British Association, at Newcastle, on the subject of the Distribution of Electricity in parts of Chelsea and Kensington, with accumulators as the main source of supply. (*The Electrician*, Vol. XXIII., p. 577.)

The Chelsea system was then described as follows :—

(*a*.) Charging the accumulators at high pressure, and discharging for distribution at low pressure, and effecting the changes necessary to the same by special automatic arrangements placed in each storage station.

(*b*.) Supplementing the main supply by means of continuous-current transformers.

(*c*.) Distributing by means of mains laid down in a network.

(*d*.) Maintaining a constant pressure by means of the introduction into the discharge circuit from the storage stations of counter E.M.F. cells.

(*e*.) The use of underground conductors throughout, laid so that the cables can be drawn in and out, and renewed or repaired whenever necessary, without disturbing the ground.

For the benefit of those of my audience who have not already heard a description of the system, diagrams showing the arrangements and connections of the charging units, batteries, and transformer motors are shown on the wall.

First, three of these plants in series charging one of the half batteries in each of three storage stations, the lighting being maintained by the other, or second half battery ; and the pressure in the distributing mains being regulated by cells which give a counter E.M.F.

Second, the three plants are shown charging the second half batteries. Those which having been previously charging are now discharging to the distribution system. Regulation is still maintained as in the first position.

Third, there is a cessation of charging, and the two half batteries are shown to be discharging together in parallel. Regulation is maintained as before.

Fourth, continuous current-transformers are supplying current to the system in parallel with both halves of the batteries.

The apparatus for effecting the various transpositions of the secondary batteries in the storage stations, and for maintaining the pressure constant in the mains, is automatic.

The movable portions are worked by the energy which would otherwise be wasted in the counter E.M.F. cells, which are used for regulating the pressure in the distribution system.

All the actuating portions of the apparatus require current at an E.M.F. of only 4 or 5 volts.

The adolescence of the system being safely reached, the Institution will be naturally desirous to know if the combination described in 1889 as "Accumulation of the main supply from a generating station in storage stations, situated at suitable distances from one another" is a success.

(*a*.) As regards the charging of the accumulators at high pressure, and discharging for distribution at low pressure, and effecting the changes necessary to the same by the special automatic arrangements placed in each storage station. The system designed by Mr. F. King has worked uninterruptedly in each of the four storage stations now in actual use.

The arrangement then described showing three units of generating plant in series, charging one of the half batteries in each of three storage stations, with a current of 75 amperes and 1,500 volts in the charging mains, in combination with the automatic regulating plant by which the changes of the half batteries in and out of charge and discharge are made, have been in daily use.

The mercury cups and contacts have behaved perfectly, and there has been absolute freedom from heating in any of them.

The very small amount of alterations that have been since necessary is a proof of the care with which the Electric Power Storage Company made trial of the regulating apparatus before putting it to work for the Chelsea Company.

(*b*.) The supplementing of the main supply by means of continuous-current transformers is a portion of the system of which our year's experience has gone far enough to satisfy us that it is an efficient and reliable way of providing for the increase in demands for current which the full discharge of the storage stations would be incapable of meeting ; and that the economy arising out of the employment of the generating units, during otherwise idle hours, compensates for the loss in conversion.

The first continuous-current transformer designed for the Electric Construction Corporation was by Mr. F. King.

* Abstract of a Paper read before the Institution of Electrical Engineers, January 22, 1891.

Careful tests, made last August in the presence of Mr. Raworth, engineer of the Brush Electrical Engineering Company, gave the following results :—

| | Primary. | | | Secondary. | | | Efficiency. |
|---|---|---|---|---|---|---|---|
| | Volts. | Amps. | Watts. | Volts. | Amps. | Watts. | Per cent. |
| No. 1 test. | 588 | 64 | 37,632 | 110·5 | 280 | 30,940 | 82 |
| „ 2 „ | 606 | 72·5 | 43,935 | 111·5 | 327 | 36,460 | 82·9 |
| „ 3 „ | 604 | 72·5 | 43,790 | 111·5 | 320 | 35,680 | 81 |

The total weight of the machine (*vide* diagram) is 4 tons, 7 cwt. 2 qrs. The field-magnet armature and shaft are carried on a cast-iron bed and pedestal, having an over-all length of about 6 feet, and a height of about 3 feet 6 inches. The armature is ring-type, carried by a 3½-inch shaft, having two commutators, one at each end. The primary circuit, or motor, commutator has 72 sections ; that for the secondary generation has half that number, namely, 36. The primary circuit on the armature consists of 72 segments, ·120in. diameter copper, well-insulated wire, corresponding to the number of commutator sections, having a conductivity resistance, measured at opposite segments, of ·1755 ohm. The conductor forming each section is wound in an ebonite channel laid between the copper strips which form the secondary, or generator, circuit, and arranged in a single layer on the outside and a double layer on the inside. The secondary, or generator, circuit is composed of copper strips of ·0593 of an inch sectional area, in 36 coils, each of which is connected with a section of the right-hand commutator. The conductivity resistance is ·0087 of an ohm. The core of the armature is composed of charcoal iron rings ·022in. thick, insulated from each other, the external diameter of which is 17¼in., and inside 8¼in. The field magnets are shown in horizontal section in the diagram, the weight of the iron in them being 2 tons 11cwt. 2qrs. They are wound with ·095in. copper, well-insulated wire, in 20 layers, having 2,720 turns on each limb, and have a conductivity resistance of 18·9 ohms, being connected in parallel with the discharging mains.

The machine is connected up on the motor side with the conductors from a unit of generating plant, running with almost the same output as is required to charge one of the half-storage stations of the Chelsea system.

The collectors on the secondary circuit commutator are also connected through switches with the low-pressure distribution systems, having measuring instruments of the output for pressure and quantity.

The behaviour of this machine, both as regards heating and sparking, has been throughout all that can be desired, and as the type improves, we expect an improvement in efficiency.

Mr. King has favoured me with the following remarks :—

"The peculiar advantages of the combination of transformer and battery circuit which is at work at Chelsea are the ability to, at all times, use the transformer to its fullest capacity, and therefore greatest efficiency both of engine, dynamo, and transformer ; and the absolute regularity with which the potential at the secondary, or generator, terminals of the transformer will follow the varying potential at the junction with the feeders to the distributing main.

"It is, of course, easy to see the reason why the machine behaves in the manner indicated. Any fall in the potential of the discharging mains means a reduction in the intensity of the magnetic field in which the armature rotates, and with a constant motor current this reduction of magnetic field means an increase of speed, until the number of revolutions is sufficient to raise the E.M.F. in those mains so as to react on the fields.

"The action of the machine, therefore, is consequent on the intensity of the magnetic field created by the E.M.F. existing at any moment on the discharge mains, and the strength of current in the primary circuit, which will cause variation in speed sufficient always to produce at the secondary armature an E.M.F. equal to that of the discharge at the station."

The method of starting is as follows :—First, the fields are made by switching on the right-hand switch. The engine and dynamo are then connected at the station switch-board through the ordinary charging mains to the motor armature. The engine and dynamo are then started with a resistance in the field, and the speed increased until the required E.M.F. at the dynamo terminals is obtained. The potential at the right-hand, or secondary, terminals will, in consequence, run up to that in the discharge system at the stations. The left-hand switch is then closed, and the current increased in the primary circuit by the gradual removal of resistance at the charging dynamo, until the maximum capacity of the transformer is reached, which will continue irrespective of the amount of storage discharge, upon which all variations of load in the system will then fall.

Digitized by Google

The Parker (Wolverhampton) C.C. Transformer. The tests of the manufacturers, which have not yet been verified by us with working loads and long continuous runs, show that—

1st. With an output of 1,600 watts, the efficiency is 81½ per cent.
2nd. With 20,000 watts, it reaches 89½ per cent.
3rd. At 40,000 watts, it attains 92 per cent.

The weight of the machine is 5 tons, and the floor space required for it is 7 feet by 3 feet.

The armature is of the drum type. The primary is wound with 200 turns connected up to a commutator with 100 bars. The secondary has 80 turns connected to 40 bars in the commutator at the opposite end. The diameter of the core is 14 and 15-16ths inches, and of the finished armature 16in. Its length is 22in. The winding of the primary is for 540 volts and 75 amperes, and of the secondary 108 volts and 350 amperes, with a speed of 550 revolutions; the resistances of the primary and secondary, and of the magnet, respectively, being ·17, ·001, and 8 ohms.

Laurence & Scott's 40-unit C.C. Transformer. The following description of it has been given me by the makers:—The conductors on the armature are laid in deep and narrow slots milled in the iron plates comprising the core; the low-tension conductor, which is of copper strip, being disposed in the bottom of the slots, with the high-tension, of fine stranded cable, above. There are 88 of these slots, each 1·8 inches deep and ·22 of an inch wide; one of the low and five of the high tension conductors being in each slot. The mechanical advantage of this arrangement is that it is impossible for the conductors to slip over one another to the smallest extent. There are 44 sections in each commutator, the low-tension having one turn per section, and the high-tension five turns.

Ventilation is secured by hollow spaces left between the shaft and each commutator, extending along the shaft to each end of the core, where ½in. spaces are left, extending to the outside of the armature. The paths of the air currents are shown in the diagram by the little arrows. The high and low tension circuits are insulated from one another, and from the armature core, by mica everywhere, except at the vertical ends; and as an additional precaution against the one breaking into the other, caps of brass wire gauze, in electrical connection with the shaft but carefully insulated from the conductors, are arranged between the two windings at the ends, so that before the high could break into the low tension circuit at either end of the armature it must come into contact with one of these caps, and therefore with the frame of the machine. In the core itself the iron plates effect the same object as these caps, as they are purposely put in electrical contact with the shaft.

The weight of the whole machine is 65cwt., and speed 660.

Current-density in high-tension winding with 375 amperes = 2,450 amperes per square inch.

Current-density in low-tension winding with 75 amperes = 2,080 amperes per square inch.

| | | |
|---|---|---|
| Loss in high-tension winding, hot ... | = | 1,425 watts. |
| ,, low ,, ,, ,, ... | = | 945 ,, |
| ,, field magnets ...................... | = | 402 ,, |
| Current in ,, ...................... | = | 3·7 amperes. |
| Electrical efficiency ...................... | = | 93·7 per cent. |

Of the endurance or efficiency of this machine I am not as yet in a position to give results.

Of the efficiency of the service to the public in the Chelsea Company's district there has been ample evidence in the contents of a long list of testimonials from customers, which without exception are unanimous in praising the constancy, regularity, and perfect steadiness of the supply.

Questions have been raised in the House of Commons, and in letters to *The Times*, as to the maintenance of the pressure prescribed by the statute in the Chelsea district.

For a few days in December last, the company found itself obliged, for the first time, to cut off the current from their system for short periods in the day, owing to the abnormal exhaustion (*see* figs. 1 and 2) of their reserve of storage, in order to save their accumulator plant from permanent injury.

Before doing so, the Board of Trade and the Local Authorities were communicated with, and the former was told that the step had been rendered unavoidable, not because of want of foresight, but through the delinquency all round of contractors for machinery who had engaged to supply plant early in the autumn. The company offered to lay before that department all the documentary evidence necessary to prove that they had early in the year made ample provision for all conceivable emergencies, and that this late delivery of plant had been the sole cause of the unfortunate position to which they had been brought by the long continuance of foggy weather. In very foggy weather householders use in the day as few gas lights, oil lamps, or candles, as possible, but we find that on such occasions there seems some peculiar temptation to turn on every glow lamp in the house.

Owing to conditions which have nothing to do with the system, and of which a detailed and intelligible narrative would occupy too much time, the nascent period of five months, previous to October 1st, 1889, has been held to be purely experimental.

The variation in the anticipated demand has been marked by its inequality in various parts of the same district. Thus, in one of the new residential gardens in the Chelsea district the custom on one side is rather above the average, whereas on the other side—

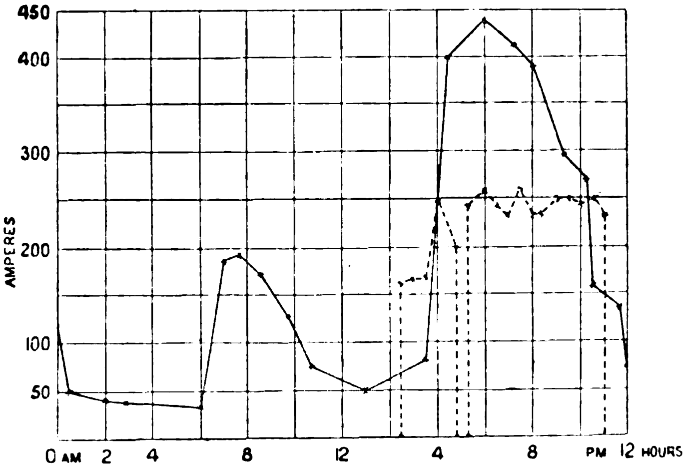



FIG. 1.—Load Curve for 4th December, 1890 (one Storage Station).
———— Discharge from Batteries *only*. Quantity of Electricity Supplied 380 units.
······ Current from C.C. Transformer at same Station, to be added to the Discharge of the Batteries for the Total Discharge.
Quantity of Electricity Supplied 185 units.

consisting of 15 or 20 houses of an average rental of £400 a year, in front of which mains have been lying ready to supply for more than a year—as yet, in only one is current being supplied.

To provide for such contingencies as this in the first instance, would have entailed a first outlay in insulated copper, and a consequent idleness of capital, which prudence forbade. In some cases the growth of demand at certain spots overtook the means of supply, with a temporary sacrifice of maintenance of the full mean statutory pressure.

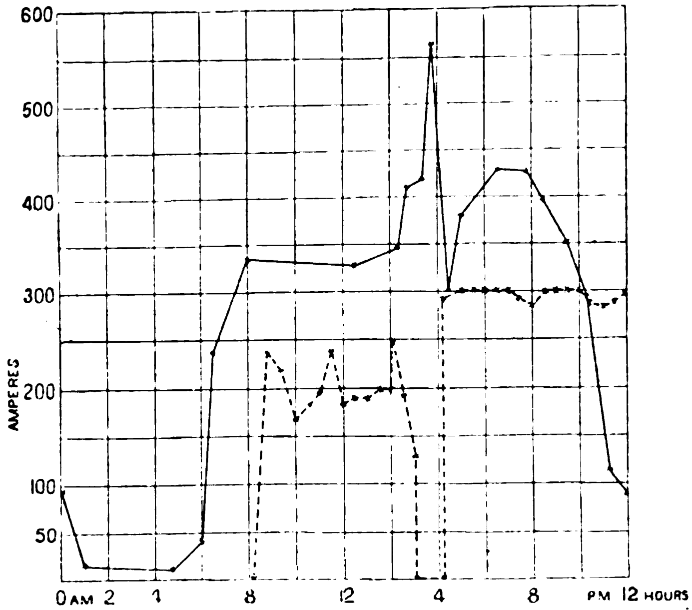



FIG. 2.—Load Curve for 10th December, 1890 (one Storage Station).
*Weather Foggy.*
———— Quantity of Electricity Supplied by Batteries 607 units.
······ Quantity of Electricity Supplied by C.C. Transformer 340 units.

The Chelsea system having started before most others, special experimental Board of Trade rules had to be summarily compiled, and these were more or less on their trial. The authorised rules, which dealt in an important way with the question of constant pressure, were only issued in November last.

The best means of providing for uncertain special demands for current had to be prepared to suit the ordinary conditions of the system, as, owing to its comparative novelty, these could not have been designed before experience had been obtained of the nature that excess.

Digitized by Google

Lastly, in first degree in importance, the Chelsea Company has, in common with other electric supply undertakers, had to make the best of the difficulty which has existed during the past year in obtaining delivery of material in face of the great demand on all electrical manufacturing firms, with a sensible sacrifice of economy in working.

As regards the efficiency of the generating plant, I will remind my hearers that the unit of power is one Willans & Robinson G.G. engine, geared direct to a 40 to 42 unit dynamo, which, running at its normal speed, can yield 70 to 75 amperes at 500 to 550 volts. This plant, when in full use, is run charging a distant storage station from midnight to 3 p.m.; and from 4 p.m. to 11 p.m. It runs, by means of the same charging mains, a C.C. transformer (already described) placed at the same point.

In practice, the yield in the first period is—

38 units during 14 hours = 532 units.

In the second period—

44 units during 7 hours = 308 ,,

Total in the 24 hours = 840 ,,

The tests of our Babcock & Wilcox boilers show an efficiency of 10·2lb. of water per lb. of combustible (ash and firing up being deducted); and also that it has required 5·74lb. of combustible to produce each unit at the terminals of the dynamo.

This corresponds to 3·64lb. per indicated horse-power, a figure which we are in process of reducing, and expect to reduce to 2·7lb.

The average loss in the charging mains, and by conversion with the two means in use, is just 20 per cent., and in the distribution between the converting stations, or sources of supply, and the consumers' terminals is 2 per cent. The 43cwt. of coal used in the generating stations to produce 840 units delivers 690 units into the company's meters, or, as nearly as possible, 7lb. of combustible per unit of electricity sold, which, at 25s. a ton, is less than ·94 of a penny, but which I prefer to take at one penny, per unit, for fuel.

My qualification of this as a report of actual consumption is that, while it is accurate for periods of useful running of the best part of the plant, it is by no means so for those portions which it has not been, for reasons I have given, possible to run efficiently. Experience early showed us in what direction to work to obtain the maximum of efficiency originally claimed by Mr. King for the system, and that course has been, and is being, followed; but necessarily improvements in a plant, which is constantly at work have to be effected with deliberation, and the rate at which they can be carried out more depends on manufacturers than on the suppliers.

The accumulators in our storage stations have now been in use for periods varying from 21 months to nine months.

During these periods the work done each day by each station has varied considerably as between the stations and between the cells.

The routine of testing the 1,800 cells which are, exclusive of reserve, in constant use, need not be described. Completely under control and supervision, it is, as can be understood, of a very perfect kind.

After 18 months' full use, it was found, from tests made by the manufacturers, that one-third of the active material of the positive plates had been exhausted. During the latter six months of the same period—which may be considered a good example of normal rate of waste—the peroxide which has scaled off and fallen to the bottom of the glass cell and been removed has averaged half a pound per month from 15 plates, or half an ounce per plate.

The general conclusion come to is that under the normal circumstances of charge and discharge of the Chelsea system the life of the brown plates can be calculated at three years at least.

The possible leakage from accumulators has been laid some stress on by critics, but, with precautions adopted, our tests on an average shown an insulation resistance to the earth of about 50,000 to 100,000 ohms.

*(To be continued.)*

## THE LIVERPOOL ELECTRIC SUPPLY STATIONS.*

BY A. BROMLEY HOLMES, M.I.C.E.

At the date of formation of the Liverpool Electric Supply Company in January, 1883, there was not a single installation of incandescent lamps in Liverpool. The first station was started in December, 1883, to supply electric light to the Grand and Adelphi Hotels and to other consumers in the neighbourhood, and continued without intermission in daily operation from that date till November, 1890, when the mains were connected to one of the newer stations. In 1887 a larger station was built, and commenced work in December of that year in Tithebarn-street. This now forms part of the Highfield-street station. In September, 1888, the Harrington-street station was completed and at work. In 1889 the Company's new works, offices, and central station were built in Highfield-street, and the supply of electricity began in October of that year. The Company's latest station, in Oldham-place, commenced work in October, 1890.

The following figures show the rapid extension of electric lighting in Liverpool, the number of lamps of 16 candle-power (or their equivalent) connected with the Company's stations being as follows:—

| | | | | |
|---|---|---|---|---|
| On January 1, 1888 ... | 977 | 16 candle-power lamps. | | |
| Do. 1889 ... | 3.330 | do. | do. | |
| Do. 1890 ... | 6.711 | do. | do. | |
| Do. 1891 ... | 11,750 | do. | do. | |

The capacity of the three stations now at work is as follows:—

| | | | |
|---|---|---|---|
| Highfield-street ... | 7,000 | lamps, capable of extension to | 13.000 |
| Harrington-street ... | 4.000 | do. do. do. | 4.000 |
| Oldham-place ... ... | 4,500 | do. do. do. | 20.000 |
| Total ... | 15,500 | Total ... | 37.000 |

The above figures give the number of sixteen-candle-power lamps that the machinery is actually capable of supplying direct at one time; and as experience has shown that never more than 75 per cent. of the lamps connected to the supply mains are in use at any one hour, the above plant would have a working margin of 25 per cent. spare power for the number of lamps stated, without taking into account the storage of electricity always available from the accumulators. The system in use is a direct current continuous supply at a pressure of 110 volts, all the mains being in simple parallel. It may be convenient to give a detailed description of the plant before describing the method of working.

The boilers are 28ft. long, 7ft. 6in. in diameter, and are made of mild steel, each flue being fitted with six steel Galloway tubes. The working pressure is from 110 to 120lbs. per square inch. Of the ten in use seven are fitted with Proctor's mechanical stoker, and the remaining three with Viccar's mechanical stoker.

The engines are Willans' central-valve compound engines of two sizes, ten of them being of the I.I. size, capable of indicating 180 horse-power, the remaining three engines being of the G.G. size, indicating 60 horse-power.

The dynamos have magnets of the single-inverted horse-shoe type, with massive wrought-iron limbs. The armature shafts are coupled directly on to the crank shafts of the engines. The dynamos for the smaller engines give an output of 300 amperes, and an E.M.F. of from 110 to 140 volts, at from 450 to 500 revolutions per minute. The larger dynamos give 900 amperes, and from 115 to 135 volts, at 375 revolutions per minute. Some of the dynamos are compound wound, but the later patterns are plain shunt wound, and all have a variable resistance attached to them, by which the current through the shunt circuit can be varied and the E.M.F. regulated at will. Two of the dynamos were manufactured by Crompton and Co., and the rest by Siemens Brothers.

The accumulators are of two kinds, manufactured respectively by the Electric Construction Corporation and by the Crompton-Howell Electrical Storage Company.

All the distributing mains of the Liverpool Electric Supply Company are laid underground, and have been manufactured and laid by the Callender Company. The largest feeding mains are composed of 91/9 cable and have a sectional area of 1·57 square inches. The conductor is covered with two layers of jute yarn and boiled in refined bitumen. It is next wrapped with parchment tape and covered with a lead casing. The lead is protected by an outside covering of rough jute yarn treated with asphalte and tar. The ordinary feeders are 61/11 cable with an area of ·6 of a square inch and the distributors 37/13 cable ·25 of a square inch in area. In both these mains the copper conductor is covered by a solid sheath of bitite or vulcanised bitumen put on under heavy pressure at one operation. This core is next taped and compounded, and finally braided with hemp yarn and passed through a bath of asphalte compound. The mains are laid in cast-iron troughs ¼-inch thick and about 6ft. long with socket joints. When the troughs are placed in position about ¼in. of refined bitumen in a molten state is run in, and, before setting, spacing bridges of wood are placed in it about 18in. apart. These bridges support the cables and hold them in place, clear of the sides and bottom of the trough and of each other. Bitumen is then run in, so as to entirely cover the cables and fill up the iron troughs to within ½in. of the top. The troughs are then finished by a covering of Portland cement concrete about 1in. think. Strong cast-iron covers are in some cases substituted for the concrete. The service lines from the distributing mains to the consumers' premises are made of 19/14, insulated and covered with lead, and run in wood grooved casing, filled in with bitumen and protected with a hard-wood cover strip.

* Abstract of a Paper read on January 21, 1891, before the Liverpool Engineering Society.

Digitized by Google

The connections of the various lengths of mains to each other, and of the feeders to the distributors, are made by sweating copper lug pieces on to the ends of the cables and by bolting copper connecting bars to the lugs. The distributing mains are jointed in a similar way, the connecting bars being fitted with terminal screws for the attachment of fusible tin strips, to which the service lines are attached. The connections described above are made in cast-iron joint boxes, measuring inside 16in. by 12in. by 12in., provided with socket pieces to receive the ends of the cast-iron troughs in which the mains are laid. Each box has a strong cast-iron cover, held down by a central bronze bolt and cross-bar. A watertight joint is secured by means of a soft indiarubber washer between the cover and the box. All joint boxes are below the level of the pavement, and the surface of the footway is completed by an iron frame and surface plate, by means of which access is afforded to the joint box. In many cases the surface plates are formed in cement to match the adjoining paving.

The general arrangement of mains is as follows:—A pair of distributing mains are laid under the footways on each side of each street, and are connected together to form a complete distributing network, to which are connected all the service lines to consumers' premises. For convenience in working, the network is divided into sections. The supply of current is brought to selected distributing points in this network by heavy feeding mains, which run direct from the generating stations. The feeding mains are so proportioned, relatively to the distance from the station of each distributing point and the number of lamps to be supplied from it, that the percentage of loss in pressure in each feeding main may be as nearly as possible the same; in other words, if the lamps were turned on and off uniformly all over the area of supply, a constant pressure might be obtained throughout the network by varying the E.M.F. of the dynamos at the central station in exact proportion to the amount of current supplied. As a matter of practice, however, the hours of demand vary in different streets and districts, and it is found necessary not only to vary the station pressure as a whole, but also to regulate the pressure for each set of feeders individually.

The following figures will give some idea of the extent of the mains already laid. The length of frontage along which distributing mains are laid is nine and a quarter miles. The total length of single cable used throughout the area is 41 miles. Taking a pair of cables to form a main, the lengths of the various classes of mains are as follows:—

| | |
|---|---|
| Feeding mains ............................................. | 10 miles |
| Distributing mains ........................................ | 9 do. |
| Service lines ................................................ | 1½ do. |
| Total......... | 20½ miles. |

The weight of copper in the mains is 210 tons. The number of joint boxes, service boxes, and pressure wire boxes is 630. The number of separate service lines is 275, but many of these serve for the supply of several consumers.

All the dynamos in a station are arranged to work in parallel on to a pair of positive and negative collecting conductors, and are switched in and out of circuit as the variations in load requires. Each negative feeding main is connected from its cut-out to the station main negative conductor, and each positive feeding main is connected through an ammeter to a main regulating switch. By moving the regulating switch it is possible to introduce accumulators in the circuit of any desired feeder. These accumulators are arranged in opposition to the dynamo current, and, consequently, the pressure in the feeder is reduced by two volts for each cell put into circuit by the regulating switch. This at first sight may appear a wasteful method of regulation, but in practice the load is found to rise so uniformly over the whole area of supply that the amount of energy absorbed in regulation is practically unimportant.

The battery of accumulators at each station is capable of supplying 500 lamps at a time, thus enabling the machinery to be stopped at from 10 to 12 o'clock at night and in some cases entirely on Sunday, and also largely in the day time in summer. The discharge from the accumulators is registered by a recording ammeter. By a special arrangement of dividing the accumulators into sections, devised by the author, they are charged from the dynamos supplying the town at the ordinary working pressure, and by a little care t is in this way possible to so regulate the load on the engines and dynamos as to run them at their highest efficiency.

Continuous tests of the insulation resistance of the mains are made at each station by means of a special apparatus devised by the author for this purpose. If two lamps be connected in series between the positive and negative mains, and a point between the lamps be connected to the earth, the lamps will be found to burn with a variation in brilliancy proportional to the relative insulation resistance of the mains to which each lamp is attached. If two voltmeters be substituted for the lamps, their readings will indicate the same ratio. In the apparatus referred to, a registering voltmeter is used to indicate this ratio continuously. By a suitable arrangement of switches, an ammeter with one terminal connection to earth can be momentarily connected to either main, and the insulation resistance in ohms of the main to which the instrument is not connected is readily arrived at by dividing the station pressure in volts by the number of amperes indicated by the ammeter.

The Hookham electric meter is used by the Company. From diagrams shown it was seen that the number of Board of Trade units used per lamp per month varies from 6·3 units in January to 1·2 units in June. Also, that in December the output reaches 4,000 amperes, whilst in June it does not exceed 500 amperes.

## THE ELECTRICAL TRADES SECTION OF THE LONDON CHAMBER OF COMMERCE.

At a meeting of the Committee of the Electrical Trades Section of the London Chamber of Commerce, held on Monday afternoon last, a prolonged discussion was held with regard to the Board of Trade Provisional Orders relating to telephones. This matter, which is o the highest importance to supply companies, has arisen from certain new clauses which the Board of Trade has seen fit to introduce into the Model Order, superseding the clause in the old 1889 order. It did not appear during the discussion how the modification has arisen. The Secretary, Mr. Murray, read the following:

November 28, 1890.

MODEL CLAUSES FOR PROTECTION OF TELEPHONES, &c.

In the Order of 1889 the provisions for protection of telephones were comprised in the two clauses, which are here printed, so far as material, in ordinary type.

In certain of the Orders of 1890 the words italicised in Clause A were inserted by Mr. Stansfeld's Committee, and the words enclosed in brackets were struck out.

It is proposed in the Orders of 1891 to include in one clause all the special provisions relative to this subject, and to define more clearly the extent of protection.

*Clauses of 1889 and 1890.*

**Systems and Mode of Supply.**

A. Subject to the provisions of this Order and the principal Act, the undertakers may supply energy within the area of supply for all public and private purposes, as defined by the said Act, provided as follows:—(1.) ........... ......................... (2.) ................................... (3.) The Undertakers shall construct their mains and other works of all descriptions, and shall work their undertaking in all respects (with due regard to other) *so as not injuriously to affect the working of any existing* electric circuits from time to time used, or intended to be used, for the purpose of telegraphic, telephonic, or electric signalling communication, or the currents in such circuits; and shall use every reasonable means in the construction of their mains and other works of all descriptions, and the working of their undertaking, to prevent any injurious affection, whether by induction or otherwise, to any electric circuit *used, or intended to be used, for the purposes aforesaid, whether existing at the time of the construction of such mains or other works or not*, or the currents in such circuits. If any question arises as to whether the Undertakers have constructed their mains or other works, or worked their undertaking, in contravention of this sub-section, such question shall be determined by arbitration, and the Undertakers shall be bound to make any alterations in, or additions to, their system which may be directed by the arbitrator.

Provided that nothing in this sub-section contained shall be held to deprive the owners of such electric circuits of any existing rights to proceed against the Undertakers by indictment, action, or otherwise in relation to any of the matters aforesaid.

**For Protection of Telegraphic and Telephonic Wires.**

B. Seven days before commencing to lay down any electric line, or to supply energy through any electric line in any manner whereby the work of telegraphic or telephonic or electric signalling communication through any wires or lines lawfully laid down or placed in any position may be injuriously affected, the Undertakers shall, unless otherwise agreed between the parties interested, give to the body or person for the time being entitled to such wires or lines notice in writing specifying the course, nature, and gauge of such electric lines, and the amount and nature of the currents intended to be sent along the same, and the extent to, and manner in which if at all earth returns are proposed to be used, and the Undertakers shall conform with such reasonable requirements as may from time to time be made by such body or person as aforesaid for the purpose of preventing the communication through such wires or lines from being injuriously affected as aforesaid.

If any difference arises between any such body or person and the Undertakers with respect to the reasonableness of any requirements so made, such differences shall be determined by arbitration.

Provided that nothing in this section shall apply to repairs or renewals of any electric line so long as the course, nature, and gauge of such electric line, and the amount and nature of the current sent along the same, are not altered.

If the Undertakers make default in complying with any of the requirements or restrictions of this section they shall make full compensation to the body or person entitled to any such wire or line for any loss or damage

Digitized by Google

which they may incur by reason thereof, and in addition thereto they shall be liable to a penalty not exceeding five pounds for every such default, and to a daily penalty not exceeding forty shillings. Provided that the Undertakers shall not be subject to any such penalties as aforesaid if the Court having cognisance of the case shall be of opinion that the case was one of emergency, and that the Undertakers complied with the requirements and restrictions of this section, so far as was reasonable under the circumstances, or that the default in question was due to the fact that the Undertakers were ignorant of the position of the wires or lines affected thereby, and that such ignorance was not owing to any negligence on the part of the Undertakers.

*Proposed Clause.*

**For Protection of Telegraphic and Telephonic Wires.**

16. (1) The Undertakers shall take all reasonable precautions in constructing, laying down, and placing their electric lines and other works of all descriptions, and in working their undertaking so as not injuriously to affect, whether by induction or otherwise, the working of any wire or line from time to time used for the purpose of telegraphic, telephonic, or electric signalling communication, or the currents in such wire or line, whether such wire or line be or be not in existence at the time of the laying down or placing of such electric lines or other works. If any question arises between the Undertakers and the owner of any such wire or line as to whether the Undertakers have constructed, laid down, or placed their electric lines or other, works or worked their undertaking in contravention of this sub-section, and as to whether the working of such wire or line, or the current therein, is or is not injuriously affected thereby, such question shall be determined by arbitration, and the arbitrator (unless he is of opinion that such wire or line, not having been so in existence at such time as aforesaid, has been placed in unreasonable proximity to the electric lines or works of the Undertakers) may direct the Undertakers to make any alterations in, or additions to, their system so as to comply with the provisions of this section, and the Undertakers shall make such alterations or additions accordingly.

(2) Seven days before commencing to lay down or place any electric line or to use any electric line, in any manner whereby the work of telegraphic, or telephonic, or electric signalling communication through any wire or line lawfully laid down, or placed in any position, may be injuriously affected, the Undertakers shall, unless otherwise agreed between the parties interested, give to the owner of such wire or line notice in writing specifying the course, nature, and gauge of such electric line, and the manner in which such electric line is intended to be used, and the amount and nature of the currents intended to be transmitted thereby, and the extent to and manner in which (if at all) earth returns are proposed to be used, and any owner entitled to receive such notice may from time to time serve a requisition on the Undertakers requiring them to adopt such precautions as may be therein specified in regard to the laying, placing, or user of such electric line, for the purpose of preventing such injurious affection, and the Undertakers shall conform with such reasonable requirements as may from time to time be made by such owner for the purpose of preventing the communication through such wire or line from being injuriously affected as aforesaid.

If any difference arises between any such owner and the Undertakers with respect to the reasonableness of any requirements so made, such difference shall be determined by arbitration.

Provided that nothing in this sub-section shall apply to repairs or renewals of any electric line so long as the course, nature, and gauge of such electric line, and the amount and nature of the current transmitted thereby are not altered.

(3) If in any case the Undertakers make default in complying with the requirements of this section, they shall make full compensation to every such owner as aforesaid for any loss or damage which they may incur by reason thereof, and in addition thereto they shall be liable to a penalty not exceeding five pounds for every such default, and to a daily penalty not exceeding 40 shillings. Provided that the Undertakers shall not be subject to any such penalties as aforesaid, if the Court, having cognisance of the case shall be of opinion that the case was one of emergency, and that the Undertakers complied with the requirements of this section, so far as was reasonable under the circumstances, or that the default in question was due to the fact that the Undertakers were ignorant of the position of the wire or line affected thereby, and that such ignorance was not owing to any negligence on the part of the Undertakers.

(4) Nothing in this section contained shall be held to deprive any owner of any existing rights to proceed against the Undertakers by indictment, action, or otherwise in relation to any of the matters aforesaid.

(5) In this section the expression "owner" includes any person entitled for the time being to the exclusive use of any such wire or line, as aforesaid.

Colonel Jackson representing the National Telephone Company, stated that to the best of his recollection there was no objection whatever to the old clause, which has been well and carefully considered in committee. He naturally felt that it was difficult for him to speak, since as far as that meeting was concerned he was in a minority of one, and indeed, as far as the Electrical Trades Section of the Chamber of Commerce is constituted, it is obvious that the important interests which he represents are not only very inadequately represented but are completely antagonistic in many respects to those of the Supply Companies. This meagre representation was considerably intensified by the fact that the telephonic interests have been so largely amalgamated, and on these grounds, before any discussion actually commenced, Colonel Jackson strongly protested against any resolution being taken and transmitted through the Council of the Chamber to the Board of Trade. He further stated that he did not think that the amendments had been sent to him. Mr. Sydney Morse remarked that they would be found in the new Model Order, and Mr. Crompton said that on finding that the Board of Trade were taking action in regard to these matters, which so seriously affected them (the supplies companies), they applied as parties interested and obtained the documents which had been read and which it was proposed to discuss. Colonel Jackson objected to a discussion taking place upon clauses whose bearing it was impossible to grasp after merely hearing them read over the table by the secretary. Every member, he said, should receive copies, and all discussions should be postponed until they have had time to give such copies their careful attention. It was, of course, open to those who are interested in the electric light companies to meet together and to make proposals and, indeed, to pass resolutions, but he protested again against drawing any authority of the Chamber of Commerce to such proposals or resolutions, when one of the interested parties was opposed by nineteen-twentieths of the section. Mr. Murray said that he would not fail to bring a strong representation to the Council of the Chamber, if a resolution should be sent up to them.

Mr. Sydney Morse then gave a sketch of the history of the action of the Board of Trade with regard to telephones. The original clause was agreed on by all parties, and related to the possible effects of the induction or leakage of the currents of supply companies upon neighbouring telephone circuits. The Board of Trade sent out a draft of the proposed amendments in November, and he at once forwarded them to the clients for whom he acted. On December 4th he sent in a strong objection to the Board of Trade, who took no notice whatever other than acknowledging the receipt of the communication. They inserted the clause in the City order without giving any notice, but upon the application of the City authorities a ready consent was given to the old agreed clause of 1889, which at the request of the Commissioners of Sewers was restored. It was very remarkable that the Board of Trade should take the initiative and should put forward a clause of this important character, without the request of the telephone companies, or without hearing the interested parties.

Colonel Jackson observed that had he known that Mr. Morse was going to represent the supply companies he would have asked Mr. Winterbotham to accompany him, in order that they might have exchanged ideas. Mr. Sydney Morse and Mr. Medcalf, who were also present, stated that they merely attended as members of the section.

Col. Jackson thought the feeling of the telephone company was that the "agreed clause" of the 1889 order was acceptable, and he was glad to hear that there was no opposition now raised to it. Mr. Garcke called attention to one of the most serious points, which was, that the supply companies may be called on to move their existing mains on account of telephone wires "hereafter to be laid down." Mr. Medcalf, however, pointed out that a proviso was made that the mains must be "constructed with reasonable precautions," and that arbitrators would have to determine what precautions were reasonable. Surely undertakers need not take precautions to avoid laying their mains in streets in the neighbourhood of which telephone wires might some day come.

In reply to an inquiry of a member, who asked for some details of a specific case in which the telephones had been seriously interfered with by induction or leakage from a supply company's system, Col. Jackson mentioned the Hop Exchange where the telephonic communication was seriously affected. Mr. Crompton said that the telephonic communication to his works at Lillie Road was very much disturbed when the House-to-House machinery was running; but he must add that the insulation of their mains was said to be practically perfect, so that the disturbance must be due to induction although the distance between them and the telephone wires was considerable, and that therefore the difficulties of the supply companies in conforming to these clauses would be enormous. He urged upon Col. Jackson that the telephone companies must sooner or later loop their circuits, and that their imperfect service had been hitherto largely, if not entirely, due to the absence of metallic returns, and he thought that if the supply companies hastened the looping they would be doing the best possible service to the telephone companies. Col. Jackson complained that the telephone companies had not statutory powers to lay their mains underground. To loop the overhead wires would inevitably rouse great indignation, but he was looping the communications between the exchanges. It was finally settled that Mr. Morse and Mr. Winterbotham should meet to discuss the clause, and that the engineering or scientific interests should also be represented.

The Board of Trade rules and regulations for overhead wires, formed the subject of a considerable amount of correspondence, and this was ordered to be printed for circulation among the mem-

Digitized by Google

bers of the section and those interested in the matter. It was observed that when these rules were first drawn up they were admitted to be of a tentative character, but the Board of Trade absolutely declined to alter them, and treated them as if they were settled for ever.

Some correspondence had been carried on between the Chamber and the Board of Trade with regard to the Electrical Standards Committee. This consists of a number of very eminent scientific men, but the electrical trades, including both those who make instruments and those who have to use them, were not in any way represented. The Board of Trade replied in most distinct terms, that they did not think it was desirable to add to the number. In a letter dated January 22nd, in reply to a further application, they consented to hear one or two witnesses, but with regard to the addition of names to the Committee they had nothing to add. In the course of a short discusssion, which ensued, strong opinions were expressed as to the action of the Board of Trade in attempting to legislate with regard to such standards without consulting those for whom the standards were to be constructed, and it appeared that to take the evidence of one or two engineers, who were in ignorance of the arguments before the Committee could be of little value.

Letters were read from Messrs. W. T. Goolden and from Major Flood-Page, with regard to a proposed electrical exhibition at St. Pancras, and another, of which Mr. Seymour Wade is the promoter. The feeling of the meeting was unanimously in favour of the opinions expressed in these letters, namely, that such exhibitions would be entirely useless, even if it were not for the fact that the Frankfort Exhibition will fully suffice for any firms who desire to exhibit during this year.

## AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *January* 13, 1891.

**The Chicago Exhibition.**—A good deal of interest has been aroused in electrical circles by the various questions that are raised in connection with the coming World's Fair in Chicago. Chief among these is the matter of appointing a suitable head for the electrical section of the exhibition. For the last six months there has been the liveliest kind of wire-pulling going on. Representatives of several prominent electrical companies were boldly advocated for this position, while others endeavoured to secure the appointment of some worthy scientific gentleman as a figurehead. At present, however, the candidate who seems to have the best chance of appointment is Mr. John P. Barrett, the City Electrician of Chicago. Certain electrical interests have bitterly opposed him on account of his uncompromising integrity; but his appointment is now well nigh settled, and will mean a vigorous and successful administration of the electrical section. Mr. Barrett is a man of great executive ability, and his long connection with the City of Chicago, as superintendent of its police and fire-alarm systems, and of its electric lighting and power plants, has given him a firm grasp of the practical side of electricity and an intimate knowledge of American electrical companies and their peculiarities.

**The Westinghouse Company.**—The financial difficulties of the Westinghouse Company, to which I have before alluded, have dropped the stock to a very low figure, but it does not at all mean that either the Company or Mr. Westinghouse is insolvent. A large amount of Preferred Stock is likely to be issued, and the proceeds of the sale of this, together with the half million loan recently negotiated by Mr. Westinghouse, will probably put the electric company on its feet again. It is likely, however, that its future management will be more businesslike and conservative than it has been in the past—that less money will be wasted in lawsuits and tied up in long credits.

**Electric Traction in Philadelphia.**—The city of Philadelphia is at present greatly exercised over the electric traction question. Attempts are being made to secure franchises in certain parts of the city for roads to be operated on the overhead trolley system, and these are being bitterly contested by various persons intimately or remotely interested in storage battery work. Just what the result of the contest will be no one can tell. Philadelphia is now afflicted with cable railroads, and an electric system would certainly be a boon to the travelling public in that city; but the storage battery party is an influential one, and while it has not yet given any evidence of accomplishing anything on its own account it may be able to block the way of its competitors.

NEW YORK, *January* 16, 1891.

**The Westinghouse Company.**—The financial condition of the Westinghouse Electric and Manufacturing Company is being watched with the keenest interest by the electrical public. It is hardly believed that a great and progressive corporation like the Westinghouse, which has done so much for the electrical industry in this country, can be forced to the wall by any temporary embarrassment such as has been produced by a tight Money Market and an extension of work beyond the proper capacity of the cash capitalisation. The Westinghouse Company has expanded its business to an enormous extent, and has apparently tied up its ready money where it is not altogether available. It has a capital of $6,500,000, and its approximate gross earnings for the last year are said to have been no less than $5,000,000. Contracts are rushing in, and the railway department alone has orders aggregating something like a quarter of a million dollars. Nevertheless the fact remains that the company is experiencing considerable difficulty in meeting its obligations. Mr. Westinghouse has thrown his private fortune into the gap, and secured by it the loan of $500,000, which was recently arranged with Pittsburg bankers. Three million dollars of Preferred Stock will be issued, and Mr. Westinghouse has just been in New York engaged in raising money for this purpose. The loan just mentioned is being held in abeyance until the Preferred Stock, or a sufficient quantity of it, can be floated. The advisory board of bankers that control this half million are indisposed to take the heavy administrative responsibility which would fall upon them in protecting their interests, if the company can be extricated from its difficulties by the issue of the Preferred Stock. Mr. Westinghouse's financial standing is of the best, and there is a strong disposition to help him over the present crisis. The real difficulty seems to have been, as I have indicated, that while the capitalisation of each of the Westinghouse companies is large, in the rush of business the ready money has been so far locked up in credits and patent rights that the working capital is hardly sufficient to meet the demands that are made upon it; in addition, an enormous amount has been spent in various lawsuits, not yet terminated, and the pressure of rival concerns have been brought to bear to increase the difficulties that have to be met.

**Electric Soldering Tool.**—A neat invention has just appeared in the shape of an electric soldering iron, and is now in experimental use in the works of a great oil company. At a recent test, its performance was everything that could be desired. It is of the same size, weight, and general shape as the irons ordinarily employed; can be brought up to and kept at the constant temperature that is found most suitable for soldering, and the expenditure of energy is not large, equivalent to about half a dozen incandescent lamps. The arrangement, as might be expected, is a heating resistance placed around the shank which supports a copper head of the form in general use.

**Proposed New Methods of Rapid Transit.**—Active steps have been taken to secure the passage of proper legislation to enable the City of New York to extend its facilities in this direction, and a number of engineers have recently come to the front with all sorts of practical and impracticable plans for securing the desired end. Some of the proposed roads are arcades, occupying nearly the entire space below the surface of the street; others viaducts that will require the purchase of enormous amounts of property; and still others, underground roads of a less pretentious character. The City and South London railway plan is making a very favourable impression here, and seems on the whole to be the most available method as yet suggested. Its cost would probably be about a million dollars a mile, but the engineering and financial difficulties to be met are very much less than in the case of the other suggestions which have thus far been made.

Digitized by Google

## AUSTRALIAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

SYDNEY, *December* 22, 1890.

During the last week the first fatal accident caused from electric lighting machinery occurred at the Sandhurst (Melbourne) station of the Australasian Electrical Company, where one of the assistant electricians in some way, which is not properly explained, received the full current from the dynamo, being killed instantaneously. The published account of the accident says that he caught hold of a switch above the handle, and thus received the shock, but does not explain the matter fully.

In Sydney, the City Council are moving at last in the question of electric light, but whether they are on the right track is open to question. The proposition now before the Aldermen is that a Commission be appointed, consisting of three aldermen and three engineers or electricians, the latter to be selected by ballot of the Aldermen. Should this Commission be appointed, it will probably be some months before their report will be submitted, and from experience of commissions of this kind in New South Wales, it is quite probable that, when submitted, the report will not be of any great assistance to the Council in deciding what had best be done. The Sydney public are now getting tired of dilatory tactics, and it is quite probable that before long a move will be made to force the civic fathers to show their hand.

The installation erected on the Westinghouse system by the Sydney Electric Light Company for the Borough Council of Newcastle will be started this week, and should be a great success, no pains having been spared by the contractors to ensure a thoroughly satisfactory result; the work has been carried out under the immediate supervision of Mr. Hitchcock, who was recommended by the Westinghouse Company, and this alone should be sufficient guarantee that this elsewhere successful system will be given a good send-off on this its trial trip in the Colonies. The street lighting comprises 400 twenty-five candle-power glow lamps, and twenty-three candle-power 2,000 arcs.

Messrs. Harrison and Whiffen, managers for the Crompton Australian Company, are busy carrying out a large installation at the works of the Proprietary Silver Mining Company, Broken Hill, New South Wales, whither Mr. Dymond has now gone to superintend the work. The Central Silver Mining Company, of Broken Hill, has also recently adopted electricity as an illuminant, the Sydney Electric Light Company being the contractors.

## CORRESPONDENCE.

### LAPSE OF THE TELEPHONE PATENT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Your editorial which appeared December 26, 1890, under the caption, "Lapse of the Telephone Patent," has struck me as being so one-sided, and therefore so unscientific. It presents the case with such partiality, that I venture thus to send a protest across the sea.

It is true that the subject of telephony was "in the air" in 1875, also that a number of physicists were at that time giving the subject much attention, and *therefore*, it seems to me the successful solution of the problem of the electrical transmission of speech was not an *easy* matter. The man finding the solution had accomplished a task upon which the best minds of the day were working. All honour and reward to the man. And surely any unbiased person who reads the records of the great telephone-patent battles fought in this country, must admit that Alexander Graham Bell was second to no man of that day in knowledge of his subject. His invention certainly was the result of patient investigation into the details of the whole science, and of the deliberate application, after long study, of the principles of harmonic telegraphy.

Gray's invention was for the purpose of transmitting articulate speech electrically. Bell applied for a patent to cover certain improvements in multiple telegraphy; but in his specification he distinctly stated, and illustrated the claim by a diagram, that the armature of his instrument could be vibrated by the human voice. Gray was endeavouring to patent a certain method of transmitting speech. Bell was endeavouring to patent a certain method of transmitting harmonic vibrations, speech included, music included, telegraphic signs included. Which was the broader invention?

Gray and Bell filed their applications in the United States Patent Office upon the same day, February 14th, 1876. They used practically the same principle, but different apparatus: nor does an inspection of Gray's first rude sketches strengthen his claims to the honour of priority of invention. A comparison of Bell's drawings with these is alone almost sufficient to convince one of the immense superiority of Bell's knowledge and inventive skill. If, therefore, Bell conceived his invention before Gray conceived his, the former was justly entitled to the patent right because of priority of invention. This was the point to be decided, and in the history of patent and civil law never were the two sides of a question more thoroughly or more ably presented. The whole world has read the decision of an honest and learned court.

It has been proven that several accounts of Bell's invention were published before he had made an application for British Letters Patent. In fact, his instruments were exhibited at the Centennial Exhibition in Philadelphia; so were Gray's: and this was before either had filed in England. Therefore, neither had a right, under British law, to a patent. But if the patent, by some hook or crook, was to be granted to anyone, surely Bell's claim was stronger than Gray's.

Your hymn of praise to Bell's abilities as a business manager is a fine instance of deductive reasoning. Because a man has made money, therefore he is a good manager. *Post hoc, ergo propter hoc!* Surely you have not read the records of the infringement cases the American Bell Telephone Company has fought. Why, the stock of this Company floated a-begging on the Boston Market here for months, with never a purchaser. Very frequently there was not enough money in their treasury to pay the workmen for their work at the end of a week or month. Nothing could better prove Bell's inexperience in those early telephonic days than the *abandon* with which he showed his instruments to all-comers in public and in private, and with which he published accounts of them before he had filed his applications for patents abroad.

Bell *believed* in his invention, worked for it almost to the point of desperation. How heroic was his struggle I have heard from the lips of men and women here and in Providence, Rhode Island, who knew him personally in those days. It forms a near parallel with the early efforts of poor Morse. Yes, it was Bell's indomitable will, his never-failing faith, his opportune luck, which placed the Company upon that sound financial basis that has enabled it to carry the great inventor's fame over the whole earth.—Yours, &c., OTIS K. STUART.

Boston, Mass., January 15, 1891.

### ELECTRIC AND MAGNETIC THEORIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I began of late to feel "blue moulded for want of a batin'," so p. 375 is quite refreshing. In reply to Mr. Heaviside, no doubt I could conceive what he suggests, as I have a fairly vivid imagination. But then the doing so would be doing the very thing I protest against. All I *know* about ether is that it has none of the properties by which we define matter. For my own part, I see no necessity to import it into electrical problems; why should I, then, "conceive" it to be what I know it is not? The people who do so try to conceive it give me no inducement, because they all differ. Ether used to be an infinitely elastic and incompressible fluid, capable of transmitting undulations: when it was dragged into electricity it was discovered that a fluid would not work; then it was made into a jelly, which also would not suit; then it became a mass of rotating wheels, which would lock or slip just as required. Now, as none of these answer (p. 360), Sir W. Thomson "has brought out a new ether, incompressible, with no true rigidity (what about the thousand millions times more rigid than steel?) but with a "quasi rigidity" of any kind required. Well, I will prophesy that when electricians have perfected *their* ether, it will refuse to transmit light, and how shall we get on then?

Clerk Maxwell said "Since the theory of direct action at a distance is mathematically identical with that of action by

Digitized by Google

means of a medium, the actual phenomena may be explained by one theory as well as by the other, *provided suitable hypotheses be introduced when any difficulty occurs.*" Of course, we can explain anything if we may use hypotheses; but are we any wiser? I consider that suggestion a grave crime against scientific morality. It corresponds to passing forged coin, or drawing cheques on a bank where there are no assets. Unfortunately it is becoming a common practice, and all these new notions are constructed by means of this fictitious capital.

Let me assure Prof. S. P. Thompson that I do not feel at all like a fossil. My idea is that it is better to travel by a good sea-worthy ship or a well-built railway than to get into a balloon and be blown about by every "wind of doctrine." I really hope he will not "cast aside" or much modify his excellent little book; if he re-writes it on the new lines it will become "a bar to progress." He will make it into a balloon. I must thank him and Dr. Lodge for a very enjoyable laugh. When I began to write some twenty-five years ago I was denounced as a thorough heretic; all my ideas were wrong, and I was a most presumptuous person. The professors of that day looked down on me as "not orthodox." Now I am told by the professors of this day that I was at that very time "so far ahead of the current science of the time" (Prof. Thompson), and that I had then "arrived by my own methods and insight at various true ideas when the ordinary text-books were very much at sea" (Dr. Lodge). I know that what I then taught as new doctrine has since become "orthodox;" and I have a strong expectation that, in like manner, my present heresy will become the orthodoxy of the future, when the professors return to the recognised ways of true science, and, giving up their cloudy hypotheses and pretended "explanations," recognise that they cannot possibly explain what they do not understand, and so seek patiently for what they can learn from nature.

I should be sorry indeed, to misrepresent any of the sayings of Prof. S. P. Thompson (or anyone). I most earnestly desire to do full justice to every worker in science, and he is a very good one. My reference was to his words (Vol. XXIV., p. 137), "The energy of a so-called electric current is not transferred *longitudinally* along the substance of the conducting wire (as used to be supposed), but is transferred into it sideways, travelling, not along the wire, but across the insulating medium which surrounds it. The truth that insulators convey the energy and do not dissipate it, whilst conductors (so called) dissipate the energy and do not convey it, is a hard saying to the half-educated electrician." He also says, "No electrician who has taken the trouble to study the facts, and has the capacity to follow their inescapable consequences, can fail to learn" all this. Well, I have taken a great deal of trouble (not over the facts, for I cannot discover that anyone has shown them), and as to capacity, that is a matter of opinion; but I am ready to maintain that the old doctrines are the truth, and the new ones cunningly devised fables; that the so called conductor *is* the conductor of current and of energy; that the insulator and surrounding medium do dissipate and do not conduct energy *longitudinally;* that they in no degree transmit the energy from the source to the work, as the new doctrines teach, but that they produce, as Faraday taught, and as everyone believed, till mere hypothesis overrode observation and induction, *retardation* of current and *loss* of energy.

In reply to specific questions. Yes, I will maintain "that Ohm's law, pure and simple, is applicable to alternating currents." But *distinguo*, as the casuists say; let us clearly separate form and substance—the law, which corresponds to the facts of nature, and formulæ, which apply it to specific conditions. When a "variable period" is under consideration a variable function operates, and must be represented in the formula without affecting the law.

No. I certainly will not fly in the face of facts; they are all on my side. But Prof. Thompson has shifted his ground. He questions me now as to the transfer of energy *laterally* through the medium. But that is dissipation of energy—retardation. The point in debate is the *longitudinal* transfer of energy. That makes all the difference; the lateral effects of the current are among the most important data in all my teachings, a fundamental element of my theory that the molecular and atomic structure of matter and the effects of energy among the molecules and atoms amply explain all the real facts of electricity.

But I cannot pretend to treat the subject itself now, as I must needs employ illustrations, so I will defer the attempt.—Yours, &c., JOHN T. SPRAGUE.

## BOULT'S WIRE TABLE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am much obliged for the care with which your review of this table has been prepared, and glad to find your testimony added as to its usefulness. Will you kindly allow me a few words in explanation, called for by some of your remarks?

Although the number of columns is, as you say, 452, the number of conductors dealt with is 469, owing to different gauges containing in a few cases conductors of exactly the same size. In these cases the names of the gauges are put side by side in the same column—*vide* columns Nos. 387, 390, &c. The size of page is crown 4to., not folio.

Your objection to "circular mils" is answered by the fact that, whatever may be thought of this method of expressing the area, it is largely used in America, and, if omitted, the *international* character of the table would have been lost; and it is the readiness with which particulars given in the system of one country are converted into that of another country that constitutes a special feature of the book.

Coming now to the small discrepancies pointed out in regard to stranded cables. As explained in the preface, the allowance for lay of strands has, in the case of S.W.G. cables, been copied from the list of the Silvertown Company, while in other cases "a very close approximation" has been obtained by the addition of suitable percentages. This is the best I could do, and is, I am sure, all that is required for practical purposes.

In regard to resistance, I have, as you point out, simply followed the usual custom, and, in default of an authoritative statement on the subject, cannot see what other course was open; though agreeing with you that the resistance of a single strand (I presume you mean only the net length of the cable), divided by the number of strands in the cable, would give a "safer" figure. The difficulty is that it might be too safe.—Yours, &c., W. S. BOULT.

Liverpool, January 24, 1891.

# LEGAL INTELLIGENCE.

### Allison v. the City and South London Railway Company.

On Friday last Mr. RENSHAW, Q.C., mentioned the above matter to Mr. Justice Kekewich, in the Chancery Division of the High Court of Justice. He said he appeared for the plaintiff, Mr. Allison, who was one of the trustees of Mr. Spurgeon's home for poor boys (the Stockwell Orphanage), and the object of the application was to obtain an injunction restraining the defendant Company from so working their railway as to become a nuisance. The defendants worked their railway by electricity, and the noise that was caused in the generation of the motive power had become so great as to be a nuisance to most people in the neighbourhood, but particularly to the Institution of which the plaintiff was a trustee. Since the notice of motion had been served an undertaking had been entered into by the Company by which they bound themselves not to work their engines or machinery, between the hours of 11 o'clock at night and six in the morning, in such a way as to cause complaint, over next motion day. These terms the plaintiff was willing to accept, and the motion therefore stood over until to-day.

### United Telephone Company and Another v. Andrew Erskine Muirhead.

In this action the United Telephone Company and the National Telephone Company sue Andrew Erskine Muirhead, merchant, Cart Forge, Crossmyloof, Glasgow, in the Scotch Courts, to have the defender interdicted from infringing the letters-patent, dated July, 1877, granted to Thomas Alva Edison, of Munlo Park, New Jersey, U.S.A., for the invention of "improvements in instruments for controlling by sound the transmission of electric currents, and the production of corresponding sounds at a distance," and from making, using, and exercising or vending during the continuance of the letters-patent the invention described therein. £500 is sought in name of damages for the alleged infringement, and delivery is also sought of all instruments possessed or controlled by the pursuer, including the "Ader" transmitters, which are made in infringement of the letters-

Digitized by Google

patent, and also all instruments made according to the manner described in the letters-patent dated December, 1876, granted to William Morgan, of Brandon and Morgan-Brown, engineers, London and Paris, for the invention of "improvements in electric telephony (transmitting or causing sounds for telegraphing messages) and telephonic apparatus," a communication from abroad by Alexander Graham Bell, of Boston University, U.S.A. The letters-patent in question are vested in the United Telephone Company, subject to certain rights to the National Telephone Company. The pursuers say that the defender has been violating their letters-patent by erecting telephone transmitters and receivers of the "Ader" type. The defender says that the statements of the pursuers, so far as material, are unfounded in fact, and that he ought to be assoilzied.

The record was closed on Saturday, and the case sent to the Procedure Roll.

## TRADE NOTES AND NOTICES.

Sale by Tender.—We have received from Messrs. Wheatley, Kirk, Price, and Goulty, a schedule of the British and Foreign Patents, fixed and loose Plant, &c., connected with Messrs. Smith and Moore's patent safety system of coal getting, which are on sale by public tender. Tenders should be sent in to 52, Queen Victoria-street, London, E.C., not later than Noon on Monday, the 2nd February.

Eastern Electric Light and Power Company, Limited (in Liquidation).—A meeting of the creditors of this Company is to be held at the offices of Mr. Latimer Clark, 11, Victoria-street, London, S.W., on March 2nd, at 1 p.m., to receive the liquidators' accounts.

Casings for Electric Wires.—Mr. F. A. Fawkes, of Chelmsford, sends us an illustrated list of casings arranged for use as skirtings, dado rails, picture rails, cornices, &c. Some of these are enriched with composition ornaments of excellent design. The grooves for the wires are parabolic, and the capping is thick enough to prevent curling.

## COMPANIES' MEETINGS.

### Elmore's Foreign and Colonial Patent Copper Depositing Company (Limited).

The second annual ordinary general meeting of this Company was held at the Cannon-street Hotel yesterday, Sir John H. Morris presiding.

The SECRETARY (Mr. J. Shurmer) read the notice calling the meeting, and the Directors' report and statement of accounts were taken as read.

The CHAIRMAN said that the position and prospects of the Company as they stood on December 31st last were set forth at such length in the report and accounts which had been circulated among the shareholders that there was not very much left for him to say on the present occasion. He must, however, congratulate the shareholders on the realisation of the hopes held out by him at the first general meeting of the Company held in October, 1889, when he stated that the Directors had the fullest confidence in the value of the Elmore inventions, and that, declining to negotiate the sale of the foreign patents until the success of the Company had been proved in this country, they would be able to obtain much better prices for them than if they disposed of them at once. This had proved to be the case. The success of the Elmore Company had, he thought, been clearly shown by the Company in this country, and they were now in a position to estimate pretty clearly the value of their patents for the various countries to which they wished to dispose of them. They had already, as the shareholders were aware, during the past year disposed of the patents for France, Austro-Hungary and Germany, and had thereby acquired a considerable sum from which they had already paid £4 per share to the priority shareholders, and they now proposed to pay another £1. They also hoped during the course of the present year to dispose of patents to two or three other countries, and if their hopes were realised, they trusted to obtain thereby a further sum, which would enable them to pay another £5 to the holders of the priority shares, and also leave sufficient to pay some dividend to the holders of the founders' shares. Before proceeding to notice the balance-sheet and profit and loss account, he wished to say a few words on the issue of £50,000 Debenture Stock by the French Elmore Company which this Company had agreed to take from that Company. It had been remarked to him by more than one of the shareholders that they saw no reason why they should have agreed to take this large amount of Debenture Stock from the French Company, and that it would have been much better to have left that Company to get any further capital it might require, either from its own shareholders or the investing public. He wished, therefore, to say a few words as to their reasons for acting as they did. On the formation of the French Company it was found to be of the greatest importance not only in the interests of that Company, but also indirectly in those of this Company, to secure the services of M. Secrétan as manager of the French Company. It was also found that those services could not be secured without at least £50,000 more working capital being raised, and it was, thirdly, discovered that in the then unsatisfactory state of the Money Market it was not possible to obtain this sum either from the investing public or from the shareholders of the French Company. There was nothing, therefore, left for the Directors, on an application from that Company, but to agree to advance this sum, provided that they were satisfied with the nature of the security offered to them. That security was that the Debentures should be secured by a first floating charge on the whole of the assets of the French Company; that they should pay interest at the rate of 6 per cent.; that the £50,000 advanced should be repaid within three years from the 1st of January of the present year—that was to say, by the 1st of January, 1894—or within any shorter period at the option of the French Company; and that they should be paid off at the rate of £105 for every £100 of stock. The Board considered those terms favourably, and while they were of opinion that the security was good, and that it was very much to their interests to promote those of the French Company, they agreed, especially as they held 33,000 shares of that Company, to these terms. The Directors were of opinion that the security offered by those Debentures was very good, and that the Debentures themselves were a very good and safe investment, so much so that applications had already been made to them on behalf of the French and their own Company to take up a portion or the whole of these Debentures. They proposed, therefore, to issue a circular to their own shareholders, and also to those of the French Company, offering them the Debentures on the same terms on which the Directors themselves accepted them; and he had only to add that, in the event of any considerable portion being subscribed, they would be in possession of a further amount of funds, which would enable them to pay a further cash dividend to the holders of priority shares. He trusted, therefore, that the action of the Board in offering to take up that £50,000 of Debentures of the French Company would meet with the approval of the shareholders. Taking the profit and loss account on the credit side, the first item, as they would see, was that the net amount received by the Company from the sale of its French, Austro-Hungarian, and German patents was £257,750. From this amount they had deducted £30,000, to represent the original capital value of the patents sold, leaving a net amount, after adding certain items of interest and transfer fees, of £228,341. Upon the debit side of the same account the balance brought forward was £1,879, being the deficit in respect of the first nine months of the Company's existence, during which, as they were aware for the reasons he had given them, no patents were disposed of. The next item was Directors' fees, and was fixed in accordance with the Articles of Association, and the succeeding one was maintenance of patents and legal charges. Owing to the large number of patents they held, the maintenance and legal charges amounted to the considerable sum of £1,270. After allowing for sundry working expenses, there was a balance carried down of £222,772. Out of this amount they had already paid an interim dividend of £4 a share on the priority shares, which absorbed £60,000, and under Clause 72 of the Articles of Association the Directors were entitled after the payment of a certain dividend to £10,605. This amount might appear very large, and probably they would be very much questioned about it. At the same time, he might point out that the amount was fixed by the Articles of Association, and he could hardly see that the Directors had any option in the matter unless the shareholders called upon them to forfeit the amount. Some might think that the work done for it was inadequate, but he could only say, having had a great deal of trouble and anxiety, and having spent many sleepless nights in connection with the Company, he did not think that their remuneration was altogether unearned. He believed that, strictly speaking, they were entitled to this amount in cash, but he need hardly say that they did not intend in any way to insist on that. It might be distributed to them partly in cash and partly in shares and Debentures as might be found convenient to the Company, and most conducive to its interests. The Directors would be prepared to take the amount in any way the shareholders might desire. Turning to the credit side of the balance sheet, they found the purchase of patents accounts credited with £110,000, which they had reduced to £80,000, by writing off £30,000, which represented the original capital value of the patents sold. Sundry debtors amounted to £22,722, but as the accounts were made up to December 31st last, he might inform them that this amount had since been paid off in full. The securities next shown were Elmore's French Company, 33,250 shares of £2 each, or £66,500; Elmore's Austrian Company, 31,075 shares of £2 each, or £62,150; and debentures in the latter, £50,000. The shares were valued at their nominal value and the debentures at par whereas they stood now at a higher price in the market, and would increase in value. The French Company's works were being rapidly pushed forward, and the contractors were under a penalty to complete the same by the end of May; and, in fact, according to the report of Mr. Secrétan, they would be in operation by the end of June next. The Austro-Hungarian Company had also selected admirable works, and had every hope of getting to work shortly after the French Company. The cash on hand and at the bankers amounted to £37,691, office furniture and fixtures £128, making a total at the credit side of the balance-sheet of £319,192. The share capital amounted to £120,000, and the various creditors at the date of making up the accounts represented £47,025. This item might require a little explanation. It consisted of three principal items. The first was a certain amount which was then due, but since paid off, on account of promoting, undertaking, and bringing out the French and Austrian companies; secondly, a percentage due to the Directors, as shown under the profit and loss account; and, thirdly, income-tax due to the Commissioner of Inland Revenue. There was only one other point on which he would like to say a few words. It was a question of very great importance, and he would be glad either now or at some future time to be favoured with the views and, if necessary, the advice of the shareholders upon it. It was the question of the realisation of the securities held by the Company. They would recollect that the matter was taken up and noticed particularly in a circular issued to them on November 13th last. Having referred to the salient features of the subject, as dealt with by the circular in question, he went on to say that there were three courses open to them. The first was the formation of an Elmore Trust Company; the second was that they should hold the shares themselves, realise the profits from them, and distribute these profits among the shareholders; and the third was that they should hold a special meeting, and alter the articles of association, and so become empowered to distribute those shares just in the same way

Digitized by Google

as if they were cash. It was a matter that would require very great consideration on the part of them all. The Directors would be prepared to meet the shareholders and discuss the subject with them before coming to any final decision. At any rate, before any decision was come to the shareholders would be fully taken into their confidence.

He concluded by moving the adoption of the report and accounts.

Mr. MACFARLAN seconded the motion.

Mr. HOSTER spoke at some length on the question of the expediency of the realisation of the Company's surplus capital, merely keeping something in hand for working capital, and moved an amendment to this effect. He considered the Company's property one of the finest he had ever known.

Mr. SIMPSON seconded the amendment.

The SOLICITOR pointed out that the amendment was out of order, and could not be put to the meeting; and that, until the Articles of Association were altered, they would have to go to the Court of Chancery for power to divide the funds in question. He suggested as an alternative course that a small committee of shareholders might be formed to confer with the Directors as to the best way of providing for the distribution of their assets, and when that was done the recommendations of the Directors and of such committee might be submitted to a meeting of the shareholders.

Mr. LOUIS RANDALL then proposed, and Mr. CHANCE seconded, an amendment, in effect requesting the Directors to consider the practicability of making a distribution of the money among the shareholders, and meantime adjourning the discussion on the report and accounts till a future meeting.

Mr. F. L. RAWSON gave a short statement as to the company's patents, after which

The CHAIRMAN put the amendment to the meeting, which he declared lost.

The substantive motion for the adoption of the report and accounts was afterwards put, and declared carried.

The CHAIRMAN then moved—

"*That a dividend of* 20 *per cent., or* £1 *per share, less income tax, be paid on the February* 4*th next on the Priority Share Capital, making, with the interim dividend of* £4 *a share, paid on the December* 8*th last, a total dividend of* 100 *per cent. for the nine months ending December last.*"

Mr. E. J. CARSON seconded the resolution, which was agreed to.

The sense of the meeting was then taken as to whether a committee of shareholders should be appointed to discuss with the directors the question of the distribution of the surplus profits of the Company, or whether it should be left to the Board to submit recommendations to a special meeting to be subsequently convened.

The CHAIRMAN declared the show of hands in favour of the latter course, adding that if he saw his way to have the distribution made legally in the interests of the shareholders, he would do his best to have it done. It was a very thorny question, and one which would give them a great deal of trouble. At any rate, a special meeting would be called and the subject discussed.

The retiring Directors, Messrs. William Elmore, George Holmes, and John Macfarlan, were afterwards re-elected, as were also the Auditors, Messrs. Pixley & Co.

The following resolution, which was passed by the shareholders in general meeting on December 29, 1890:—

"*That once at least in every year the Board of Directors shall lay before the Company in General Meeting a statement of the income and expenditure for the past year, made up to December* 31*st, then last past, instead of to March* 31*st, as provided in Clause* 113 *of the Company's Articles of Association,*"

was, on the motion of the CHAIRMAN, seconded by Mr. CARSON, confirmed as a special resolution.

The CHAIRMAN, in reply to a vote of thanks to himself and the Board, proposed by Mr. Hoster, and seconded by the Solicitor, said that if the Directors were not, perhaps, deserving of all the praise which had been showered upon them by the proposer and seconder of the resolution, no one could have been more anxious to promote the interests of the Company than they were, and they would, he hoped, continue to be so.

The proceedings then terminated.

## Elmore's Austro-Hungarian Patent Copper Depositing Company (Limited).

The SECRETARY (Mr. J. Shurmer) having read the notice convening the meeting,

The CHAIRMAN said: It is quite needless in a meeting of shareholders in the City of London to tell them what a statutory meeting is; but I will say what it is not, and that is, that under ordinary circumstances it is not a meeting for business. Usually the shareholders and Directors meet face to face, the Chairman makes some statement as to what has been done since the Company was registered, makes his bow, and the meeting is at an end. But to-day the Board have thought it well to utilise the meeting to avoid calling you together on another occasion by placing before you the resolutions which you have just heard read. With regard to these resolutions, I defer any reference to them until I have said a few words as to what your Directors have done since they were entrusted with the management of your affairs. The Company was registered nearly four months ago, and we have had in that time to meet very frequently to get through the number of legal formalities which are necessary from the nature of this Company. You may, of course, be very well aware that it is much easier to start a company to do business in England than it is to start an English company in a foreign land to do business in that land; and especially as this business is based upon patents we had the formalities in reference to them to get through besides to get the necessary Government licence for trading. In order to do that a solicitor has taken the proper steps. I may say before that that as far as the English formalities go everything has been done and is perfectly complete. We have taken the absolute transfer of the Austro-Hungarian patents, and in regard to Austria itself everything is going on as fast as possible through the assistance of our legal representative in Vienna. But again another difficulty arises, inasmuch as that is a sort of double-barrelled country. You may well understand that we have had a great deal to do in arranging for getting through the earlier stages of the matter, but at the same time we have not been idle with regard to the carrying on of the business. We have not waited for the completion of these formalities before setting to work. Our General Manager, Mr. Stephen Rawson, has been in Austro-Hungary, and has inspected a number of sites for works, and taken into consideration the commercial and geographical advantages or disadvantages of all the different sites offered to us. Under his advice, we have gone so far as this, that we have decided, provisionally of course, upon a site in a remarkably good situation for the transport both of our raw material and finished products, as well as for cheapness of fuel and abundance of labour, and we have the option of land for our purposes in the site that I refer to. We have also negotiations in hand for a portion of our work being carried on through existing industrial agencies, which I would rather, however, not refer to now, more particularly as it might interfere with the progress of the negotiations. As regards Germany, you are aware by the circular which has been addressed to you that not long after we started the Austro-Hungarian Company we had an opportunity of acquiring the German wire patents and the other rights arising from them and from the Elmore process generally in Germany. We thought it was of extreme importance that we should acquire these rights, because Germany is really a larger field for this kind of manu-

PATENT

SILICIUM BRONZE AND SILICIUM COPPER WIRE.

The best for overhead Telephone and Telegraph Lines,

AND ALL ELECTRICAL PURPOSES.

Hard Drawn High Conductivity Copper Wire.

ROLLED AND DRAWN PHOSPHOR BRONZE.

PHOSPHOR BRONZE — VULCAN — PHOSPHOR — DURO METAL

PHOSPHOR BRONZE BEARINGS, BUSHES, AND OTHER PARTS OF ELECTRICAL MACHINERY

SOLE PROPRIETORS of the British, Indian and Colonial Patents,

THE PHOSPHOR BRONZE COMPANY (Limited),

87, Sumner Street, Southwark, London, S.E.

WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

Digitized by Google

facture than Austro-Hungary, and we hope probably better progress there than in Hungary. We have arrived at this stage that we are at the present moment in close negotiation for acquiring a very large and suitable manufactory which was built for another purpose on an exceedingly good site both for transport and other purposes. The manufactory is large and new, one portion of it being not quite finished. It has besides this most important feature: it has 550 horse-power of water-power, turbines quite new and perfectly fitted up with all the gear belonging to them. One important point in connection with the water supply which to any practical man is of great importance is that the dam in which our supply rests is not likely to break away as it is a natural rock. Besides that it has steam power, boiler power, and a fine chimney 100 feet high—in fact, everything necessary for our purpose—and Mr. Elmore, one of our colleagues and the founder of this process, is now in Germany with the object of completing the arrangements and obtaining the necessary plant, dynamos, and other mechinery. I have myself important letters from him in which he writes in the strongest way as to the importance of the property. Mr. Elmore went to Germany for the purpose of examining the different sites. He went there to meet a friend of mine and the result is what I am stating, that we are on the point of settling terms for this important site, and although we have not, like the French Company, a M. Secrétan to assist us, or a Hercules to call in to our aid, we are putting our own shoulders to the wheel, and we believe that if we do not beat the French Company we shall run a good second in the race. With regard to the process itself, I may take it for granted that you all know it. It is the manufacture of copper articles by a process which almost takes them from the raw and puts them into a finished state by natural and automatic means. It is a wonderful process. I have seen it myself, and I believe nothing more beautiful was ever invented. With regard to its value we have abundant authority from experts in this country, such as Dr. John Hopkinson, who reports in the highest terms as to its merits. We have also the testimony of such a practical man as M. Secrétan, an eminent French copper authority, as to its commercial value. We have allotted 50,000 shares, and they are largely paid up, much more so than we expected. They are allotted to about 580 shareholders, a tolerably large *clientèle*, and I am surprised not to see more of them here to-day. I think, however, when we see a meeting of this kind sparsely attended, it is *prima facie* evidence that the shareholders have confidence in the concern.

The following resolutions, proposed by the CHAIRMAN, and seconded by Mr. MACFARLANE, were then unanimously agreed to:—

"*That the name of the Company be changed to Elmore's German and Austro-Hungarian Metal Company (Limited).*

"*That Article 84 of the Company's Articles of Association be rescinded, and that the following new article be inserted in lieu thereof:—*

"*That the following clause be substituted for Article 84:—' The qualification of a Director shall be the holding of 200 shares of the Company; a first Director may act before acquiring his qualification, but shall in any case acquire the same within one month from his appointment, and unless he shall do so he shall be deemed to have agreed to take the said shares from the Company, and the same shall be forthwith allotted to him accordingly.'*

"*That Article 107 of the Company's Articles of Association be altered by omitting the following words at the commencement thereof:—*

"*'Notwithstanding anything in the last preceding article contained, or any rule of law or equity to the contrary.'*"

## NEW COMPANIES REGISTERED.

**LEEDS COPPER COMPANY (LIMITED).**—Registered by Kerly, Son and Verden, 14, Great Winchester-street, E.C., with a capital of £450,000 in £1 shares. Object, to acquire the undertaking of the Excelsior Copper Company (Limited) incorporated in 1888, including certain mines, mining claims, water and other rights and properties situate in the county of Megantic, in the Province of Quebec, Canada, and for such purposes to carry into effect an agreement made between the Excelsior Copper Company (Limited) of the first part, Charles Harrison Smith (the liquidator of the Company) of the second part, and the Company of the third part.

**NEW YORK BELTING AND PACKING COMPANY (LIMITED).**—The prospectus of this Company was issued early this week, and applications were invited for 7,000 ordinary shares of £10 each, 9,500 Preference shares of £10 each, and 1,000 Founders' shares of £1 each, being a portion of a total capital of £651,000, divided into £426,000 share capital, and £225,000 First Mortgage Debentures. The Preference shares are entitled to an 8 per cent. preferential dividend, and are also preferential as to capital. The ordinary shares are entitled to dividends up to 12 per cent., and the balance of profits (if any) is divisible, half to the ordinary shareholders and half to the holders of Founders' shares. The Debentures are divided into 2,250 Six per Cent. Debentures of £100 each, of which the present issue is 1,350. Interest is payable half-yearly, on January 1st and July 1st. Amongst the Directors are Mr. Samuel Pope, Q.C., Chairman of the International Okonite Company (Limited) and Director of Woodhouse and Rawson United (Limited). The Company is established to acquire the business of the New York Belting and Packing Company, of Connecticut, U.S.A., manufacturers of all kinds of india-rubber goods, &c. The lists opened on Monday last, and closed yesterday (Thursday) for London, New York, and Boston.

## CITY NOTES, &c.

**BRAZILIAN SUBMARINE TELEGRAPH COMPANY.**—The receipts of this Company for the week ended December 26th amounted to £6,367.

**CITY AND SOUTH LONDON RAILWAY COMPANY.**—The receipts of this Company for the week ended January 24th amounted to £742.

**ELECTRICITY SUPPLY COMPANY FOR SPAIN (LIMITED).**—This Company announce the issue of £75,000 Six per Cent. First Mortgage Debentures of £100 each, the price of issue being 98, payable as follows: £10 per debenture on application, £20 on allotment, £30 on March 2nd, and £38 on May 15th. The interest is payable half-yearly on January 1 and July 1, and the debentures are to be paid off at par on January 1st, 1901, or before that date, at the Company's option, at the price of £105 per £100 Debenture on six months' notice. The Company was formed in October, 1889, with a share capital of £100,000, which is fully subscribed and paid up. The present issue will form a first mortgage on the Company's freehold land, buildings, and machinery, and be a floating charge on all the Company's other property. The Company recently obtained an official quotation on the Stock Exchange. A supply station has been erected, and is regularly supplying electricity. The number of lights being supplied by the Company on the 31st December, being 11,987, in addition to 1,114 lights ready for connection, 2,068 lights being wired, and 1,429 lights on order, a total of 16,598 lights, most of which the prospectus states should be in work within the next three months. The managing director in Spain, Senor don Pedroy, Pastor Landero, gives the above figures in his report dated January 1st.

**ELMORE'S FOREIGN AND COLONIAL PATENT COPPER DEPOSIT COMPANY (LIMITED).**—Notice is given that the transfer books of this Company will be closed from January 28th till February 4th, both days inclusive, for the purpose of paying a dividend.

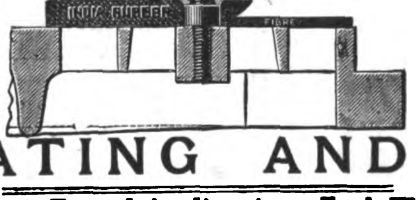
**CUBA SUBMARINE TELEGRAPH COMPANY.** — The Directors of this Company (after providing for the dividend on the Preference shares and placing £4,450 to the reserve fund) recommend a dividend on the ordinary shares at the rate of 8 per cent. per annum, tax free, carrying forward £715.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY.**—The traffic receipts of this Company for the week ending January 23, 1891, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £5,195.

**WESTERN UNION TELEGRAPH COMPANY.**—The numbers are announced of seven bonds of £200 each and six bonds of £100 each of this Company's Six per Cent. Sterling Loan, to be paid off on and after March 22nd next, at the office of Messrs. Morton, Rose, and Co., Bartholomew-lane, E.C.

NEW VALVE

No Rubber, Percha, or Leather.




One-half the price of Rubber or Metal.

FOR CIRCULATING AND AIR PUMPS.

Unaffected by any Lubricating Oils. Does not Expand in diameter. Feed Water may be worked at any temperature Suitable for any shaped guards. Only one quality manufactured.

"12, John-street, Sunderland, 20th Sept. 1888.

"DEAR SIRS,—In reply to your letter of the 25th inst., the Valves I got from you have done their work well, and ARE AN UNQUALIFIED SUCCESS. I will continue o get them from you as required.—Yours faithfully, JAMES WESTOLL."

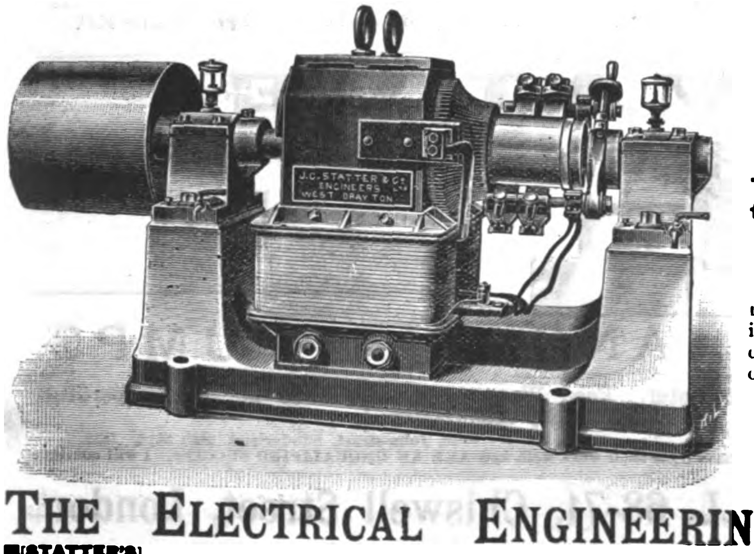
For further Testimony and Prices, apply to MOSSES & MITCHELL, 68-71, Chiswell Street, London.

Digitized by Google

# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name. | Previous Week's Price, Jan. 21. | | Price Wednesday, Jan. 28. | | Rate per Cent. Yielded. | Dividend Due. | Business Done During Week Ending Jan. 28. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **TELEGRAPHS.** | | | | | £ s. d. | | | |
| £1,381,380 | Stock | 15/0 | Anglo-American | 48½ | 49½ | 48 | 49 | 5 12 3 | Jan., Apr., July, Oct. | .. | .. |
| £3,809,310 | Stock | 30/0 | Do. Preferred | 85 | 86 | 85 | 86 | 6 18 9 | | 86 | 85 |
| £3,809,310 | Stock | .. | Do. Deferred | 13 | 13½ | 12½ | 12⅞ | .. | " " | 13¾ | 12⅞ |
| £250,000 | 100 | 4% | African Direct, Telegraph 4% Debentures | 98 | 101 | 98 | 101 | 3 19 3 | January and July .. | 99⅞ | .. |
| 130,000 | £10 | 3/0 | Brazilian Submarine | 11½ | 11¾ | 11½ | 12 | 6 5 0 | Mar., June, Oct., Dec. | 11¾ | 11½ |
| £84,500 | £100 | 5% | Do. 5 per Cent. Bonds | 102 | 105 | 102 | 105 | 4 15 3 | January and July .. | .. | .. |
| £75,000 | £100 | 5% | Do. 5 per Cent. Bonds (2nd Series, 1906) | 102 | 106 | 102 | 106 | 4 14 4 | June and December | .. | .. |
| $7,216,000 | $100 | 7% | Commercial Cable Capital Stock | 104 | 105 | 104 | 105 | 6 3 10 | April and October .. | 104½ | .. |
| 16,000 | 10 | 8/0 | Cuba Submarine | 11 | 12 | 11 | 12 | 7 1 8 | February and August | .. | .. |
| 6,000 | 10 | 10% | Do. Preference 10% | 16½ | 17½ | 16½ | 17½ | 5 14 3 | " " | 17½ | 17½ |
| 12,931 | 5 | 2/4½ | Direct Spanish (£4 paid) | 3¾ | 4¼ | 3¾ | 4 | 6 0 0 | April and October.. | .. | .. |
| 6,000 | 5 | 10% | Do. Preference 10% | 9 | 10 | 9 | 10 | 5 0 0 | | .. | .. |
| 60,710 | 20 | 3/6 | Direct United States | 10½ | 10¾ | 10½ | 10¾ | 6 15 0 | " " | 10½ | .. |
| 400,000 | 10 | 2/6 | Eastern | 14¼ | 14¾ | 14 | 14½ | 4 11 3 | Jan., Apr., July, Oct. | 14¼ | 14 |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference | 14¾ | 15½ | 14¾ | 15¼ | 3 18 8 | " " | 15½ | 15 |
| £1,200,000 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock | 105 | 108½ | 105 | 108 | 3 13 9 | May and November | 107 | 105¾ |
| £200,000 | 100 | 5% | Do. 5 per Cent. Debentures, 1899 | 108 | 111 | 108 | 111 | 4 10 1 | February & August | 108½ | .. |
| 250,000 | 10 | 2/6 | Eastern Extension | 14⅜ | 14⅝ | 14⅜ | 14⅝ | 4 15 9 | Jan., Apr., July, Oct. | 14⅝ | 14 7/16 |
| £320,000 | 100 | 6% | Do. 6 per Cent. Debentures, 1891 | 101 | 103 | 101 | 103 | 5 16 6 | February & August | .. | .. |
| .. | £100 | .. | Do. 4 per Cent. Debentures Stock | 102 | 104 | 103 | 105 | .. | .. | .. | .. |
| £91,800 | 100 | 5% | Do. 5 p. c. (Austin. Gov. Sub.) Debs. 1900 | 102 | 105 | 102 | 105 | 4 15 3 | January and July .. | .. | .. |
| £145,300 | 100 | 5% | Eastern & S. African 5 per Cent. Mor. Deb., 1900.. | 102 | 105 | 102 | 105 | 4 15 3 | " " | 103 | .. |
| 180,227 | 10 | 1/9 | Globe Telegraph and Trust xd | 9 | 9½ | 8¾ | 9¼ | .. | Jan., Apr., July, Oct. | 9½ | 9 |
| 180,042 | 10 | 6% | Do. 6 per Cent. Preference xd | 14¾ | 15 | 14¾ | 15¼ | 3 19 4 | " " | 15 1/16 | 14¾ |
| 150,000 | 10 | 5/0 | Great Northern | 16½ | 17 | 16¾ | 17¼ | 4 6 11 | Jan., April, and July | 17 | 16 11/16 |
| £130,000 | 100 | 5% | Do. 5 per Cent. Debentures, 1883 | 105 | 108 | 105 | 108 | 4 12 7 | March & September | .. | .. |
| 17,000 | 25 | 12/6 | Indo-European | 33 | 37 | 35 | 37 | 6 15 2 | May and November | 36½ | .. |
| 38,348 | 10 | 4/0 | London Platino-Brazilian | 6 | 7 | 6 | 7 | 5 14 4 | " " | .. | .. |
| £100,000 | 100 | 6% | Do. 6 per Cent. Debentures | 107 | 110 | 107 | 110 | 5 9 1 | March & September | .. | .. |
| 9,000 | 8 | 4/0 | Reuter's | 8½ | 9 | 8½ | 9 | 5 11 1 | April and October.. | .. | .. |
| 3,381 | £100 Cert. | 6% | Submarine Cables Trust 6% | 112 | 115 | 112 | 115 | 5 4 4 | " " | .. | .. |
| 15,609 | 10 | 4/0 | West African Telegraph | 8 | 9 | 8 | 9 | 5 11 1 | January and July .. | .. | .. |
| £290,900 | 100 | 5% | Do. 5 per Cent. Debentures | 98 | 101 | 98 | 101 | 4 19 0 | March & September | 99½ | 98⅞ |
| 30,000 | 10 | 3/0 | West Coast of America | 2 | 4 | 2 | 4 | .. | January and July .. | .. | .. |
| £150,000 | 100 | 8% | Do. Debentures 8% 1902 | 95 | 100 | 95 | 100 | .. | June and December | .. | .. |
| 88,321 | 10 | .. | West India and Panama | 2⅜ | 2⅞ | 2⅜ | 2⅞ | .. | .. | 2⅜ | 2 1/16 |
| 34,563 | 10 | 6/0 | Do. 1st Preference 6% | 11½ | 11¾ | 11½ | 11¾ | 5 2 2 | May and November | 11⅞ | 11⅜ |
| 4,669 | 10 | £3 | Do. 6 p. c. 2nd Pref. | 11 | 12 | 11 | 12 | 5 0 0 | " " | .. | .. |
| 64,174 | 15 | 6/0 | Western and Brazilian | 11¼ | 11¾ | 11¼ | 11¾ | 5 2 3 | " " | 11 7/16 | 11 7/16 |
| 27,873 | 7½ | 6/0 | Do. 5 per Cent. Cumulative Preferred | 6½ | 7 | 6¼ | 7 | .. | — | 6¼ | 6 5/16 |
| 27,873 | 7½ | 4/6 | Do. 5 per Cent. Deferred | 5 | 5½ | 4¾ | 5½ | .. | .. | 5 5/16 | 5 |
| £200,000 | 100 | 6% | Do. 6 per Cent. Debs., Series "A" 1910 | 103 | 106 | 103 | 106 | 5 13 2 | February & August | 105½ | .. |
| £250,000 | 100 | 6% | Do. 6 per Cent. Mort. Debs., Series "B" 1910 | 103 | 106 | 103 | 106 | 5 13 2 | " " | .. | .. |
| $1,336,000 | $1,000 | 7% | Western Union 7 per Cent. 1st Mortgage | 120 | 125 | 120 | 125 | 5 12 0 | May and November | .. | .. |
| £175,100 | £100 | 6% | Do. 6 per Cent. Sterling Bonds | 99 | 103 | 99 | 103 | 5 16 0 | March & September | .. | .. |
| | | | **TELEPHONES.** | | | | | | | | |
| 224,850 | 14/0 | 0/4½ | Consolidated Telephone Const. & Maintenance.. | [illegible] | [illegible] | [illegible] | [illegible] | .. | | .. | .. |
| 220,000 | £1 | 3% | Oriental (11s. paid) | [illegible] | [illegible] | [illegible] | [illegible] | 5 5 9 | May and November | .. | .. |
| 433,984 | 5 | 2/6 | National | 4¾ | 4⅞ | 4⅞ | 4⅞ | 5 12 10 | Yearly | 4 13/16 | 4⅞ |
| 15,000 | 10 | 6/0 | Do. 6 per Cent. Cumulative 1st Pref. | 12¾ | 13 | 12¾ | 13 | 4 12 4 | June and December | 12¾ | .. |
| 15,000 | 10 | 4/9½ | Do. 6 per Cent. Cumulative 2nd Pref (£8 pd).. | 10¼ | 10¾ | 10¼ | 10¾ | 4 9 5 | " " | 10 7/16 | 10⅜ |
| 209,750 | 1 | ½% | South of England, Ordinary | [illegible] | [illegible] | [illegible] | [illegible] | .. | " " | .. | .. |
| 20,000 | 5 | 2/1 | Do. 6 per Cent. Cumulative Pf. (£3 10s. pd) | 2¾ | 3¼ | 2¾ | 3¼ | 6 9 0 | .. | .. | .. |
| 58,000 | 5 | 5% | United River Plate | 3 | 4 | 3 | 4 | .. | .. | .. | .. |
| £146,128 | Stock | 5% | Do. 5 per Cent. Debenture Stock | 90 | 95 | 90 | 95 | 5 5 3 | January and July .. | .. | .. |
| £3,200 | 100 | 7% | Do. 7 per Cent. Debentures | .. | | .. | | .. | .. | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | | | |
| 209,000 | 5 | .. | London Electric Supply | .. | | 1¼ | 1¾ | .. | — | .. | .. |
| 43,900 | 10 | .. | Metropolitan Electric Supply (£8 paid) | 7¾ | 8¼ | 7½ | 8 | .. | .. | 8 3/16 | .. |
| 42,853 | 5 | .. | Westminster Electric Supply (£3 paid) | 3½ | 4 | 3½ | 4 | .. | .. | 3⅞ | .. |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | | | |
| 63,416 | 3 | .. | Brush Electrical Engineering | 2¼ | 2½ | 2¼ | 2½ | .. | | 2 7/16 | 2⅜ |
| 63,416 | 2 | 0/10 | Do. 6 per Cent. Preference | 1½ | 2 | 1½ | 2 | 6 0 0 | June and December | 1⅞ | 1¾ |
| 20,000 | 5 | 3/6 | Crompton and Co., 7 per Cent. Pref. Shares | 5 | 5½ | 5 | 5½ | 6 7 3 | January and July .. | .. | .. |
| 17,130 | 5 | .. | Edison and Swan United | .. | | .. | | .. | .. | 4½ | .. |
| 45,000 | 10 | 6% | Electric Construction | 6¾ | 7¼ | 6¾ | 7¼ | 8 5 5 | .. | 7½ | 6¾ |
| 70,000 | 2 | 10/0 | Elmore's Patent Copper Depositing | 3¾ | 4¼ | 3¾ | 4¼ | .. | .. | 4¼ | 3½ |
| 20,000 | 5 | .. | Fowler-Waring Cables (£4 paid) | 2¾ | 3¼ | 2¾ | 3¼ | .. | .. | .. | .. |
| 41,600 | 10 | 10/0 | India Rubber, Gutta Percha & Telegraph Works.. | 18½ | 19½ | 18½ | 19½ | 5 2 7 | February & August | 19½ | 19 |
| £300,000 | 100 | 4½% | Do. 4½ per Cent. Debentures, 1896 | 103 | 105 | 103 | 105 | 4 5 9 | March & September | .. | .. |
| 11,334 | £10 | 10% | International Okonite Limited Ordinary | 9¼ | 9¾ | 9¼ | 9¾ | 10 4 7 | .. | 9⅜ | .. |
| 11,334 | £10 | 8% | Do. Preference | 9½ | 9¾ | 9½ | 9¾ | 8 4 1 | .. | .. | .. |
| 78,949 | 5 | 4/10 | Swan United (£3. 10s. paid) | 4½ | 5 | 4½ | 5 | 6 19 10 | May and November | 4 13/16 | 4¾ |
| 37,350 | 12 | 12/0 | Telegraph Construction and Maintenance | 44 | 45 | 44 | 46 | 5 9 7 | March and July | 46½ | 45¾ |
| £150,000 | 100 | 5% | Do. 5 per Cent. Bonds, red. 1894 | 101 | 103 | 101 | 103 | 4 17 1 | January and July . | .. | .. |
| | | | **RAILWAYS.** | | | | | | | | |
| 50,000 | £10 | .. | City and South London Railway | 7 | 8 | 7 | 8 | .. | .. | 7 | .. |


# IMPROVEMENTS IN DYNAMOS.




## STATTER-BRUNTON DYNAMO.

**The latest design in the market, made with all the advantages of the latest scientific knowledge and the highest mechanical skill.**

The woodcut represents our B TYPE DYNAMO. A most efficient machine, working noiselessly, and without sparking or overheating; is highly finished and well proportioned. The output is so rated in our Catalogue that the machines may be worked very much in excess of their stated full output for short periods.

**STOCK SIZES UP TO 77 KILOWATTS.**

**MACHINES BUILT TO 500 KILOWATTS.**

**THE ELECTRICAL ENGINEERING CORPORATION, LIMITED,**

(STATTER'S) (UNITED.)

68, Victoria Street, London, S.W. Works:—ALLIANCE ENGINEERING WORKS, WEST DRAYTON, NEAR LONDON.


Digitized by Google

# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 664.—Vol. XXVI. FRIDAY, FEBRUARY 6, 1891. Price Fourpence.

## NOTES.

The application of electrical transmission of power to mining, which has engaged the attention of Messrs. Ll. B. Atkinson and Mr. C. W. Atkinson for several years, was the subject of a very interesting paper on Tuesday last at the Institution of Civil Engineers. To the paper itself we are debarred from alluding by the rules of the Institution; but having had some personal acquaintance with the matter, we take the opportunity of referring to it, now that the publication of the results has for the first time been made. A machine of a very crude form was used in a mine near Leeds for cutting coal in 1887, and was driven by rope transmission, with an efficiency probably not exceeding ten per cent. The manager thought otherwise; and it was not until a motor capable of delivering six horse-power was put to the work that he realised, by the continual breaking of the cutter-bars, how little power he had hitherto been using, and what an unfailing supply of energy could be provided by the use of electricity. The experimental machine to which the motor had to be fitted was a very primitive affair; but from the very first it was obvious that the coal-cutting by electricity would be a great success.

We cannot here explain the details of the work of "holing." Suffice it to say that it consists in undercutting the "face" of the coal walls. As done by hand, a cut some two or three, or even six, feet deep is made, and to allow room for the man to work while on his side, the width of the cut must be from 1ft. 6in. to 2ft. The cutting machine will cut 3ft. 6in., and has done 5ft., while the width of the cut is only about 6in., part of it being in the "parting" below the coal. The machine can be drawn along at about one yard per minute, and with a cut 3ft. 9in. deep 160 tons of coal can be won in a shift of eight hours, including stoppages for propping, &c. By the use of an electrical coal-cutting machine one man can easily replace four working by hand, and it is found that from 20 to 40 per cent. more large coal can be produced, partly on account of the narrowness of the cut, and partly by reason of the rapid and continuous progress of the work. The old cutter-bars, $2\frac{5}{8}$in. diameter, were continually broken, not unfrequently by having to take the whole weight of the machine when it left the rails. A $3\frac{1}{4}$in. bar is now used, and its design, together with the tools set in it, is a matter of considerable importance.

The subject contains many points of interest, and in many respects the teaching of experience has set aside theoretical ideas. The first motor was shunt-wound, in order to regulate the speed, and was provided with series coils for starting. It was naturally supposed that a series motor on such irregular work would run away when the load was removed. But it was soon found that the series winding offered important advantages, and as the friction increases at a much higher proportion than the speed, the theoretical difficulty disappears. The question of safety from explosions is also very interesting. The armature, as illustrated in a recent issue, is enclosed in an air-tight case. If an explosive mixture of air and gas were to penetrate into the casing, an explosion would, of course, take place, but if gas were to leak into the casing which previously contained air, it would quietly burn away before an explosive mixture could be formed, as it does in the ordinary miner's lamp. The gas, containing no little proportion of carbon would form $CO_2$, and when 14 per cent. of this is present any possible mixture of gas becomes absolutely inexplosive. It is satisfactory to learn that the experienced Government inspectors are quite satisfied on this point.

The little ceremony which took place outside the Mansion House on Tuesday may be taken as marking the close of the period of discussion and the commencement of actual work. Much as the cause of electric lighting has suffered in the past by ill-considered schemes, we are unable to regard the protracted labours and thirty-nine reports of the Streets Committee of the Commissioners of Sewers with quite the same degree of satisfaction as they themselves do, being of opinion that the lighting of even such an area as the City of London would not have been injuriously affected by a little more expedition. However, the final plunge once taken the City Commissioners in pleasing contrast to many other local authorities, seem disposed to afford the contractors every support, and the contractors in their turn may be trusted to carry out this important undertaking in a manner which shall reflect credit on all concerned. As to the financial success of the scheme, we see no reason to doubt it, provided ordinary prudence is observed, even though the City may not possess all the advantages from a central station engineer's point of view, as does the West End area, aptly termed by General Webber "the cream of the world." Apart from such considerations, however, the spirited policy of the Commissioners of Sewers may possibly cause those responsible for the lighting of the main streets and open spaces of our big cities to illuminate them in a style more befitting the end of the nineteenth century than is at present the case. The undertaking, therefore,

Digitized by Google

which was inaugurated on Tuesday has the good wishes of all who have the interests of electric-lighting at heart.

THE press visit to the Elmore Company's works, if it has not brought to light any information as to the commercial value of the copper, the cost of production, the probable price (for it is not even yet on the market), or the advantages which may be expected from Elmore wire, has at all events shown that some commencement has been made in manufacturing tubes, which are said to be used by brewers and calico-printers, and that the whole affair is something more than a mere catchpenny excuse for financial speculation and the promotion of companies. A process in which the density and mechanical qualities of the product depend on the elasticity of a few india-rubber bands, which press the burnisher against its work, must at present be considered unsatisfactory, while the only electrical feature that is offered is a 2 per cent. increase of conductivity, which is of little or no more importance than a 2 per cent. reduction of price. We hoped to have given some illustrations of the works, and we deferred the publication of the description, which will be found in another column, for this purpose; but the photographs sent to us proved to be quite unsuitable for reproduction.

AN example of the small importance with which a difference of 2 per cent. in conductivity is regarded in practice, is afforded by the correspondence elicited by our review of the excellent tables of Mr. BOULT. To test the question there raised, Mr. CONNOLLY has made measurements of the weight and resistance of a seven-stranded conductor, with a special short lay, and his results show that the divisor to give the resistance is 7·052, while the multiplier to give the weight is 7·142. There is an increase of conductivity amounting to ·743 per cent., while the weight is increased by 2.03 per cent. That the conductivity can never be proportional to the weight, is evident on a little consideration, though the exact calculation would be tedious, and might trench on Sir ROBERT BALL's favourite study of the mathematics of screws. If the strands were in perfect contact, the conductor might be considered as a solid piece of metal like clock-makers' pinion wire. It is obvious that the resistance and the weight of a foot of such wire when straight, must be less than a foot of the same when twisted to form an archimedian drill. The average weights given by Mr. CONNOLLY are of interest, and mount to an increase of 1 per cent., 1·843 per cent., and 2·44 per cent. for 7, 19, and 37 strands respectively. The difference between the increase of conductivity and the increase of weight in Mr. CONNOLLY's measurement is a little over $1\frac{1}{4}$ per cent., which is worth the consideration of those who point to 2 per cent. better conductivity as an important feature in a kind of wire which has been more talked about than used.

SINCE the days of ZAMBONI, a good dry battery has often been sought for, but the difficulties which arise from polarisation and local action have retarded any marked progress in this direction. The dry piles used by BOHNENBERGER and by FECHNER in connection with gold-leaf electroscopes were not intended to pass any current, but even for electrostatic purposes they were unreliable. Many attempts have been made of late years to construct batteries which, while not strictly dry, do not require continual attention and replenishing. Such a battery would be very useful for domestic bell-work, if it would save the great annoyance which is often occasioned by the sudden refusal of a battery to respond to the endeavours of a visitor to ring the front-door bell. Frequently the bell is at fault, since the complete silence is due rather to the fact that when the current falls below a certain point it fails to act at all, without passing through stages of faint ringing and mere trembling, corresponding to the gradual evaporation of the contents of the battery. Half-a-dozen dealers in electrical apparatus have dry batteries to offer, and among these the Gassner and Silvertown are well known, while the E.C.C. of the Electric Construction Corporation is one of the latest on the market, and we hear of others that are ready to be pushed. In another column we give an abstract of some tests of the Hellesen cell, from which a good deal more was demanded than need necessarily be expected from such a battery. Five ampere hours given in twenty-four hours through three ohms is a good output; but it is one which can hardly be expected from a dry cell. A really practical test would be to ring an electric bell once an hour for ten seconds at a time; if a battery can be made to do this for three years it would be very useful, especially if it were unaffected by climate and frost.

WE publish this week the results of an interesting study by Prof. NICHOLS, of the alternating electric arc between a ball and a point. As is well known, the sparking distance between two electrodes depends upon their size and shape, and if the terminals differ from each other in either of these respects, it is also found that the voltage needed to produce a spark depends upon the electrode which is made positive. Thus, if a ball and point are connected with some source of alternating potential it is possible to so adjust the distance between them that the arc only forms in one direction, in spite of the fact that the voltage is alternating. Some of the phenomena occurring under these circumstances are very curious; one of the most striking being the steady deflection produced on a high resistance galvanometer when shunted to the electrodes. The experiments seem conclusive as to the explanation of the phenomena, although the attempts made to utilise them for the purpose of alternate current measurement have as yet been unsuccessful. The method of investigation adopted, that of determining the instantaneous values of current and voltage for each moment of the cycle, is one which has been used with striking success by American electricians, and is the only satisfactory process where the more difficult phenomena caused by alternating currents have to be examined. Analytical and geometrical methods are only possible to the few, and the results yielded by them are too complex to be easily intelligible, besides being founded on doubtful assumptions regarding the sinuous character of the periodic changes in current and voltage.

COMPLAINTS have often been made that numerous patent agents in and near Chancery-lane exhibit conspicuous brass plates and other signs bearing the words "Patent Office." A

Digitized by Google

dozen or so of these impudent inscriptions, with which none of the first-class patent agents are connected, are obviously calculated to mislead the unwary. We have just had an experience of this kind ourselves, an arrangement having been made by one of our valued contributors to meet at the Patent Office someone who has a slight acquaintance with London. Although the latter was carefully warned, and the real building was described to him, he was fascinated by a staring brass plate, which he could not believe to be other than genuine, and so failed altogether to keep the appointment. On communicating with the Comptroller, and pointing out this clear case of deception and inconvenience, attended by the loss of time of two busy individuals, we are glad to learn that "the matter is now under consideration."

**Street Lighting in Paris.**—According to official returns, the public electric lighting of Paris comprises 297 arc lamps and 115 incandescent lamps.

**"The Manufacturer and Inventor."**—The new year's issue of this journal contains a remarkably well illustrated description of the City and South London Railway; also an illustrated supplement.

**Electrical Bills in Parliament.**—Among the Bills which have been formally brought in in the House of Commons are the London Central Railway, London Overhead Wires, and West London Tramway.

**Appointment.**—Mr. Bolton, assistant-superintendent of the Eastern Telegraph Company's London station, has been appointed the Company's superintendent at Liverpool in place of the late Mr. T. Moore.

**Chemical Society.**—The Chemical Society, having been founded in 1841, is now in the fiftieth year of its existence, and arrangements have been made to celebrate this important occurrence in the history of the Society on February 24th and 25th.

**Telephonic Development in Spain.**—Six telephone trunk lines are to be laid between Madrid and some of the most distant provincial capitals. It is also intended to connect all towns, including even the small ones, by telephone with the nearest telegraph station.

**Institution of Electrical Engineers.**—The annual general meeting of the students of the Institution will be held at the offices of the Institution, 28, Victoria-mansions, on Friday, the 13th inst., at 8 p.m., to hear the report of the committee on the last year's proceedings, and to elect a secretary and committee for the present year. All students are earnestly requested to attend.

**Technical Education in Lancashire.**—The Committee of the Lancashire County Council, in their report on technical education, recommend that the whole of the grant in aid, made under the Local Taxation (Customs and Excise) Act, 1890, should be appropriated for purposes of technical education, including agricultural and commercial instruction. The amount of the grant at the disposal of the county of Lancaster may be estimated at £39,000.

**The American Edison Company's Annual Report.**—The report shows a growing business of $10,000,000 per annum, with orders on hand for six months for 6,000 employés, the net earnings for the past year were 8 per cent. on the total stock, and the gross profits, allowing depreciation, $1,896,177. Plant sold shows an increase of 117 per cent. over the preceding year, and the output of the lamp works has increased 64 per cent., while its capacity has just been raised from 11,000 to 25,000 amps per day.

**Terrestrial Magnetism.**—M. Moureaux, of the St. Maur Observatory, is of opinion that he has found the cause of the remarkable deviation of the isogonic line when near Paris, a disturbance which extends across the Channel to the South Coast. He has found that centre line of the disturbance is coincident with a fault in the cretaceous strata to be found in north-west of France and the south-east of England, and he attributes the phenomenon to this fault, and not to the presence of iron ore deposits.

**Owens College, Manchester.**—The Council of this College will shortly nominate to one of the science scholarships offered by the Commissioners of the 1851 Exhibition. The scholarship is of the value of £150 per annum, and is tenable for two years. The scholar must devote his time to the prosecution of some special study with the view to advancing science or its applications to the industries of the country. Applications should be forwarded under cover to the Registrar not later than March 1st. For further details see our advertisement columns.

**Liverpool Overhead Railway.**—The Liverpool Overhead Railway is expected to be completed by the end of the present year. It extends along a dock line of nearly seven miles—that is, from Fort-road, Seaforth, at the north end of the Mersey Docks and Harbour Board estate, to the Harrington Dock at the south end. The railway will be a double line for passenger traffic only, and a traffic of 5,000,000 passengers is expected to be obtained during the first year's operations. Electricity, as has already been announced, is to be the motive power, and the particular system to be adopted is now under consideration.

**Edison Arc Light Dynamo.**—The Edison General Electric Company of America have recently brought out an arc light dynamo; the only feature of interest in it is the regulator which is attached directly to the dynamo base frame. It consists of a small flat piece of iron, pivoted near one pole piece, and a rack and pawl mechanism driven by a short belt from the dynamo shaft arranged to shift the brushes around the commutator in one direction or the other, as the governing armature is attracted more or less powerfully by the pole pieces. The field magnet is thus the controlling magnet of the regulator, as in the Hochhausen machine.

**Soldering Glass to Metal.**—At a recent meeting of the Société de Physique, M. Cailletet described a process of soldering glass and porcelain to metal. The glass tube to be soldered is first covered with a thin coating of platinum or silver, by treating it with a film of platinum chloride or silver nitrate and heating to dull red. A ring of copper is next electro-deposited on the platinised tube, which can then be soldered like any ordinary metallic tube. Solderings effected in this manner are said to be very strong. The top of a tube attached to M. Cailletet's apparatus for liquefying gases terminates in a soldered end, and successfully resists pressures of over 300 atmospheres.

**Electrical Standardising Institution.**—On Monday, February 16th, the first of what we believe will be a series of annual conversazioni, is to be given by Mr. and Mrs. Hammond at the Electrical Standardising, Testing, and Training Institution, Faraday House, Charing Cross-road. The Board of Control of this Institution consists of Lord Crawford, as Chairman, Lord Castletown, the Hon. Reginald Brougham, Mr. F. Francis Ince, Mr. W. O. Smith, and Mr. Hugh E. Harrison, who also acts as principal. It has just moved into the spacious premises built for it in Charing Cross-road, to which the appropriate name of Faraday House has been given.

**The Bradford Municipal Station.**—On Tuesday last week the Crompton-Howell battery ordered by the Corporation for the purpose of supplying current during the hours of light-load was formally switched on to the mains by Alderman Priestman. There has also been added to the plant at the works a Willans engine of 300 indicated horse-power, which drives a 5,000-light Siemens dynamo. The total available horse-power at the station is now about 800. Since the beginning of November three new feeding mains have been put down. When the works were opened, in September, 1889, there were 1,000 8 candle-power lamps connected. At the present moment 15,000 lamps are wired.

**The Cowles Process.**—The Cowles Electric, Smelting, and Aluminium Company, of Lockport, N.Y., have brought an action for infringement in the United States Circuit Court at Pittsburg, against the Pittsburg Reduction Company. Infringement is alleged on four patents, described as "improve-

Digitized by Google

ments in electric processes of smelting ore for the production of alloys, bronzes, and metallic compounds;" "an electric furnace and method of operating the same," and two improvements on the furnace. The Cowles Company claims that these patents, taken out in 1885 by Eugène and A. H. Cowles, are being used and operated by the Pittsburg Reduction Company for the purpose of making aluminium and alloys.

**Interchange of Electrical Statistics.**—A most important circular, says the *Electrical World* of New York, has recently been sent out by the Electrical and Allied Trades Section of the London Chamber of Commerce, dealing with the importance of a fuller interchange of ideas among the electrical engineers of all countries and a freer publication of the data obtained in the course of commercial work than is now possible. Of the enormous ultimate usefulness of such an organisation there can be no doubt. There has been far too much secrecy from purely commercial motives in the operation and administration of various electrical industries. In the long run, that course is best for all parties concerned that tends to improve the conditions under which electrical energy is supplied to the consumers.

**Personal.**—Mr. E. Garcke, formerly Manager and Secretary of the Brush Electrical Engineering Company (Limited), has been appointed Managing Director of that Company, and Mr. Broadhurst succeeds him as Secretary.——Mr. Wilson, late of the London Electric Supply Corporation, informs us that he has commenced business on his own account.——Mr. Orl V. Thomas, A.I.E.E., has resigned the position of Managing Electrical Engineer to the Taunton Electric Lighting Company, and has been appointed by the Crown agent for the Colonies to take charge of the installation at Singapore. The electrical staff of the company have presented Mr. Thomas with a photograph of themselves in a handsome oak frame.

**Expiry of Telephone Patents.**—The Bell patent expired on December 9, 1890, and the next important telephone patent to expire is that of Edison (No. 2,909 of 1877), which comes to an end on July 30th of the present year. This patent had originally 30 claims, the second of which ran as follows:—"In an instrument for transmitting electric impulses by sound, the combination with a diaphragm or tympan of an electric tension regulator for varying the resistance in a closed circuit, substantially as set forth." The life of the Hunnings' patent (No. 3,647 of 1878) terminates on September 16, 1892. This patent covers the use of a layer of finely powdered carbon, or some similar substance, between thin metallic diaphragms, as a telephonic transmitting device. The Blake transmitter patent expires on January 20, 1893. In this patent the electrodes are pressed against the vibrating diaphragm by means of adjustable springs. Finally, on February 1, 1893, Crossley's "compound microphone" patent expires.

**Regulation of Pressure.**—In a recent number of the *Elektrotechnische Zeitchrift*, C. Heim describes the following method of keeping the pressure at any point in a system of distribution perfectly constant under wide variations of load. A pressure wire is run from the switch-board to the point in question through the armature of a little electric motor, the magnets of which are separately excited from a source of constant E.M.F. The back E.M.F. of the motor will within certain limits be proportional to the current traversing it, and therefore to the loss of pressure on the line. The power developed by the motor is absorbed by a powerful spring. The angle of torsion of the spring is proportional to the power. Now the power being equal to the product of back E.M.F. into current the angle of torsion is a measure of the volts lost on the line. The movements of the spring can be utilised to vary the field resistance of the dynamo, the resistance of the feeder, the speed of the dynamo, or the number of cells in circuit, where accumulators are employed.

**Obituary.**—We regret to record the death at Liverpool on January 29th of Mr. Thomas Moore, at the age of 51. He entered the Secretary's office of the Eastern Telegraph Company in May, 1870, and at the end of 1872 became the Company's agent at Liverpool, being appointed, in December, 1882, superintendent on the opening of the station there. Mr. Moore's conscientious conduct and courteous manner gained him the esteem of all who were brought into contact with him.—On Monday, January 26th, Dr. Nicol August Otto, the inventor of the "Otto" gas engine, died at Cologne, from apoplexy, after a brief illness. Some 25 years ago Dr. Otto's attention was drawn to gas engines, and in connection with Mr. Eugène Langen he brought out an engine called Langen and Otto's atmospheric gas engine. Subsequently he invented the "Otto" engine, which found great favour, and enabled him to obtain large royalties. Dr. Otto was not brought up as an engineer, but had great mechanical talent and theoretical knowledge.

**The Westinghouse Record for 1890.**—During the year ending December 31, 1890, this Company turned out 217 alternators, having an aggregate capacity of nearly 16,000 kilowatts, or an average capacity of 73 kilowatts. This makes a grand total of 730 alternators, with a total capacity of 46,080 kilowatts, which have been turned out by the Company since its organisation in November, 1886. Last year the Company added another branch to its business, in the manufacture of electric street railway apparatus. The Company did not commence to despatch motors until July 1st. Since then 211 15 horse-power motors have left the shops for the equipment of forty electric railways. This makes an average shipment of over 35 motors per month. The Company also commenced last year the manufacture of alternating-current arc light apparatus. The first of these machines were despatched in January, 1890. Since that time the Company has despatched 107 alternating-current arc light dynamos, having an aggregate capacity of 5,680 2,000 candle-power lamps. There are now over 20,000 Shallenberger meters and more than 30,000 Westinghouse converters in use.

**Electric Traction in Guernsey.**—It will be seen by our advertisement columns that the Guernsey Railway are about to adopt electric traction. The line in question was constructed by the Guernsey Steam Tramway Company, and worked by them from June, 1879, till January, 1888, but having for some time previously been subjected to fierce competition by omnibuses, running was for a time suspended until the present Company took over the property and resumed working in December of that year. Though up to this steam locomotives have been employed, the Directors have from the first been looking for a cheaper means of propelling the cars, which usually run in trains of two or three, as the traffic demands, and they have decided to try the direct system of electric traction, the Local Government having given the necessary permission for the erection of the overhead wires at their meeting on January 28th. The line is 2 miles 65 chains long, single, with five crossing-places, practically level, but very crooked, fully 75 per cent. being deviations from the straight. One-half of the distance it runs on the public road, and the other part on the Company's own property. When the line had the whole of the traffic it did a heavy business, especially in the summer, when the island is full of visitors.

**Experiments in Magnetism.**—It has long been known, says Mr. A. E. Dolbear, in the *Electrical Engineer* of New York, that a common sewing needle will float if carefully placed upon a surface of water; also, that if the needle be magnetised it will assume a position in the magnetic meridian. Iron and steel filings will also float, and they can be sprinkled upon a liquid surface nearly as well as upon a solid. Let a strong U-magnet be brought near to the iron filings. They will at once arrange themselves in the well-known forms. If the magnet be removed the filings will retain their arrangement, and if it be in a vessel large enough to permit the rotation of the whole body the arrangement will swing into the magnetic meridian, thus showing that it constitutes a single magnet. Now bring gently near the floating magnet one pole of a bar magnet. If this be presented to one of the poles of the molecular magnet the whole body will rotate more or less. If, now, a magnetic pole be brought near to the middle of the arranged filings, some of the groups will be more or less disintegrated from the rest, and will rotate upon a vertical axis and turn quite round. The opposite pole presented will cause them to rotate back again. Great numbers of these can be seen to turn in this way when-

Digitized by Google

ever a pole is presented to them. This phenomenon is evidently precisely the same in character as that illustrated by Prof. Ewing with his small magnetic needles mounted upon pivots.

**Electricity and Natural Gas and the United States Customs Laws.**—The Treasury Department at Washington has recently given two decisions which have attracted a great deal of attention. A clerk of Customs on the Texas border asked the Department what tax should be levied on a certain electric company which was wiring its electricity across the Rio Grande into American territory. The Department has decided that, inasmuch as electricity is intangible, and cannot be measured, it can come in free. About the same time, an official at Buffalo inquired how he should treat the importation of a certain company in Buffalo which had made arrangements to bring natural gas across the Niagara River from Canada into the United States through an eight-inch pipe. In this case the Treasury Department has decided that natural gas is an unmanufactured product not otherwise provided for, and is therefore dutiable at the rate of 10 per cent. *ad valorem*. The manufactured product electricity can be brought into the United States free under this decision, but the unmanufactured natural gas, from which electricity could be produced, is taxable at the rate of 10 per cent. The Buffalo concern, if it desires to evade this 10 per cent tax, can, remarks the *Electrical Engineer* of New York, turn its gas fuel into an electric current on the Canadian side of the Niagara River, and carry it across the river through wires instead of pipes.

**The St. James's and Pall Mall Company.**—In another column, says the *Journal of Gas Lighting*, will be found a "Note" descriptive of the working results of the St. James's and Pall Mall Electric Lighting Company, to which the attention of gas engineers may be profitably directed. . . . In the first place, it is something for which we were hardly prepared, to observe that the whole of this particular business was done by meter, which shows that the electrical engineering of this London Company is far in advance of most others. . . . According to this statement, the St. James's Company can account for all their electrical output except 2½ per cent., which is an astonishingly high duty. It means that there is practically no loss through the mains and services, and that the consumers' meters are either very good, or very good for the Company, which is not precisely the same thing. Upon the former and more charitable interpretation, however, it appears that the St. James's electricians have nothing more to expect in the way of technical advancement; for a duty of 97·5 per cent. from the whole plant is practically perfection. It may be noticed that the Company charge 7d. per unit for their supply, which they say costs 1·8d. in the engine-room. On the face of it, one would suppose that the margin here shown ought to be sufficient to pay for administrative and capital charges. We have already admitted that if central station lighting is to pay anywhere in England, it will pay in the choice district occupied by this particular Company.

**Electrical Traction on the North Metropolitan System.**—At the general meeting on Wednesday of the North Metropolitan Tramways Company, Mr. George Richardson (the chairman) announced that the Board had thought it necessary to go to Parliament again in consequence of the action of the West Ham Board, to which they had applied for permission to use electricity. They were already using it, but the West Ham Board could at any time, by giving them 24 hours' notice, compel them to cease running. The Directors considered that this was unreasonable, and the County Council had given them power to run electricity for seven years without any restriction. They thought that the County Council had as much wisdom as the West Ham Corporation, and, therefore, they thought that the latter should be requested to give them the same privilege in this matter. If this body gave them the same power as the County Council had given them, they would not go on with the Bill; but otherwise they would ask the shareholders for power to continue their application. Replying to questions afterwards, the Chairman stated that the subject of electricity remained, so far as the Company was concerned, in just the same position as it did last year. The Electric Traction Company were running the same line at 4½d. a mile, including the driver, according to the contract. They had not much encouragement to go on with the use of electricity until they were perfectly satisfied that they could not be called upon at 24 hours' notice to give up its use. The Bill referred to was subsequently approved by the meeting.

**A Simple Temperature Correction for Copper Wire.**—Correcting the resistance of copper wire for temperature involves a formula which is somewhat too complicated for everyday calculations. The simple method described below may, therefore, be of use. It is due to Mr. Carl Hering, and appeared in the *Electrical Engineer* of New York. The Matthiessen standard of resistance of copper taken in calculating the table is that proposed by the Committee of the American Institute of Electrical Engineers, namely, 9·612 *legal* ohms for a wire of pure soft copper, one foot long and one mil in diameter, at 0deg. C., and called a "mil-foot." The temperatures have been calculated at which this mil-foot constant has regularly increasing values, the increase being 1 per cent. between each two successive values. In calculating the resistance $R_t$ of any copper wire of length L feet, diameter $d$ mils, and temperature $t$, one has only to use the formula $R_t = \frac{L}{d^2} K$, K being the mil-foot constant taken from the table for the temperature nearest to $t$:—

| Resistance per mil-foot in ohms (legal). | Temperature, Degrees Fahrenheit. | Temperature, Degrees Centigrade. |
|---|---|---|
| 10·00 | 50·47 | 10·26 |
| 10·10 | 55·15 | 12·86 |
| 10·20 | 59·79 | 15·44 |
| 10·30 | 64·40 | 18·00 |
| 10·40 | 68·97 | 20·54 |
| 10·50 | 73·51 | 23·06 |
| 10·60 | 78·01 | 25·56 |
| 10·70 | 82·47 | 28·04 |
| 10·80 | 86·90 | 30·50 |
| 10·90 | 91·31 | 32·95 |
| 11·00 | 95·69 | 35·38 |
| 11·10 | 100·04 | 37·80 |
| 11·20 | 104·36 | 40·20 |
| 11·30 | 108·64 | 42·58 |
| 11·40 | 112·90 | 44·95 |
| 11·50 | 117·14 | 47·30 |

**Inauguration of the Electric Lighting of the City.**—An interesting ceremony took place at the Mansion House on Tuesday last, when, at the invitation of the Directors of the Brush Electrical Engineering Company and the Laing, Wharton, and Down Construction Syndicate, the Lord Mayor inaugurated the lighting of the City by electricity by laying the foundation stone at the main junction which connects the conductors to be laid down by the two contracting companies in Walbrook. After the laying of the stone the company proceeded to luncheon at the Cannon-street Hotel. The Duke of Marlborough proposed the toast of "The Electric Lighting of the City of London," coupling with it the name of Mr. Preece. The following are a few particulars of the projected City stations:—The streets will be lighted by 400 arc lamps of 2,000 candle-power, and 1,000 incandescent lamps, absorbing from 100 to 200 watts per lamp. The cost of the illumination of the whole of the streets of the City will exceed £20,000 per annum. The site of the Brush generating station is on the south side of the river, and the mains will cross the river by the Southwark and Blackfriars Bridges. This station will ultimately have a capacity of 600 2,000 candle-power arc lamps and 120,000 8 candle-power incandescent lamps, this being for the supply of the central division. The generating station for the eastern division will be situated on the banks of the river between the Custom House and the Tower of London, and the Laing, Wharton, and Down Construction Syndicate have designed the plant to have an ultimate capacity of 600 2,000 candle-power arc lamps and 120,000 8 candle-power incandescent lamps. The Brush Company will employ Brush apparatus for street lighting and Mordey alternators and transformers for private lighting. The Laing, Wharton, and Down Construction Syndicate will employ Thomson-Houston apparatus throughout.

Digitized by Google

## THE HISTORICAL DEVELOPMENT OF THE INDUCTION COIL AND TRANSFORMER.*

BY DR. J. A. FLEMING, M.A.

(*Continued from page 397.*)

In Sturgeon's *Annals of Electricity*, Vol. I., p. 418, there is a mention of the meeting of the London Electrical Society held on August 5, 1837, when Sturgeon read a paper on "Secondary Electric Currents," illustrated by a powerful double-wire horse-shoe electro-magnet which had been presented to him by Prof. Callan, of the R.C. College, Maynooth. This paper or lecture stimulated several minds, and particularly that of Sturgeon himself. On page 470 of the *Annals*, Vol. I., we have another Paper by him on "An Experimental Investigation "of the Influence of Electrical Currents on Soft Iron as regards "the thickness of metal requisite for the full display of

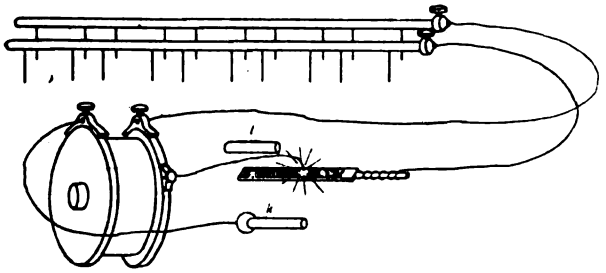


Fig. 3.—Sturgeon's Coil with Wooden Core.

Contact breaker at terminal *l* provided by a file Free terminal, provided with handle *k*

"Magnetic Action, and how far these pieces of iron are "available for Practical Purposes." He constructed a double-wire helix on Callan's plan. He wound on a wooden bobbin a naked copper wire insulated with sealing-wax varnish. One wire was a copper bell wire, 260 feet long, forming the inner or lower coil; and the upper or outer coil was a thinner copper wire, 1,300 feet long. The end of the fine wire was soldered to one end of the thick wire, so that it made one continuous con-

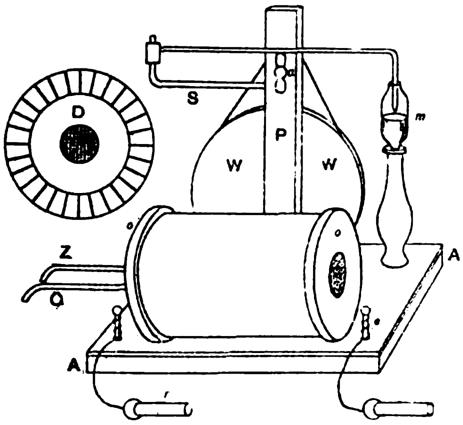



Fig. 4.—Sturgeon's Induction Coil.

Z and C, wires from battery *o o*, coil. A A, base of coil. W W, driving wheel for contact breaker. *a*, cam lifting a wire attached to arm S. *m*, a mercury contact.

ductor, wound all the same way on the bobbin. The reel, or bobbin, was of wood, two inches long between the cheeks. (*See* Fig. 3.) Strips of silk were interposed between the layers of wire. Hence, Sturgeon's coil was a short, wide coil, wound on a hollow wooden core, and not like Callan's magnet, which was long and thin. Sturgeon applied to his coils a break-and-make arrangement, consisting of a wire dipping in a mercury cup in one case and of a notched zinc disc in the other. (*See* Figs. 4 and 5.) The mercury cup-break was worked by a revolving cam and lever, and gave about 36 breaks per second when the cam was turned round by a winch. With the zinc disc he got 540 breaks per second. He put a *solid* iron core in the bobbin, and he was delighted to find that he got powerful shocks from the secondary circuit when the current from one or two cells was interrupted in the primary. He then made a very curious observation. He found that with the solid iron core the shock was much diminished in amount when the revolving contact-breaker went above a certain speed. After some trials he substituted a bundle of fine iron wires for the solid core, and he got very much better results. He draws attention to the fact that (*Annals*, Vol. I., p. 481,) Prof. G. H. Bachhoffner had tried a divided iron core about a fortnight before he had with one of Sturgeon's own coils, which he had lent him. Bachhoffner observed that a bundle of fine iron wires used

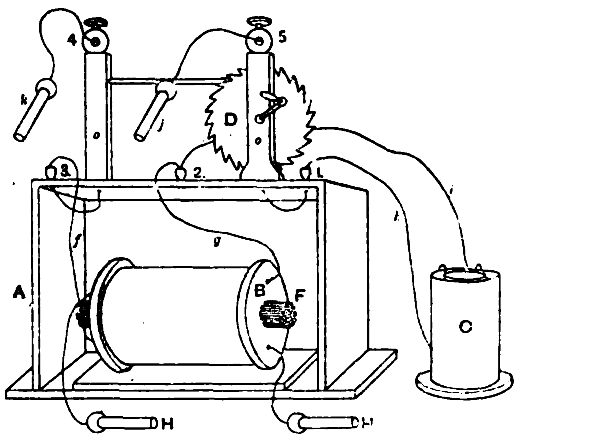



Fig. 5.—Sturgeon's First Induction Coil.

A, box containing coil. B, induction coil. C, battery. D, zinc disc contact breaker. F, iron core. H H, handles on secondary. *h* and *i* wires from battery to contact cups 1 and 2. 4 and 5, terminals. *k* and *j* handles.

as a core in Sturgeon's coil gave far better shocks than when a solid iron bar was employed. We must therefore credit Bachhoffner with being the first to recognise the value of a divided iron core. W. Sturgeon noted that a rolled-up sheet of tinned iron put in as a core increased the shocking power in an extraordinary degree beyond that obtained when a solid core was used, and that with a bundle of fine iron wires as a core the shocks were more increased still. Sturgeon claimed that his coil was an advance on Callan's, and certainly when we regard the sketch of Sturgeon's first coil, we see that he gave to the appliance practically the general form which it has retained ever since. This coil of Sturgeon's was exhibited to the London Electrical Society in August, 1837.

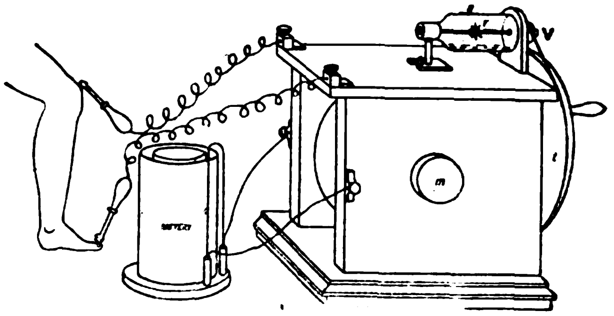



Fig. 6.—Clarke's Induction Coil

*m*, core of coil. *t*, driving wheel of contact breaker. V, driven pulley. *r*, star wheel breaking contact with mercury in vessel *x*.

We come next to another important Paper by Callan, dated September 11, 1837, printed in Vol. I., p. 491, of Sturgeon's *Annals of Electricity*: "On a Method of Connecting Electro-magnets so as to Combine their Electric Powers, and on the Application of Electro-magnetism to the Working of Machines."

Callan wound on each of two iron bars a couple of wires, first a copper wire one-twelfth of an inch in diameter put on in one layer, and second, a copper wire one-ninetieth of an inch in diameter, and 150ft. long wound over the first. Each wire was carefully insulated both from itself as well as from the iron and the other wire. It is clear from the description which follows that in making these two induction coils Callan did *not join* the end of the secondary wires to the end of the primaries, but left the secondary distinct and insulated from the

* All rights are reserved.

Digitized by Google

primary. He then *joined the primaries of these two induction coils in parallel* on a large galvanic cell, and the secondary coils he joined in series, and he obtained from the secondaries in series, a shock greatly in excess of that which he obtained from either of them separately. He points out that the secondaries must be so united that the electromotive forces in each are added and not opposed to each other, and he surmises that if a hundred such induction coils could be arranged with secondaries in series and primaries in parallel on a very large quantity battery that it would be possible to have a shock equal to that of 100,000 or 200,000 single cells.

On page 493 (*Annals*, Vol. 1) he says:—"In making "electro-magnets which are to be connected for the purpose "of obtaining increased electric intensity, care must be taken "*not to solder* the thin wire to the thick wire of the magnet, "but to leave both ends of the thin wires projecting."

In a note he recommends that for lecture purposes the thick wire coil and the thin wire coil should be wound on separate bobbins, the thick wire bobbin being made to slide inside the thin wire bobbin, and he says that such a pair of separate coils was given by him to Mr. Cottam, the secretary of the Manchester Mechanics Institute, during the lecture he gave there. Hence it is to Callan that we owe this simple piece of apparatus, now found in every physical laboratory, and it is to him that we are indebted for an induction coil having two separate wires, one thick and the other thin, used as an induction coil. Furthermore, he says that about four months before writing this Paper he coiled on a cylinder of wood (hollow) about 10 feet of covered copper wire, one-eighth of an inch in diameter, and over this 200ft. of very thin-covered wire, and an iron bar was put into the hollow of the bobbin. With 20 pairs of plates (*i.e.*, cells) on the primary, he got severe shocks even without the iron core, and when the core was put in he got a shock even on making the contact with the battery.

A little later in the first volume of Sturgeon's *Annals of Electricity* we reach a Paper by a Mr. E. M. Clarke, on an induction coil (*see* Fig. 6), for giving shocks with a single pair of plates. There is nothing more in this than a description of a Callan's or Sturgeon's coil. The secondary wire was one ninety-second of an inch in diameter, and the contact breaker was a Barker's wheel, or copper star, revolving so that the tips of its spokes just dipped in mercury in a bottle.

Some time previously Mr. Barker had invented this device for interrupting a current. Mr. E. M. Clarke was a philosophical instrument maker, having a shop in the Lowther Arcade, and his memory is also handed down to us as an improver of Pinii's magneto-electric machine. Mr. Sturgeon comments on Clarke's Paper, and, for appropriating without sufficient acknowledgment Mr. Barker's wheel and his own coil, he gives Mr. Clarke, of 11, Lowther-arcade, a dignified rebuke. Various improvers having been given the clue, took up the manufacture of induction coils. On page 205 of the *Annals of Electricity*, Vol. II., a Mr. Nesbit sends a description of a coil; it had a revolving rachet wheel as a contact breaker. A primary coil, consisting of 400ft. of thick wire, and a secondary of 1,700ft. of thin wire, and as a core a bundle of very fine iron wire. This description is dated February 10, 1838. This coil gave very severe shocks when the primary was excited, with one cell of half a square foot of active surface. Nesbit put oil on his break to reduce the noise and check the spark. Four days later, on February 14, 1838, Prof. G. H. Bachhoffner has a description of a coil which he made with two separate insulated copper wires and a core of insulated iron wires, and he notes that if the core of fine iron wires is enclosed in a tinplate tube it ceases to act as a divided core, and becomes no better than a solid core. He claims the original suggestion of using a divided iron core, and it appears from what he says that at first he used lengths of cotton-covered iron wires in a bundle as a core.

Bachhoffner refers also to a self-acting contact breaker which he put on one of his coils, and which he says was made by Mr. Neeve, of 11, Great St. Andrew's-street, Seven Dials, who made for him this magnetic contact breaker superior greatly to the spur wheel of Barlow or the notched disc of Sturgeon, both of which required to be actuated by hand.

(*To be continued.*)

## THE ELMORE PROCESS OF DEPOSITING COPPER.

We have already recorded the fact that a Press visit was made on Tuesday, January 27th, to the Elmore Company's works, near Leeds.

Towards 9 o'clock on Tuesday morning a goodly gathering of Press-men for both technical and non-technical journals, engineers, chemists, electricians, and other experts assembled at St. Pancras, and were conveyed in a special Pullman to Leeds, luncheon being served *en route*. With but little delay the tour of inspection began, the company being conducted by Mr. F. L. Rawson, Mr. Stepney Rawson, Mr. F. Elmore, and Mr. A. Elmore. The arrangements left something to be desired, the number of visitors being too great to permit of any one cicerone sufficing, while no systematic attempt to break up the crowd into several small parties was made. Mr. Rawson acted chiefly as spokesman when necessary, a duty that should rather have been performed by one of the Messrs. Elmore, on account of their more direct and intimate knowledge of the working of the process.

After regarding a heap of Chili bars which serve as the raw material, and which were stated somewhat hyperbolically to contain "97 per cent. of copper, and any amount of impurities," the visitors signed their names to guard against the possibility of the unauthorised intrusion of any hated rival in the shape of a copper manufacturer, left their watches to avoid risk of magnetisation, and passed to the melting shed. The installation is of a somewhat temporary character, the present output being small; the furnaces are of the usual type, and merely serve to run down the bars for the production of granulated copper. The time occupied in fusing each charge is about three hours. On this occasion this time had not fully elapsed, but in order to show the actual operation of granulating, the metal from one of the furnaces, though still somewhat sluggish, was run into a ladle, conveyed therein to the water tank, the slag skimmed off, and the copper allowed to trickle into the water.

The violence of the evolution of steam resulting from this operation was not very great, the chief cause of crackling and spurting being the presence of remaining particles of slag which cooled less evenly than the metal. A portion of the product was taken out of the tank for inspection; it was in the form of fairly even sized irregular fragments, mixed with a little slag.

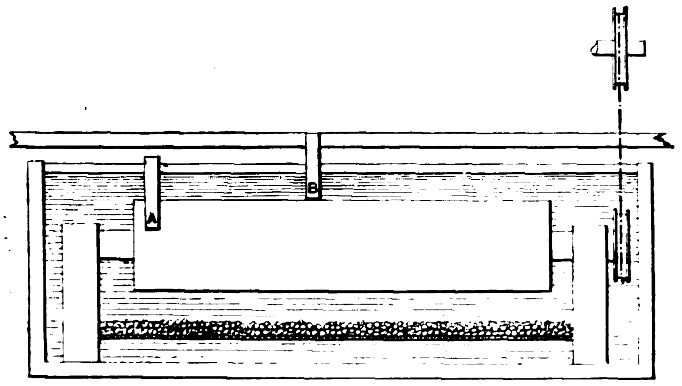
From the melting shed a move was made for the dynamo-room, the boiler-house, containing two boilers, each capable of developing 250 horse-power, being passed on the way. Here was a fairly-complete plant. Three Edison-Hopkinson dynamos, by Mather and Platt, and one Elwell-Parker dynamo not yet in position, constitute that part of the equipment at present. Three engines, each of 70 horse power, by Willans and Robinson, are in place, two driving Mather and Platt dynamos, and one with a dynamo on the same bedplate as itself. A place for a horizontal Fowler engine was being prepared to cope with the larger output that will be required when the second tank-shed is fitted. One of the Willans engines, coupled to a Mather and Platt dynamo, has the excellent record of having just completed a seven months' run, absolutely continuous; its companion is at present supplying all the power needed, which is only about 50 horse power. This yields a current of 750 amperes, at a pressure of 50 volts, the dynamo being run at 450 revolutions per minute; a larger nominal output is possible, but cannot be safely attained from these dynamos with continuous running, as they heat too much, the temperature rising steadily for about 24 hours after starting. The process being essentially one in which continuous running is necessary, even the possibility of injurious overheating must be carefully avoided.

The leads are copper bars, about $1\frac{1}{16}$ in diameter, and run to a switch-board in one corner of the room. By means of these, the current from any one of the dynamos or of the whole number can be distributed to the tank-sheds.

After inspecting the dynamo-room the company passed to the tank-shed, containing 60 tanks, part only of which are at present in use. Nothing particularly novel or striking had been seen up to this point, but in the tank-room the plant and methods of working characteristic of the process were open to inspection. The arrangements are of the simplest. Their nature can best

Digitized by Google

be gathered from the accompanying diagrammatic sketch; a wooden tank lined with bituminous material, at once insulating, adhesive, and unattacked by dilute acids, contains the solution of sulphate of copper. On the bottom of the tank is a copper tray, upon which is placed the granulated crude copper produced in the manner already described. A cast-iron mandrel, the ends of which are covered by a non-conducting composition to prevent deposition of copper taking place upon them, is supported in bearings, which at present are of wood, coated with bituminous material, but are in the future to be made of glass. The mandrel is rotated by a simple chain gear at the right-hand end. Contact is made with it by the brush, attached to a brass conducting strip (not shown) resting across the top of the tank. It is noteworthy that these brushes may be of the most feeble and ragged description without impairing the contact; it appears that so good a contact is secured by the continually renewed presence of freshly deposited copper actually *between* the end of the brush and the surface of the mandrel, that no precautions, such as would at first suggest themselves as desirable, if not necessary, are needful to ensure proper conduction. A metal burnisher, shod with agate, is pressed upon the surface of the revolving mandrel by means of india-rubber bands, the tension of which can be increased as the deposition proceeds. The amount of pressure used was somewhat quaintly stated to be 10lb. upon 9 sq. millimeters; such of our readers as are sticklers for uniformity of nomenclature can doubtless reduce these to more directly comparable units. The burnisher is carried by a bar at the back of the tank, which also carries the bur-




Depositing Tank.—A, Contact Brush; B, Travelling Burnisher.

nishers belonging to the whole series of tanks in line with it. This bar is given a longitudinal motion by a simple screw gear at one end, and thus causes all the burnishers to travel from end to end of the mandrels to which they respectively pertain; at the end of the stroke the motion of the bar is automatically reversed, and the burnisher returns in the same path. The result of this arrangement is as follows:—The crude copper forming the anode dissolves in the bath of sulphate of copper, which fills the tank (covering the whole of the mandrel and the agate end of the burnisher), and is deposited upon the cathode, that is to say, the revolving mandrel. As it is formed it is burnished by the agate burnisher, and rendered dense and coherent. The rate of revolution of the mandrel, the travel of the burnisher, and the width of the agate end of the latter, are so adjusted that the burnisher leaves no blank unburnished strip on the newly deposited copper, each burnished strip overlapping the one before it. By the use of this burnisher a comparatively high current density (15-20 amperes per sq. ft.) can be employed without producing weak crystalline copper. Those portions of the mandrel (the extreme ends) which do not come under the action of the burnisher, presented the rough irregular appearance usual when copper is deposited by currents of considerable density. It was also afterwards shown that copper of this description is vastly inferior in strength to that deposited with continual burnishing. The tanks are arranged in series, and require a pressure of something under one volt apiece. A tube ⅛in. thick takes about six days of 24 hours each to produce.

The chief portion of the work done in this shed is the production of copper tubes for use as such, but rollers for calico-printing and rams and propeller shafts are, or soon are to be, coated in a similar manner. In these cases the iron to be sheathed is first coppered in a cyanide bath, to ensure adhesion. When tubes are made, the point of importance is naturally not perfect adhesion to the mandrel, but merely close contact with its turned surface. Considerable difficulty has been experienced in making mandrels with a surface sufficiently smooth, the least irregularity being fatal to the formation of a satisfactory tube. Once a flaw or pimple has appeared, nothing will suffice to get rid of it; the tube in which it is must either be rejected altogether or at least the damaged portion cut-out. In our opinion this is a decided drawback. It cannot be easy, even if a thoroughly satisfactory surface be obtained at the beginning, to make certain of excluding all foreign particles, any one of which might start a roughness or flaw, and cause an imperfect tube to be turned out. This objectionable property has, however, one good side—as no flaw can be concealed by later layers, it follows that a tube of unexceptionable exterior must be sound throughout. Sundry sections that we saw confirmed this idea.

The only other matter in the tank-room needing comment is the question of residuals. The Chili bars used contain about 3oz. of silver and ¼oz. of gold per ton, and these are, of course, left with the insoluble portion of the anode. Up to the present time this, like the slag from the melting furnaces, has been allowed to collect until sufficient is available to make it worth while working it up. The Company intends carrying out this operation itself, though it would seem more natural to dispose of it to those who make the recovery of the precious metals their special business. Similarly the renewal of the electrolyte, which will doubtless be necessary from time to time as soluble impurities accumulate in it to an inconvenient extent, is to be effected with sulphate of copper made on the spot.

The tube formed in the manner described above is removed, mandrel and all, to the machine shop. As it adheres to the mandrel pretty closely, it is not at first sight a perfectly simple matter to separate them. The plan at present used consists in causing an arrangement of three small rollers to pass from end to end of the composite cylinder, whereby the sheath of copper is very slightly stretched, freeing it from the iron and allowing it to be drawn off without difficulty. The rough ends are then cut off, and the tube is complete. It is proposed in the future to vary this procedure by taking advantage of the greater coefficient of expansion of copper as compared with cast iron, and by heating the mandrel with its coating by means of steam to loosen the latter. This will leave the copper tube, on cooling again, of absolutely the same dimensions as the mandrel, and untouched by tool of any kind.

In the laboratory department, next visited, there are three distinct divisions, the first being a small laboratory for the routine work of analysing raw material, residuals, and electrolytes, and generally supervising the work of deposition. The second is the testing-room, where the product is subjected to mechanical tests. The third is the research laboratory, for improving the existing process and devising new methods. From this last visitors are, not without reason, rigorously excluded. With the exception of its noticeably neat and new air, and its short beam balance, unkindly exposed to the general atmosphere of the place, instead of being provided with a separate room, the first named presented little of interest. In the testing-room there was matter of more immediate moment. The miscellaneous gathering, including experts thoroughly familiar with every detail of mechanical testing, and non-technical journalists who had probably never seen a testing machine in their lives, flocked into the small room, and crowded it almost to suffocation. The first glance at the testing machine, which is a 30-ton one, makes one think for a moment that it is the well-known Wicksteed; but a second look dispels the illusion. It is certainly most curiously like, but the maker's name is Herriot not Buckton, and he hails from Glasgow instead of Leeds. Except that the water is supplied to the ram from a different pattern pump, and the gear for shifting the jockey-weight is not quite the same, it is practically identical with its forerunner. On this machine a test was made of a strip of copper cut from an unannealed cylinder

Digitized by Google

in the direction of its circumference, the curved piece thus obtained being of course first flattened out. With a crowd of gaping sightseers, with their noses almost in the clips, great nicety was not to be expected, but a rough test was performed, and gave a result of 20·8 tons per square inch, with an extension of 21 per cent. The high tensile strength, coupled with the considerable extension, is a feature in this copper which distinguishes it from that made by any other process with which we are acquainted. Nor is this the only remarkable property it possesses. It is stated that it can be worked cold to any extent without hardening; in consequence, it can be flanged or drawn into wire without undergoing any annealing process. Beautiful specimens of wire said to have been thus produced were exhibited. So much for its mechanical qualities. Of more direct interest to the electrician is its conductivity; on account of its method of production, more especially by reason of the low E.M.F. used, it is as nearly as possible pure. Arsenic, and such objectionable constituents, are entirely absent, and as a result its conductivity is extremely high, being stated as 102, when compared with Matthieson's standard, taken as 100. Since the metal used for the latter was also very pure electrotype copper, it seems tolerably certain that the higher conductivity must be attributed to the denser structure brought about by the continual burnishing during deposition.

The claims of the Elmore Company to have produced a copper in many ways unique can hardly be disputed. With the monetary aspect of the process we are indisposed to deal; that is a matter for the financial papers and the shareholders in the Company. Their directorate seems well satisfied, and is confident of underselling other makers of such articles as they manufacture, and at a very handsome profit to boot. The process is eminently rational, and certainly practicable, and the question of cost cannot be decided off hand.

It would be interesting to know on what particular claim the validity of the Elmore patents mainly rests. According to the account of the Company itself, and the evidence that could be gathered in a necessarily hasty visit like that we have just described, *the* point of all others is the burnishing of the copper with an agate style at the moment of deposition. But the process of burnishing copper with an agate style at the moment of its deposition has been known and practised for a decade. It must then be some special form of apparatus for executing the burnishing operation, or the combination of the burnishing with other prescribed modes of working, that are the essential means of protection of the Elmore process. However it may be protected it has been well wrought out, and its introduction marks a distinct epoch in the industrial history of what is *par excellence* the electrician's metal—copper.

## THE HELLESEN DRY BATTERY.

On the suggestion of Prof. Lommel, of the Physical Laboratory of the University of Munich, a series of experiments were conducted in November, 1889, by Herr Heinrich Krehbiel, Dr. Narr, and Dr. Doule, in order to obtain a comparison of the electrical qualities of six of the principal dry batteries in existence, viz., those of Hellesen, Bender, Thor, Gassner, Jenisch, and Wolfschmidt. A full report of these interesting experiments was published on August 1, 1890, in No. 31, Vol. II., of the *Elektrotechnische Zeitschrift* of Berlin, containing a detailed account of the following investigations :—

1. Change of E.M.F. on open circuit.

2. Variation of E.M.F. with temperature.

3. Determination of internal resistance.

4. Fall of E.M.F. on closed circuit, and subsequent recovery on open circuit under the following conditions:—(*a*) With an external resistance of 3 ohms furnishing a strong current; (*b*) with an external resistance of 50 ohms furnishing a weak current.

The E.M.F. was measured by an Edelmann's cylinder quadrant electrometer by comparison with a Latimer-Clark standard cell of 1·407 V (the coefficient for reducing the E.M.F. to the standard temperature being taken as 0·08 per degree Centigrade, as given by Helmholtz and Kittler). The measurement of resistances was effected by Kohlrausch's method, using alternate currents with the telephone introduced into the bridge. The Hellesen cells had the following dimensions: 8cm. square by 16cm. high (3¼in. square by 6¼in. high).

The mean original E.M.F. at 15°C., taken immediately after the receipt of the cells, was 1·415 V. The E.M.F. of each cell was tested periodically during 2½ months, and remained, with slight variations, practically constant, no current, however, being taken from them during that time. The E.M.F. was practically unaffected by change of temperature. The mean original internal resistance, taken immediately after the receipt of the cells, was 0·067 ohms; this resistance being lower than that of any of the other cells submitted for testing.

After these tests, one element of each kind was continually closed for 36 hours through an external resistance of three ohms, and periodically tested; the result obtained with Hellesen's cell being as follows:—At the beginning, 0·066 ohm; after four hours, 0·087 ohm; after 36 hours, 0·172 ohm. The experiments proved that all the elements increased somewhat in resistance when short circuited in this way for a long time.

To test the recuperative power possessed by these cells they were closed for 60 minutes through an external resistance of 50 ohms, after which time the circuit was opened, and the amount of recovery observed at intervals. This was repeated 25 times. After 60 minutes, the E.M.F. fell to two per cent., and after 24 hours recovery rose to 99·4 per cent. of the original value. All the elements, after 24 hours of open circuit, regained very nearly their original E.M.F. After closing continuously for 96 hours, through an external resistance of 50 ohms, the Hellesen cell fell 87·5 per cent, the Bender cell 86·9, and the Gassner 61·3. After 24 hours recovery, the E.M.F. was 94·1, 93·4, and 78 per cent. respectively. On closing the cells for 60 minutes through 50 ohms the Hellesen cell fell from 1·361 volt to 1·321, and after 24 hours' recovery gave 1·349 volt. The figures for the Bender cell are 1·359, 1·309, and 1·352 respectively; and for the Gassner 1·284, 1·170, and 1·285.

The investigation contains also the calculation of the ampere-hours from the values of current observed, and thus of the amount of work done by each element, the ampere-hours during the twenty-fifth hour being 96·7 per cent. of that furnished during the first hour of closed circuit.

The batteries when closed during 24 hours through an external resistance of 3 ohms gave the following aggregate ampere-hours:—Hellesen 5·0792, Bender 4·9898, Thor 3·4552, Gassner 2·6670. This investigation of the comparative efficiency of the above elements was concluded by the experiment of regenerating the partially-exhausted cells by a treatment similar to that of a secondary battery, *i.e.*, by sending a current from two Bunsen elements during two hours through the cells. The elements thus regenerated were again worked for five periods of closed circuit (each period of 30 minutes duration) through an external resistance of 3 ohms.

The Munich report contains the following conclusion, as the results of this exhaustive and carefully conducted series of experiments :—

"The most efficient elements, even for circuits of a small external resistance, are Hellesen's and Bender's elements. Hellesen's element excels Bender's by having somewhat less polarisation and much smaller internal resistance; it has, however, when exhausted by long working not quite so much recuperative power as Bender's.

"A similar relationship exists between Thor's and Gassner's element. In a circuit with a small external resistance Gassner's is less constant than Thor's, but the former has the advantage of more recuperative power, even after the E.M.F. has been reduced to a very small value.

Digitized by Google

"Jenisch's and Wolfschmidt's elements are in consequence of their very rapid polarisation only applicable when duration of closed circuit is very short."

The above experiments prove that dry elements are well adapted for many practical purposes, especially for telegraphic, telephonic, and similar services, and the considerable power of recovery possessed by such elements gives them a long duration of life. Besides the electrical advantages shown in the Munich report, there are various other advantages of a purely practical character possessed by such cells when compared with wet elements. The former are transported with far more facility, being always, and without any previous preparation, ready for use, and require no inspection or attention until they are completely exhausted. The Hellesen cell is made in England by Messrs. Siemens, Brothers & Co.

## ON THE INFLUENCE OF THE ELECTRIC SPARK ON THE DISCHARGE IN GASES.*

BY P. BACHMETJEW.

In our issue of January 2nd, p. 254, we had a brief note referring to the researches of M. P. Bachmetjew, on the influence of the electric spark on the electric discharge. The following is a more detailed account of these investigations:—

According to the investigations of A. Naccari, of Turin, it is the electric spark itself, and not its ultra violet rays, which alters the resistance of the surrounding medium through which an electrified body discharges itself. In particular it was observed that in air the discharge ceased if the sparking took place at a sufficient distance from the charged body, whilst if the air that had been in the neighbourhood of the spark was blown towards the charged body, a discharge immediately occurred. This, however, ceased to be the case as soon as the sparking was stopped.

The author is of opinion that one of the elementary gases of which air is composed undergoes, through the action of the electric spark, some chemical combination or allotropic modification, and that the resulting gas has a lower resistance than air. The gas produced must be of a somewhat unstable nature, so that it undergoes decomposition as soon as the sparks cease. But since no combinations of oxygen and nitrogen will satisfy the observed conditions, we must look for some allotropic modification of one of them. Ozone will immediately occur to the mind, but ozone at high temperatures resolves itself again into oxygen. The unknown conductor of electricity must, therefore, be a prior modification of oxygen, which may be called antozone.

The following consideration is also an argument in favour of the existence of antozone. In the well-known ozone tubes of Siemens, Babo, &c., in which oxygen is ozonised by means of a silent discharge, it is impossible to raise the proportion of ozone to over 40 per cent. This can only be explained on the supposition that the silent discharge produces from the oxygen both ozone and antozone simultaneously; a continuation of the discharge cannot increase the proportion of ozone, and when the discharge ceases the antozone being unstable breaks up again into oxygen. That the antozone actually behaves as has been supposed, can easily be made clear by the investigation of discharges in gases in which it cannot be produced.

The author compared the phenomena occurring at discharges in air, carbon dioxide, hydrogen, oxygen, and coal gas. The gases were enclosed in glass bell jars, at one end of which was placed a brass ellipsoid, to which was attached a copper wire. The end of the wire was connected to an electroscope, and two electrodes terminating in small copper spheres were introduced through the sides of the globe at a distance of one centimetre from the brass ellipsoid. Sparks from a Ruhmkorf coil were passed between the electrodes, whilst the ellipsoid was charged alternately in a positive and negative sense by a Holtz machine. The length of the spark between the electrodes was at first 1·5mm. and afterwards ·5mm. The experiments proved that the passage of the electric spark accelerates the discharge of electrically charged bodies, though to a degree varying according to the nature of the charge and the nature of the gas. Thus in air and oxygen the effect was more noticeable when the charge was negative, whilst the effect was greater with a positive charge in carbon dioxide, hydrogen, and coal gas. It would therefore also seem that under the influence of the spark hydrogen undergoes an allotropic modification which enables it to conduct negative electricity. The phenomena above mentioned are quite in accordance with the investigations on the electrification of conductors by red-hot bodies, published by Elster and Geitel.

* Exner Rep., Vol. XXVI., Part 10.

## "THE DISTRIBUTION OF ELECTRICITY, WITH ESPECIAL REFERENCE TO THE CHELSEA SYSTEM."*

BY MAJOR-GENERAL C. E. WEBBER.

*(Concluded from page 399.)*

In February, 1885, Prof. George Forbes delivered certain Cantor Lectures before the Society of Arts. One of his objects was to assist electrical engineers in drawing out specifications, and selecting between systems. He then expressed his difficulty to be the probability that an expensive system proposed to-day would be superseded by a more economical one next year. He referred to the low-pressure multiple-arc distribution as being "enormously expensive," and the necessity with it of the generating station being in the centre of the district lighted, and also to the then absence of practical perfection of any system of high-pressure distribution.

Many of us can recall the able line of reasoning following which Prof. Forbes was led to select 1·5 square inches section of copper to the maximum current of 1,000 amperes, and his exhortation to engineers to withstand the pressure of financiers, and to tell them honestly what is the most economical thing to do; and that if a financier wants to lay out capital in a way to cause a waste of energy, the engineer ought to have nothing to do with it.

We are all agreed with what Prof. Forbes urged in February, 1885, namely:—

(1.) To use as large a number of points of alimentation and connection as we economically can.

(2.) That each of these points shall possess it own separate feeder.

(5.) The relative section of conductor at every point of a street to be the same as if every lamp had a separate wire going by the shortest street route to the central station.

But practice has shown us that we cannot, and need not, adhere always to two of his propositions, namely:—

(3.) That each distributing box must be nearer to the central station than any lamp fed from it.

(4.) That small groups of lamps should be fed from the distributing box by separate wires.

As regards the economical aspect of the case, practice shows, in any comparison, that, where a small section of copper in each conductor in the same line only is required, other conditions being alike, it is much cheaper to use insulation of the character of bituminous compound, in ducts, or "ways," of a small size and economical material, than to look for insulation to non-conducting supporting surfaces, with a large surrounding of air space subsisting in a subway of which the minimum first cost must be represented by a substantial figure.

It is in connection with large mains that the engineer who has first adopted the use of a dielectric material to surround his copper first turns his attention to bare copper, with a view to obtain a saving in construction. The size of these mains is controlled by the distance between the points of source of supply for a given demand in a given area.

Obviously, if these points can be placed nearer or further apart, according to what may be called the density of demand, there can be found a fairly definite limit to the size of the largest mains.

The positions of the feeding points in the areas between the points of source of supply are so much governed by conditions connected with the routes and communications of streets, that their theoretical frequency can rarely be maintained. In this respect only, then, apart from localisation of demand, need there be any uncertainty as to their size.

But where the source of supply is a large generating station, distributing at low pressure direct into a network of mains over a large area, say three-quarters of a mile a side, then I regard the adoption of a system of underground construction, such as that known as Mr. Crompton's, and used in part of Kensington, as unavoidable, owing to the necessity of using stems or feeders of large capacity. Indeed, such a system is the natural outcome of the conditions under which running machinery is the primary, and accumulation is the secondary, source of supply, with low-pressure distribution from one source.

On the other hand, when these conditions are reversed, the proximity of the sources of supply reduces the section of copper required for feeding the distributing network, and, as I have said, the cost of the underground works is by its simplification much reduced. Also, the position of the generating station is a matter of comparative indifference.

* Abstract of a Paper read before the Institution of Electrical Engineers, January 22, 1891.

Digitized by Google

Accumulators used in connection with any system which virtually distributes direct from the dynamo at low pressure can be regarded only in the light of auxiliaries, and in no sense as a main source of supply, or even as a stand-by. So far as I have observed, they act as little more than regulators, and are generally charged and discharged at the same time, and therefore not really fairly treated, and cannot be expected to have an average life.

The meeting will see that what is claimed for the Chelsea system in this respect is also possessed, under other circumstances of distribution, by any alternate-current high-pressure system, of which the transforming stations may be called sources of supply for low-pressure distribution.

I wish some one of my audience would, on an early occasion, favour us with a description of a well-designed converting station worked with transformers.

I am led at this stage to refer to the question of the candle-power of the lamp, to which supply companies refer when they give a popular estimate of the work they are doing. We hear of companies supplying 45,000 lamps, and others 100,000, and so on. Now the question is, What do they mean?

Not long ago a "glow lamp" meant a 16 or 17 candle-power lamp, consuming 60 watts per hour. If a calculation is based on such a unit, it is certainly not one that exaggerates the position of the suppliers.

Most engineers, if they thought in numbers of lamps at all, meant 10 to the nominal horse-power.

Now I wish this meeting to understand that from the first I have been one of the few that have steadfastly opposed the 60-watt lamp being the standard, for several reasons. Some five years ago, at a lecture I gave to the Society of Arts on the subject of the manufacture and use of incandescent lamps, I gave practical illustrations of the effect on the eye of the direct and reflected rays of various sizes of lamps—I think they were 5, 10, 17, and 30 candle-power—which showed that, so far as the appreciation of the eye is concerned, the naked filament only more and more paralysed the powers of vision, the larger the incandescent surface, and that the comparative effect on the sight of the reflected light of the various powers did not show proportionally to the disadvantage of the smaller ones.

In Chelsea we have from the first endeavoured, in the true interests, I believe, of an eventual large general consumption, to use the 8-candle lamp as our standard. In all circulars issued to the inhabitants and to customers we have consistently urged the use of that candle-power only, and the expediency, when more light is wanted at one point, of having rather two 8 candle-power than one 16 candle-power. We have pointed out over and over again that even in the largest houses, if there are no 16 candle-power lamps existent, their want is never felt, and that multiplication of 8 candle-power at each point is far the best way of illuminating.

At the risk of having the appearance of an endeavour to multiply numbers, all reports and publications of the Chelsea Company since 1885 have spoken of 8 to 10 candle-power lamps as the standard; and I believe that by degrees this policy—the wisdom of which cannot, I submit, be doubted—is having its effect, and that grumblers at the cost of the light who began, in spite of our remonstrances, by using 16 candle-power lamps, are gradually adopting eights. In the case of shops we have erred still more. We have overlooked the reasons for the successful rivalry of the Wenham and Sugg gas-burners, and instead of showing how electric light can be used more easily than other means for illuminating the tradesmen's wares, we have followed the lead with a poor imitation of gas, which obscures the vision of the passers-by, and makes it impossible to examine the details of the articles exposed. I have studied this question in our own and foreign streets, and am convinced that, in the long run, electric lighting will suffer, for the reason that, whatever its advocates may now say, a large number of tradespeople who are now employing it, after a trial of its use and cost, will return to that of gas.

The other day, in Paris, I was asked to meet a wiring contractor on the subject of fitting up for electric light a handsome ground-floor show-room which has large plate-glass windows. He had no other idea than to suspend half a dozen arc or "sunbeam" lamps from the ceiling, each consuming, at Paris prices, about 6d. an hour, which would have had the effect, doubtless, of lighting the footway brilliantly, and of attracting some attention from the casual passer-by, but also of preventing anything inside the show-room being efficiently inspected by the half-blinded beholder. I am no advocate for the other and equally unreasoning extreme of procedure by which light is wasted foolishly in frosting bulbs, or enclosing them in obscured and coloured globes.

In Chelsea we have come to the conclusion that out of five lamps installed in private houses two represent the maximum number in use at one time, and that we cannot expect that the gross earnings of each lamp installed will exceed 8s. 6d.; with the added fact that 70 is the average number of lights installed in private residences. This gives 28 in use at one time, at a cost of a little under £30 per annum at 8d. a unit. I know that this compares unfavourably with such districts as St. James's; but Chelsea is an average residential district, and St. James's is simply the cream of the world. I am sure that my friends who deal with the electric lighting of that part of London will understand that I am only drawing comparisons so as to give an idea of the demand in different kinds of districts. I see clearly that our experience heretofore in that direction shows us that the companies which supply current in what might be called the second-class districts have much to learn. We do not envy our brethren the fact that they have struck gold while we have only struck silver, and only ask them, in the interests of the industry, to make a good use of their luck.

In the districts in Chelsea and Kensington originally allotted to the Chelsea Company, the total number of houses in the streets and squares within the areas of supply is 1,258. This number includes all shops and residences, except those in quite the smallest streets. In this area the ultimate possible demand might be for 86,000 8 candle-power glow lamps installed, two-fifths of which—34,400—will probably be the maximum in use at one time. At present, of these houses, 252 take current, in which actually the equivalent of 20,000 8 candle-power lamps are installed, and of which the maximum of about 8,000 are in use at one time.

There are at present in the district four sources of supply, and 17 intermediate points where a constant pressure is maintained. The area within the parish of Chelsea which has been last added, and which contains no compulsory, or scheduled, streets, circumstanced as follows: The number of houses is approximately 4,400. The probable custom is likely for a long time to be confined to favoured spots, in which the ultimate demand will be 230 houses, having 18,400 lamps installed. The ultimate possible demand in this latter area cannot be estimated until a large portion of it is rebuilt.

To meet one-third of the total possible demand the central station will shortly contain seven 75 horse-power units of power to charge the five distant sources of supply and drive one transformer motor at each, with three 105 horse-power units to generate directly at low tension and charge the storage reserve in the station when required to do so.

Without going into financial details, it is easily seen how the gross earning capabilities of the station and surrounding system of supply and distribution in its present state will exceed £13,000 a year when one-third of the houses in the first area take current. How much of this may be expected to go to make up the net earnings is a matter I for the present may be allowed to forbear to suggest, as I am not engaged in compiling a company prospectus, but rather asking you to contemplate a sample of the industry under certain conditions from a scientific and commercial point of view.

In any system of distribution which employs—

(1.) Charging mains between the source of generation and the source of supply;

(2.) Stems, or feeding mains, between the source of supply and the points where the branches of the "tree" diverge;

(3.) Branches, or distributing mains, which start from these points of divergence and are connected with one another, or not, as the case may be.

Occasionally, in practice, instances are found in which the energy on its way to the consumers' lamps passes three times in one or other direction along the same route. Its first journey is caused by the need to convey it under comparatively high pressure to a point where it is to be converted to low pressure. The second is necessary in order that as uniform a pressure as possible may be obtained throughout a system. The third may arise out of the necessity to violate Prof. Forbes's rule, and supply backwards towards the centre of generation from the end of a stem, where the branches diverge.

This, be it observed, may occur with any system of conversion, if the converting plant is concentrated in stations. Anything which avoids it constitutes at first sight one important and very fascinating factor in favour of using alternate-current transformers in parallel series, as is being commonly done now in the case of many infant systems. The question is, must these systems be regarded as still in the stage "experimental," and must those who have laid them down be held to be wilfully shutting their eyes to their obligations under Provisional Orders—namely, to prepare to be able to supply every house and are they only desirous of picking up custom casually where it is surest and largest? Those undertakers who are now earning revenue with the service to theatres, hotels, clubs, and places of public resort, by such experimental means, would have still much to learn if, instead, they were dependent chiefly on domestic lighting.

It is only necessary to remind my hearers that if two points (occasionally called E.M.F. points) have a distributing main connecting them, there must be, if the conductors are of uniform section throughout, a depression which diagrammatically will be represented by a curve of a form which will vary according to the distribution of the load. To meet this condition of things the

Digitized by Google

Board of Trade, in the rules lately issued, prescribe that undertakers shall maintain a standard pressure which may be different for different portions of a distributing main, and shall declare to any consumer the constant pressure at which they propose to supply energy at his own terminals. Obviously, it is directed that, once declared, that pressure shall not be altered or departed from without authority, except within prescribed limits. These rules go further, however, and say that before using a distributing main the amount of such pressure (which, to meet an obvious condition, may be different for different portions of a main)—*i.e.*, the amount of those pressures—shall be determined, and given to the local authority.

Now, with great deference to the Board of Trade, our daily experience in Chelsea shows that this rule, professedly made as a help, may be used to bear very hardly on a supply company, if enforced to the letter. For instance, take a compulsory street, say with 30 houses along one frontage: we lay a main along it, calculating on a demand, say, from one-third of the houses, and an estimated maximum consumption in each. We don't know really how to proceed under the rule. At first, two houses, at irregular intervals, require current. What are we to declare to them and the local authority before letting them have it? Suppose we declare—what we know will be the case even if five or six houses require a supply—the same pressure throughout. Suddenly the owners of six more houses require current. This demand will at once cause a curve in the line of pressure; and, failing substitution of fresh figures in the declarations to some of the houses, near the centre of the street, which may be those that first came on—a change of intention that would not be easily allowed—or a substitution of a larger conductor, a state of dilemma is produced which neutralises the beneficent effect of this rule, designed for an almost completed system, and not a growing one.

The fifth part of the combination is the "use of underground conductors throughout, laid so that the cables can be drawn in and out, and renewed or repaired wherever necessary, without disturbing the ground."

This system, which the above description was intended to include, is the one known as the Callender-Webber system. Although an interested critic, I have not been lenient to it, and yet have no reason to go back on the reasons given last year for resorting to it. The network laid down in this system is situated along one or both sides of 41 streets, squares, and gardens of Chelsea and Kensington. The total length, in yards, of line of route followed is 9,520—nearly 5½ miles. The total length of insulated copper cable, varying between 61/12 and 19/15, in use for distribution of current is 27½ miles. Besides the above, there are 1½ miles of pilot wires, making a total of conductors of 29 miles. And the total weight of copper actually under the ground and in use is 51¼ tons.

Without the power of withdrawing and renewing or replacing cables, we should in Chelsea already have had a good deal of trouble and expense, having in several instances had to enlarge the mains. In this respect only—namely, that the conductors can be drawn in and out—is there any resemblance between this system and that referred to as Mr. Crompton's. But in the latter, to be able to do this, a box with a stone cover has to be placed over each point where the copper strip is supported on insulators.

But there are two limits to its applicability—one, where the probable demand is so scattered or sparse along any one route as not to justify so large an initial preparatory expenditure; the other, where the available space under the footways is insufficient. The former limit is at once appreciable when it is understood that the conduit complete, *without copper*, costs about £1 a yard, and in some cases more. The latter will be best understood by those engineers who have had occasion to carry on much excavation under the footways of our streets. I say the "footways," because, owing to the frequency of boxes necessary to give access to the insulating supports, the system, though feasible, is not well suited for a line under the roadway.

As regards the comparative cost of the two systems, it may be of practical assistance to let the meeting have the following result of my observations:—Generally speaking, if the section of copper in a pair of conductors is 1in. and under, then a main constructed with insulated cables in separate "ways" is cheapest—increasingly so with small conductors. Between 1in. and 1½in. the comparison varies according to circumstances. Over 1½in. of section, then uninsulated copper in conduits bears away the prize for economy. Actual experience in Chelsea enables me to give an example of the actual cost of a three-2-inch-way line laid in Lowndes-square.

Its length was 585 yards. The cost of supplying and laying the casing, including vestry charges and an allowance for engineering profit, was £189 17s., or at the rate of 6s. 6d. a yard.

For purposes of comparison, the cost of the surface boxes must be added to the above. Allowing draw-boxes for large angle changes of direction, and one service box for every two houses, we must add 2s. 3d. per yard, or a total of 8s. 9d. per yard.

On the three-wire system—for which provision is, I believe, always made in Mr. Crompton's mains—the three ways in the above example can receive two bitumen high-insulation cables of 61/12, having an external diameter of 1·71 of an inch, and one 61/15, with an external diameter of 1·40 of an inch.

The section of copper in these three cables is 1·335 of an inch, and their cost per yard *in situ* is 31s. per yard, giving a total cost of the completed line at less than £2 per yard. Supposing that the space between the stones of the footway and the cellars of the houses did permit of the introduction of culverts for the passage and insulation of bare copper—which, as it happens, they would not—even then the cost of the mains must be less per yard than if constructed on the Crompton system.

Recently, when in Paris, I was interested in having the opportunity of watching the laying down of mains by the Compagnie Popp, and by the Compagnie Edison. The former uses a cast-iron trough having a cover and means of jointing one trough to the other. These joints are by way of being water-tight. The cables are laid in three or four layers, three or four in each layer, and are separated from one another by slips of deal, with a deal board resting on the slips between each layer. These cables are laid in dry while the line is being made. Mons. Popp assured me that, when required, they can be easily drawn out, and others drawn in in their place; but this remains to be proved. The draw-boxes at the angles of streets, which have round iron covers in a square frame of the same material, are large, capacious inside, and consequently very convenient.

The mains of the Edison Compagnie, which I saw being laid, consisted of exceptionally large cables of uninsulated copper strand. They were being laid in concrete troughs of about 15in. in width and 10in. in depth. They were supported, without any possibility of being strained, on porcelain insulators, and the troughs covered in with stone flagging. These cables not only approached one another, but also the sides of the trough so closely, that I was startled at seeing the covers being laid on and the earth and footway made good. Being at a considerable depth—5 or 6 feet in many places—and having no access to the insulators, I cannot conceive how sufficient insulation can be attained or maintained. My impression was that the only obligation on the contractor was to get as many tons of copper under the ground as he could.

With low-tension distribution it seems evident that the size of the copper that may be eventually required cannot be easily estimated, and that, even if it could be so, it is not expedient to place underground quantities of copper which may have to lie partially idle for a long time to come. Hence the provision of sufficient capacity in culverts, ducts, or ways, into which copper can be introduced, either bare or insulated, as it is required, is a sound act of foresight.

But with high-tension distribution, accompanied by caution at the consumer's premises, the question can be regarded rather differently. For example, at Bath, where the "tree" system may be said to be in use, I have encountered the following conditions:—A stem of about 800 yards in length without any house connections on it; at the end of that two branches, traversing both sides in some cases, and one side in another, of two groups of streets and squares: in one case five streets, containing 150 residences, are passed along; in the other group six streets, containing 92 houses. Suppose that each house requires an average of 10 amperes at 100 volts, it will require half an ampere at 2,000 volts. The distributing mains in the first case will have to carry 75, and in the other less than 46 amperes, or cables of an average of 19/15 and 19/17 respectively. Now it is obvious that the least proportion of the cost of these mains is in the conductors themselves, and thus some such system as that for which the Messrs. Callender contracted with Mr. Massingham at Bath is probably the most economical. Such a main is described in Messrs. Callender's specification for what they call their "solid system," and, exclusive of the restoration of the surface, of which the cost varies according to its nature and the scale of charges of the local authority, would cost less than 9/- a yard run.

The line, once down and well laid, need, so far as one can see, never be disturbed, except by accident or injury, and a sufficiency of capacity for probable future demands is secured without heavy cost. For instance, the cost of a main with two insulated conductors of 7/16, laid in cast-iron troughs 3in. by 2in. internal section, and having 5/32 of an inch thickness of metal, the cables supported and kept apart by bridges of bituminous wood 2ft. apart, and the vacant space run in solid with bitumen, including taking up the paving, excavating, laying, filling in, and restoring the surface, is about 7s. a yard, including engineer's profit and superintendence—of course, if executed in lengths of not less than 500 yards.

In proportion to the number of cables and the section of copper, this cost is reduced, if four or more larger cables are laid. For instance, a main with a metal case containing four cables of 19/18 and four of 7/16, and having together ·23 of an inch in section of copper, can be laid and completed for about 15s. a yard.

I have had some of these lines tested for insulation resistance. In the case of one pair of 19/18 cables, with only two service

Digitized by Google

branches, on which the transformers were disconnected for the time in a length of 1,450 yards, which had been buried over six months, I found an actual resistance of over 100 megohms, or 60 megohms per mile. With the primaries of the two transformers in circuit, the result under the same conditions was 15 megohms, or 12·2 megohms per mile.

Another pair of similar cables, 1,500 yards in length, with seven transformers in circuit, gave only 3 megohms, or 2·55 megohms per mile.

As regards the question of depreciation, and cost of renewals and maintenance, we have a good deal still to learn. There are clearly four main classes, the conditions of which affect those prices, as well as that of capital cost, namely :—

(*a.*) Bare copper in the case of which the conductors and their means of insulation are inaccessible without excavation.

(*b.*) Bare copper where insulators are accessible, and the conductors can be drawn in and out without special excavation.

(*c.*) Insulated conductors which can be drawn in and out without excavation.

(*d.*) Insulated conductors which are fixed, and which, except at the boxes, are inaccessible throughout their length without excavating.

I may say that I have not yet seen a case of (*b*) class in its integrity—that is to say, without having in combination short lengths of (*c*).

Only lately the London Chamber of Commerce has rather startled us by issuing a circular in which it lays down the rule that depreciation for mains with "bare conductors insulated by means of glass, porcelain, or other such like imperishable materials," may be calculated at 1 per cent. ; while that on "all cables or other conductors covered with continuous insulation" should be calculated at 5 per cent. Now, if that body had accompanied their statement by a few words of explanation as to whether the calculation is to be on the cost only of copper insulated in the one way or the other, we might have thought it worth while to discuss with them the question, even though it is quite outside their province to lay down any such laws. But as we are left to suppose that the cost of the whole structure of the main may be included in the figure from which the percentages are to be deducted, I really do not think it worth while to take up the time of the meeting beyond drawing marked attention to the document, which probably several present have seen, in the hope that some speaker, struck with the adventurous nature of the statement, as I have been, may be led to give an opinion on it in the discussion which I hope may follow.

## ELECTRICAL UNITS OF THE PRESENT AND FUTURE.

The following extract from an address delivered to the New York Electric Club on December 18th, by Prof. F. B. Crocker, may be of interest :—

The more exact requirements of advanced work at first only required definite standards. Therefore the standard yard and the standard quart were adopted, but they were arbitrary. Some person decided what they should be, and they were carefully made and deposited in the national archives, and exact copies of those were made and sent around to various points, and they became in some cases the legal standards.

Self-induction is somewhat unfamilar, nevertheless, it is becoming important. It happens that there are several ways of defining self-induction, but the best way, I think, is to consider it as a counter electromotive force, and to define the unit self-induction to say that it gives a unit change of current in a unit time. The ordinary way, however, for deriving this unit is to multiply resistance by time. That seems to be an odd way to get it, but what it means is this: that self-induction is the apparent increase in resistance that we get when we try to pass a current through a circuit.

I would like to point out the fact that we have "absolute units" and "practical units," so called. I put both of these in quotation marks. Absolute units are not absolute, they are based on an arbitrary dimension of the earth incorrectly measured. Practical units, in the same way, are not practical, because we have one, the farad, that is 1,000 times greater than the greatest practical capacity in existence. Therefore, I maintain that we must have a third system of units, and that is the "working" units. You could call them "commercial," but the objection to that is that they are equally used in the laboratory as in commercial work. We use a microfarad in the laboratory the same as in the office of a telephone or cable company. Therefore, they are not, strictly speaking, commercial, but they are *working* in both cases. Sometimes the working units agree with the practical and sometimes they do not. The ampere, coulomb, and volt are the same, although in telegraphy we use the milliampere. Then we come to the ohm. That is, the ohm is right for most practical work, but for insulation tests we have to use a megohm. Nobody thinks of giving insulation tests except in megohms. Therefore for that class of work, the working unit is the megohm and not what is called the practical unit. When we come to the microfarad, there is no question. The practical unit ceases entirely to be practical, and we have to adopt the working unit, which is almost infinitely different. The watt is a convenient unit for a great many purposes, but when we use it for large work we use the kilowatt, which, by the way, is a good way of rating dynamo, because it is fairly near a horse-power.

Then we come down to the last of all—the henry, the new member of the family, and it is a question whether the working unit will be a henry or a millihenry. I did think of reducing the value of the henry to one-thousandth of its value ; but it would have been a mistake, for the reason that, instead of having its value one second multiplied by one ohm, we would have its value a second multiplied by a thousandth of an ohm or a hundredth of an ohm. That would be destroying the simplicity and the harmony of this system—a feature which it certainly does possess. Every one of these units is derived from every other one in the simple ratio of one to one, and in no case is there any complex relationship of a thousandth or ten-thousandth or anything of that sort. You see that the coulomb is an ampere multiplied by a second, a volt is one ampere multiplied by an ohm, a farad is a coulomb divided by a volt. A joule is a volt multiplied by a coulomb, and a henry is a second multiplied by an ohm ; and to make any one of them variant would, I think, be a mistake, particularly as it would have been the only exception to the harmony of the system.

Fortunately, the henry approximates a practical value. For example, a large Edison dynamo shunt wound will run up to one or more hundred henrys. A telephone magnet will be between one-hundredth and one-tenth of a henry. We could not expect that to be a very large value. An ordinary relay is several henrys in value. A large induction coil is often 1,000 or more henrys in value. Therefore, there is nothing preposterously small or large about the henry. It is about right.

In regard to future units, which the requirements of advanced work will soon necessitate, we need a unit of the strength of a magnetic field. We can express it as so many lines of force to the square centimetre, &c., but that is a very clumsy way. If we simply called it one Franklin, it would be very preferable to a long sentence.

## MEETINGS OF SCIENTIFIC SOCIETIES, &c.

**FRIDAY, February 6th.**

ROYAL INSTITUTION.

*9 p.m.* Evening Discourse: "Some Applications of Photography," by Lord RAYLEIGH, F.R.S.

**MONDAY, February 9th.**

SOCIETY OF ARTS.

*8 p.m.* Cantor Lecture II. 3. "The Construction and Capabilities of Musical Instruments," by A. J. HIPKINS, F.S.A.

**TUESDAY, February 10th.**

INSTITUTION OF CIVIL ENGINEERS.

*8 p.m.* Ordinary Meeting. Paper to be discussed: "Electric Mining-Machinery," by LLEWELYN B., and CLAUDE W. ATKINSON, A.M.M.I.C.E.

**WEDNESDAY, February 11th.**

SOCIETY OF ARTS.

*8 p.m.* Ordinary Meeting. Paper to be read: "The Proposed Irish Channel Tunnel," by Sir ROPER LETHBRIDGE, M.P.

**THURSDAY, February 12th.**

INSTITUTION OF ELECTRICAL ENGINEERS.

*8 p.m.* Ordinary Meeting. Paper to be discussed: "The Distribution of Electricity with Especial Reference to the Chelsea System," by Major-Gen. WEBBER, R.E.

**FRIDAY, February 13th.**

PHYSICAL SOCIETY.

*5 p.m.* Annual General Meeting, after which the following Papers will be read or discussed: 1. "Photo-Electricity," by Prof. MINCHIN. 2. "The Change in the Absorption Spectrum of Cobalt Glass produced by Heat," by Sir JOHN CONROY, Bart.

INSTITUTION OF CIVIL ENGINEERS.

*7.30 p.m.* Students' Meeting. Paper to be read: "The Cleaning and Deepening of Rivers and Canals by means of the Transporting-power of Water," by W. HERBERT WHEELER, S.I.C.E.

ROYAL INSTITUTION.

*9 p.m.* Evening Discourse: "Some Results of Recent Eclipse Expeditions," by Prof. A. SCHUSTER, F.R.S.

**SATURDAY, February, 14th.**

ROYAL INSTITUTION.

*3 p.m.* Afternoon Lecture: "The Forces of Cohesion," by LORD RAYLEIGH, F.R.S.

Digitized by Google

# The Electrician.

**Published every Friday, Price Fourpence; Post Free, Fourpence Halfpenny**
**Editorial, Publishing, and Printing Offices:**
**SALISBURY COURT, FLEET ST., LONDON, E.C.**
*Telephone No.* 2714. *Telegrams:* "ELECTRICIAN NEWSPAPER, LONDON."

*All Letters relating to Subscriptions, Advertisements and other business matters should be addressed to the Publisher,* "THE ELECTRICIAN," *Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to* "THE ELECTRICIAN" *Printing and Publishing Company, Limited, and be crossed "Coutts and Co." All other letters to be addressed to the Editor.*

*All letters intended for insertion in* "THE ELECTRICIAN," *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

"THE ELECTRICIAN" *is published every Friday morning, in time for the morning mails. Subscribers should receive their copies by the first post on Friday morning.*

"THE ELECTRICIAN" *is on sale at the railway bookstalls throughout the Kingdom on Friday morning, and can be obtained of all Booksellers and Newsvendors; or direct from the Publishing Offices as above.*

*New Volumes of* "THE ELECTRICIAN" *commence in May and November.*

## SUBSCRIPTION RATES.

The rates for Subscriptions to "THE ELECTRICIAN" are as follows:—

| | 3 months. s. d. | 6 months. s. d. | 12 months. s. d. |
|---|---|---|---|
| For the United Kingdom | 5 0 | 10 0 | 19 6 |
| For Foreign Parts and Colonies:— Within Postal Union | 6 6 | 12 6 | 24 0 |
| Aden Borneo, Ceylon, China, India, Japan, Java, Labuan, Mozambique, New Caledonia, Persia, Philippine Islands, Siam, Transvaal, and Zanzibar | 7 6 | 14 6 | 28 0 |



## TO ADVERTISERS.

"THE ELECTRICIAN" *offers exceptional advantages to Advertisers.*
**It has by far the largest circulation of any English Electrical paper, and circulates all over the World.**

*Particulars relating to Advertisements will be promptly forwarded on application to the Offices as above.*

TRADE ADVERTISEMENTS *intended for the current issue must reach the Offices not later than First Post on Thursday morning. Renewals of expiring advertisement orders and alterations to standing advertisements should be in the Publisher's hands by Wednesday at latest. No alteration can be made in Wrapper advertisements after Wednesday evening.*

SMALL PREPAID ADVERTISEMENTS *(for Rates see page xvii.) are accepted up to 4 p.m. on Thursday.*

## TECHNICAL PRINTING.

"THE ELECTRICIAN" PRINTING AND PUBLISHING COMPANY (LIMITED) *inform Electricians, Electric Light Engineers, &c., that they make a specialty of Technical Printing, and have a large Staff thoroughly acquainted with Electro-Technology. They can, therefore, promise Accuracy and Despatch in the Printing of Electro-Technical Literature, &c.*

## "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. (Royal 8vo.)

*Early in each year is issued* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. *The* DIRECTORY *was established in 1883, and the 1890 Edition consisted of about 850 pages of printed matter. The names and addresses of all persons engaged in the Electrical Industries at home and abroad may be relied upon as accurate. Useful Tables and Electrical Formulæ, and information specially compiled for this work are given, together with popularly-written Biographical Notices of the leading Electricians, Electrical Engineers, &c., accompanied in many cases by Portraits.*

*The 1891 Edition is now actively preparing, and Subscription and Advertisement Orders, New Names, Corrections, &c., can be received.*

## ELECTRICAL BOOKS AND PUBLICATIONS.

***All Books, Newspapers, and other publications, dealing with Electrical and kindred subjects, can be ordered direct of* "THE ELECTRICIAN" *Printing and Publishing Company, who are proprietors of the well-known* "ELECTRICIAN" *Series of Standard Electrical Works, and are agents for all the leading publishing houses at home and abroad.***


## CONTENTS OF THE CURRENT NUMBER.


NOTES .......... 411
The Historical Development of the Induction Coil and Transformer. By Dr. J. A. Fleming, M.A. Illustrated. Continued .......... 416
The Elmore Process of Depositing Copper .......... 417
The Hellesen Dry Battery .......... 419
On the Influence of the Electric Spark on the Discharge in Gasses. By P. Bachmetjew .. 420
"The Distribution of Electricity, with Especial Reference to the Chelsea System." By Major-General C. E. Webber. Concluded .......... 420
Electrical Units of the Present and Future .......... 423
Meetings of Scientific Societies. 423
MORE BOARD OF TRADE RULES 424
Review .......... 426
The Magnetisation of Iron: Phenomena occurring at a Red Heat .......... 426
On the Alternating Electric Arc between a Ball and a Point. By Edward L. Nichols. Illus. 429
An Old Telephone Switchbaord. Illustrated .......... 429
The Applications of Geometry to Practical Life. By Prof. Karl Pearson .......... 431
Hine and Robertson's Planimeter. Illustrated .......... 432
The Cutter Arc Lamp Supporting Pulley. Illustrated.. 432
American Notes .......... 433
CORRESPONDENCE—
Electric & Magnetic Theories —R. S. Cole and John T. Sprague .......... 433
Resistance Coils—J. Clement Cuff .......... 435
Conductivity of Stranded Wire—James Connolly ... 435
Trade Notes and Notices .......... 435
PATENT RECORD .......... 436
COMPANIES' MEETINGS, &c.—
Anglo-American Telegraph Company (Limited) .......... 437
The City and South London Railway Company (Ltd.)... 439
Cuba Submarine Telegraph Company (Limited) .......... 441
City Notes, &c. .......... 441



## STEEL-PLATE PORTRAITS

*Of W. H. Preece, F.R.S.; Michael Faraday; Sir John Pender, K.C.M.G.; Sir William Thomson, F.R.S. (Past-President of the Institution of Electrical Engineers); C. H. B. Patey, C.B. (Late Secretary of Telegraphs, G.P.O.); Dr. John Hopkinson, F.R.S. (Past-President of the Institution of Electrical Engineers); Dr. Oliver J. Lodge, F.R.S., and Prof. William Crookes, F.R.S. (President of the Institution of Electrical Engineers), have been issued as Supplements to* "THE ELECTRICIAN." *A few Copies of these admirably-executed Steel Engravings can be supplied, price 1s. each, post free on roller, 1s. 2d. Or framed in neat Black Pillar or Brown Ornamental Frames, price, post free, 4s. 6d.*


## MORE BOARD OF TRADE RULES.

The legislation of 1882 stifled the beginnings of electric lighting by the imposition of conditions which discouraged its most energetic advocates, and it would seem that an additional load of statutory embarrassments is likely to be added to those which already encumber its progress, in a way which must delight its opponents. We refer to the new "Model Clauses for the protection of Telephones," printed in our last week's issue. The first Electric Lighting Act was a unique measure, inasmuch as it was intended to care for an industry which at that time had hardly passed beyond the stage of experiment, and about which no practical knowledge whatever had been gained, and little evidence could be procured, except such learned generalities as form the stock-in-trade of eminent scientific witnesses. Fortunately for the community, originality is not common among those who frame our laws, and it is undoubtedly to the credit of those who drew up the Act in question that so few errors were made in its provisions. After the continual mention of the local authorities, who were then, as now, so favoured by the Board of Trade, no references are so common in the 1882 Act as those which cite the Gasworks Clauses Act, and it is evident that those who were responsible for the new Bill adopted the common practice of following as closely as possible the steps of those who, if they did not know more about their work than their copyists, had at least produced something which, after the usual trimming and polishing, had for many years been established as an Act of Parliament.

Digitized by Google

When railways were in their infancy STEPHENSON made his experiments, locomotives were built, lines were laid and trains were run without troubling anybody in Whitehall. Some fourteen or fifteen years elapsed before it was found necessary to extend the powers of the Board of Trade to railway matters. The old Railway Acts were closely modelled on the Canal Acts, and so little were future developments realised, that it was assumed that anybody who wished to do so could run their own locomotives and coaches on the new lines. The only difficulty indeed, and one which was carefully noticed by the Great Western Railway, was, that any troublesome person who desired to avail himself of the privileges accorded by the law would have to commit trespass before he could place his engine on the rails. Gas lighting, again, had become firmly established before the Board of Trade had to undertake any supervision, though the regulations that were found to be necessary were of a very simple character, and did not develop in a gradual manner as in railway work. The engineering regulations of the Board of Trade are to this day of a very permissive nature. Whether it was a good thing for railway enterprise and for public safety or no, the fact remains that half a century ago no zealous official, with the doubtful assistance of a nonchalant council of laymen, drew up a set of regulations for the protection of public safety, and ordered continuous brakes to be fitted to all trains, automatic couplings to be provided forthwith, and every line to be immediately worked on the block system. Such an official could have adduced with but little difficulty excellent reasons for such simple and valuable proposals; but fifty years have passed, and while the able advisers to the Board of Trade know well enough the importance of such appliances, they admit that the railway engineers have a right to be heard, and they respect their statements, and acknowledge the difficulties which exist.

Bearing these antecedent facts in mind, there was nothing ominous in Section 6 of the Electric Lighting Act, which enacts that the undertakers shall be subject to such regulations and conditions as may be inserted in any licence, order, or special Act with regard to (*a*) the limits and conditions of a compulsory or permissive supply, (*b*) a regular and efficient supply, (*c*) securing the safety of the public, (*d*) the limitation of prices, (*e*) inspection, (*f*) enforcement of duties, and, lastly, a convenient and elastic section (*g*) to cover any unforeseen or forgotten point, "generally with regard to any other matters in connection with the undertakings." The first of these has as yet given rise to no friction. In respect of (*b*) and (*c*), the Board has done its best, or perhaps its worst. As to prices, a healthy competition has rendered interference unnecessary in London. Inspection, we have still to experience, and little is known about it beyond the ridiculous salaries offered in London and Liverpool. Of enforcement of duties it is as yet too soon to speak. But apparently one of the "other matters" is now to claim the attention of those who are engaged in the supply of electrical energy. We refer to the interference of telephonic service by induction or leakage. Having secured the safety of the British public, and being satisfied that they have done their best to render overhead wires innocuous by coating them with a feeble and clumsy covering of vulcanised india-rubber (forgetting mechanical protection in their zeal for insulation), the Board of Trade have turned their attention to fostering a business which another Government department recently declined to purchase. Can it be that the Post Office did not care to take over the telephones while they were in so defenceless a condition, and preferred to wait until the Board of Trade have shielded them from insidious induction, and guarded them from those vagrant currents that leak out through faulty insulation and creep home the wrong way through earth connections that ought not to exist?

We cannot, on the present occasion, go into the legal question of the creation of a property in the ground as a conductor. From the earliest days of telegraphy everyone has considered that he has a right to earth a line and to use the soil as a return circuit, or to bring his line to zero potential, or to use the earth as a common reservoir of electricity according to his ideas of the matter; and the cases of interference, until extended use was made of the telephone, were more interesting than annoying. But to-day there is scarcely a telephone line in London on which one is not disturbed by the wail of a Wheatstone or the tattoo of a tape instrument, and the Company is well aware that these and other annoyances diminish the value of the service which they provide by at least one-half. They have more subscribers than they can properly deal with, and they are well advised in endeavouring to improve their service rather than reduce their rentals. We should, indeed, welcome any measure that would render the use of the telephone less exasperating than it is to-day; but it seems to us most unreasonable to attempt to restrict the use of other electric lines, as though they were inherently inimical to the telephone; and the one thing suggesting that the proposed regulations are not inspired by the Post Office is that, where that body has undertaken telephony, it has from the first adopted the proper measure of looping all wires and providing a metallic circuit. We understand that the Telephone Company is looping the trunk mains which connect the various Metropolitan exchanges; but finds great difficulties in the way of carrying this out for subscribers' wires. If statutory powers to lay these under the street will solve the difficulty, the objection at present urged against metallic circuits, viz., the outcry which would be raised if the present overhead wires were doubled, would disappear. A sensitive instrument like a telephone—the most sensitive instrument, in fact, that is at the disposal of ordinary mortals (Mr. BOYS being excepted)—must be used with special precautions. The electric supply companies have their Acts of Parliament; and what have these been obtained for, at so great expense, if not to enable them to do certain things at a profit, for the eventual good of the public, which they could not otherwise have done? Railway companies have their Acts, and having their Acts no neighbour can complain that they rattle and roar. It is partly because they rattle and roar that Acts are necessary, but they must not commit any needless nuisance such as the establishment of gas works. So, too, an electric supply company must not pollute the air with smoke. If it were a fact that a telephone with a metallic circuit was liable to be disturbed by induction or leakage, there would then be more justice in their demand for the peaceable and quiet enjoyment of their property. But the present proposals relate also to future telephone wires, which may some day be laid, and it is assumed that there is some property in the future in a district as yet uncivilised by telephone or electric supply. The rights of the first comer are comparatively easy to settle, but this is indeed a wide demand. The gas companies having their Acts lay their mains, and do not mind if a few hundred thousand feet leak away into the surrounding earth. But anyone who afterwards builds a conduit in the reeking soil has to make it gas tight if he can, and ventilate if he may, and take the consequences, whether he likes them or not, when an explosion occurs. Imagine the feelings of a gas company (the feelings of a gas company!) if they were told that they must so reconstruct their existing mains, and so lay all new ones, that any person who shall hereafter build a conduit within a reasonable dis-

Digitized by Google

tance shall have so little trouble with any leakage of their gas that he need not go to the expense of ventilating it; and to make the parallel more complete, it must be imagined that the conduit builder has as yet no statutory powers whatever.

Electric supply companies have been sorely tried in the past with grandmotherly rules. First of all the protection of the lines of the POSTMASTER-GENERAL, and then the safety of the public, have been the occasion of most stringent regulations, and now a new trouble, arising from the incomplete character of other people's work rather than from any fault in their own, threatens their operations. Is it too much to hope that this latest difficulty may be speedily adjusted by mutual concessions without troubling the Board of Trade for any more of the regulations of which they have of late given us so many specimens. This powerful Government Department has taken up a position which may almost be described as hostile, and the frequent rebuffs encountered by commercial men in their dealings with the Board of Trade only tend to widen the breach which at present unfortunately exists.

## REVIEW.

**Electric Light Installations and the Management of Accumulators.** Sir DAVID SALOMONS, Bart. Sixth Edition. (Whittaker and Co.)

This book has grown considerably since its first issue, and, moreover, it has been found advisable to give it a more comprehensive title. The impression produced on reading the section dealing with accumulators is not unlike that which an uninitiated reader receives on perusing a book on medicine. It gives the idea that an accumulator can never be anything but a mass of diseased plates, although the author gives assurance that a properly managed battery ought to give no trouble at all. From a practical point of view the work is an excellent book of reference for persons engaged in the management of accumulators and installations generally, and teems with useful hints, suggestions, and figures for every-day working. In the chapter on governing are described several highly-ingenious devices of the author's for rendering the action of switches and apparatus automatic. A short history of the Broomhill installation is highly interesting and instructive.

Looked at from a scientific point of view, the book does not show to such advantage. There are several mistakes and misleading statements, which must be eliminated and corrected before anything like perfection is reached. For instance, on the first page, before the introduction, we find the following interesting statement:—

Watt = volt × ampere = measure of *force* or energy.

This is new to us. The author treats us also to a new expression for the chemical action which takes place in charging a secondary cell. It runs as follows:—

| | Positive. | Electrolyte. | Negative. |
|---|---|---|---|
| First stage | $PbSO_4$ | $H_2SO_4 + H_2O$ | PbO |
| Second stage | PbO | $H_2SO_4 + H_2O$ | PbO |
| Third stage | $PbO_4$ | $H_2SO_4 + H_2O$ | Pb |

In the second stage three O's and one S are missing, one O re-appears in the third stage, but the remaining O's and the S are apparently resolved into the primordial ether. On page 152 the author depreciates the insulating powers of ebonite; we presume this material is only good enough for bridges, condenser keys, and such-like rough apparatus. Again, we are told in the section relating to arc lamps that "an increased current greatly increases the light, *the proportion of current to light not being direct, as in the case of glow-lamps.*" Now, Sir David knows better than this, as is shown by a remark which occurs in a later chapter. The book has a distinct and extended sphere of usefulness, and, when still further revised and corrected, will be a valuable addition to electrical literature.

## THE MAGNETISATION OF IRON: PHENOMENA OCCURRING AT A RED HEAT.[1]

In the interim report presented last year it was stated that this Committee, which was appointed some time ago to inquire into the various molecular changes connected with the magnetisation of iron, proposed to confine itself, as we believe was the original intention on the appointment of the Committee, to those remarkable physical phenomena which are found to occur in iron and steel, about the temperature of a red heat when iron ceases to be a magnetic metal.

The suddenness with which iron loses its magnetic susceptibility at a red heat has often been noticed by different observers. Prof. Rowland[2] was the first to point out that for small magnetising forces, the susceptibility of iron increases as the temperature rises, reaches a maximum at a red heat, and then falls suddenly to zero, but that the susceptibility diminishes as the temperature rises when large magnetising forces are used. Bauer[3] subsequently established the same fact. Later, one of us (H. F. Newall[4]) has experimented with small spheres of iron and steel enclosed between closely fitting hemispherical caps of brass, so that the iron sphere was held by and heated in the brass, and thus allowed to heat and cool slowly, the susceptibility being tested by means of a mirror magnetometer. It was found that during cooling from a white heat the reappearance of magnetic susceptibility was much more leisurely in steel than in soft iron, the *rate* of return to the magnetic state corresponding with the rate of recalescence; where recalescence was absent the susceptibility suddenly returned; where the reglow was pronounced the return to the magnetic state was slow. This is to be expected, for the rise of temperature during recalescence is more than sufficient to carry the iron out of the magnetic condition it had just entered upon by cooling, hence there will be a sudden oscillation at this critical temperature. Ledeboer[5] was, we believe, the first to assign the exact temperature of the loss of susceptibility. He found the susceptibility of iron to disappear at a temperature ranging from 750° to 770°C. Hopkinson[6] more recently has investigated the effect of different magnetising forces on the loss of permeability of iron and steel with increasing temperature, more especially near the critical temperature. Hopkinson found that with very low magnetising forces, less than 1 C.-G.-S. unit, the permeability of *iron* gradually rose up to a temperature of 785°C., when it almost suddenly dropped down to unity; in like manner mild steel at first rose and then suddenly fell at a temperature of 735°C.; hard steel behaved similarly, falling off at a temperature of 680°C. Prof. J. A. Ewing has shown recently,[7] in his beautiful experimental model representing molecular magnets, how a state of magnetic instability may occur in the magnetic metals as a certain critical temperature is approached, the chief facts of permeability and retentiveness, and what Ewing terms hysteresis, being explicable by supposing that a magnetised bar is made up, as in Weber's hypothesis, of molecular magnets but "constrained by no other forces than those due to their own mutual attractions and repulsions." Increase of permeability due to rise of temperature, for magnetising forces far short of saturation, being caused by the expansion and separation of molecular centres creating a reduction of stability. And as regards the sudden loss of susceptibility at the critical temperature, Ewing conjectures that the violence of the oscillation of the molecular magnets at this temperature may cause a state of rotation to be developed, wherein, of course, all magnetic polarity would disappear. Prof. Ewing's suggestive Paper shows us that we may well expect other remarkable phenomena—and abrupt changes in the physical properties of the magnetic metals *are* found to take place—at this critical temperature. The Committee have been engaged in investigating some of these.

I. We will first take the sudden anomalous expansion observed when steel and some specimens of iron wire cool from a white heat first noticed by Gore in 1870, and the corresponding anomalous contraction on heating first noticed by one of us in 1873.[8] The wire steadily expands as the temperature rises till a low red heat is reached, when a halt occurs, then a sudden momentary retraction of the wire takes place, after which expansion continues to the fusing point. On cooling, the wire regularly contracts till a temperature a little *lower* than that at the jerk on heating is reached, when a sudden momentary elongation of the wire occurs, and then contraction ensues till it is cold. If the wire be vertical or horizontal, with or without tension, the effect is equally present. To

[1] Abstract of the Report of the British Association Committee on Molecular Phenomena associated with the Magnetisation of Iron. Prof. G. F. Fitzgerald (Chairman), H. F. Newall, F. Trouton, and Prof. W. F. Barrett (Secretary).
[2] *Phil. Mag.*, November, 1874.
[3] *Wied. Ann.*, xi. (1880).
[4] *Proc. Camb. Phil. Soc.*, Vol. VI., Part 4 (1888).
[5] *La Lumière Electrique*, T. XXVII., No. 2. [6] *Phil. Trans.*, May, 1889.
[7] *Phil. Mag.*, September, 1890. [8] Barrett, *Phil. Mag.*, January, 1874.

Digitized by Google

perceive the jerk on cooling, it is, however, absolutely essential that the temperature of the wire should be raised above that at which the jerk on heating occurs, otherwise no anomalous effect is observed. In the experiments made by one of us in 1875 but not hitherto published, Barrett found that in some specimens of steel wire *two* anomalous contractions on heating and expansions on cooling were noticed, the feebler one taking place at a lower temperature. Further, that in some specimens of iron *no* anomalous expansion or contraction was noticeable, whilst more generally in other specimens the effect *on cooling only* was noticed, and that usually this effect could be wiped out by a few successive heatings and coolings. But in *steel* the jerk in cooling was always present and was not wiped out, though at first slightly reduced, by repeated incandescence and cooling. Further, judging by the amount of the expansion of the wire, the effect on heating took place, as stated above, at a slightly higher temperature than the jerk on cooling.

A series of unpublished experiments were long since made by the Secretary on the effect (*a*) of the diameter of the wire, and (*b*) of the tension on the wire, the effects observed being represented by a curve. Up to Nos. 14 or 15 B.W.G. steel wire, *i e.*, up to a diameter of about $\frac{8}{100}$ of an inch, there is, at the critical temperature, decided retraction on heating, but at this diameter a halt, with just a perceptible retraction, occurs, and as the diameter increases the halt becomes more and more prolonged, until when No. 3 wire is reached (a rod of $\frac{1}{4}$-inch diameter) at the critical temperature a halt of six seconds takes places in the expansion of the wire during heating, and a halt of twelve seconds in the contraction of the wire during cooling. As regards the effect of *tension* on the wire it has the effect of diminishing the anomalous retraction on heating and increasing the anomalous expansion on cooling. The anomalous contraction on heating appears to wear out in thin wires even of steel, but not the anomalous expansion on cooling. In thicker wires of hard steel, continued heating and cooling appeared to make but little difference. We shall discuss later the cause of this curious wiping out of the jerk by annealing or repeated heating and cooling, and are continuing the investigation with samples of steel of known composition.

II. The permanent stretching of the wire under load occurs only when the critical temperature is reached. At this temperature an abrupt and remarkable softening or plasticity of the iron or steel occurs which renders it extraordinarily ductile. Mr. H. Tomlinson[9] has, already published some interesting experiments on the enormous loss of rigidity which occurs in iron at the critical temperature.

In a series of interesting papers communicated to the Physical Society, he has added much to our knowledge of the physical changes which occur in iron at the critical temperature. Mr. Tomlinson places near 1,000° C. the remarkable alterations he has observed in an iron wire under stress or strain. At this temperature "when stretched by a slight weight it suddenly unstretches, when under a slight bending stress it suddenly unbends, when under a slight twisting stress it suddenly untwists, whilst on the contrary, if it has been previously bent or twisted permanently and then released from stress, it suddenly bends more or twists more as the case may be."[10] Opposite changes occur in cooling. One of us[11] has suggested that the probable explanation of the effects observed by Mr. Tomlinson is due to the difference in the rate of heating and cooling between the interior and exterior of the wire. It is probable that the anomalous contraction and expansion in iron which we have been studying is an effect due to the longitudinal strains in the wire produced by wire-drawing, and which are destroyed by frequent heating; the non-existence or rapid subsidence of the effect in some specimens of very soft iron follows from this explanation, together with the more pronounced and enduring effects noticed in steel. Nevertheless, some other cause appears to exist in hard steel where the effect appears to be more or less permanent. We hope to throw more light on this point next year, as our experiments are being continued.

III. We now come to the reglow or *Recalescence* of iron and steel at the critical temperature first noticed by Barrett (*Phil. Mag.*, 1873), and which M. Osmond has made the starting-point of his admirable investigations. It was noticed by one of us[12] soon after the discovery of recalescence that a faint second glow could be seen; the first and far stronger afterglow being exactly coincident with the sudden elongation of the steel wire during cooling. We now come to M. Osmond's valuable investigations, which commenced in 1886.[13] By means of a pyrometer similar to that used by M. Ledeboer, devised by M. H. Le Chatelier, and consisting of a thermo-electric couple of platinum and platinum rhodium alloy, associated with a dead beat galvanometer, Osmond has made a careful study of the recalescence in iron and steel.

Osmond finds three critical points to exist in mild steel when, during cooling, the temperature remains stationary for a sensible interval of time. These three points he designates $a_1$, $a_2$, and $a_3$; $a_1$ being that at the lowest temperature about 660° C., $a_2$ about 730° C., and $a_3$ about 850° C. In hard steel $a_1$ only is present, but is much more pronounced, and occurs somewhat higher, about 700° C. In electrolytic iron, which, however, contained 0·08 per cent. of carbon, $a_2$ and $a_3$ only are present, occurring at about 720° C. and 860° C. respectively. The temperature of these critical points he finds, just as we found with the anomalous expansion and contraction, to be higher during the heating than during the cooling of the same specimen. Osmond, however, has not noticed any sudden rise of temperature at recalescence, only a longer or shorter halt in the cooling. But this difference probably arises from his mode of experimenting; one of us has pointed out the necessity of precaution in this respect.[14] We have recently repeated our experiments, using a thermo-couple similar to that employed by Osmond, and find that there is not the least difficulty in observing and measuring the sudden large *increase* of temperature that occurs during recalescence. It is only necessary to use somewhat fine wires for the thermo-couple, to bind them to the steel wire under experiment, and wrap the part round with asbestos to prevent too rapid cooling in the air.

The temperature of the critical point Osmond finds, as occurred with the jerk on heating or cooling, to be higher on the up side of the curve (that is, during heating) than on the down side of the curve. Like ourselves, he finds the critical point higher in iron than in steel, and that on reheating the same sample the point of recalescence is lowered somewhat. Experiments we have recently made show that after the first two or three heatings stable conditions appear to be reached, recalescence then occurs at the same temperature and to the same amount on subsequent heatings and coolings. This is assuming the metal to be raised to the same temperature before cooling each time; if the temperature before cooling be not so great Osmond finds that the critical point is raised. Our experiments point rather the other way, but they need repeating. When the cooling of iron or steel is slow recalescence begins at a somewhat higher temperature, and lasts longer than when the cooling is very rapid. Osmond finds that when the cooling is very rapid, by quenching the white hot metal in water, recalescence is entirely absent. The steel is thus hardened, and Osmond concludes that the latent heat of the change which takes place in the metal at recalescence is still in the steel, and he terms it the latent heat of hardening.

IV. The difference in the temperature at which recalescence occurs on the up and down side of the curve of heating, has led two of our Committee independently to suggest the explanation of the remarkable thermo-electric current which is produced in iron and steel by a *moving source* of heat.[15] If an iron or steel wire be heated to redness at any one point of its length, and the source of heat, such as a Bunsen flame, be moved along, an electric current is set up in the direction in which the flame travels. By means of clockwork the flame can be caused to move continuously, and hence a continuous circuit is thereby obtained. There are, however, no signs of E.M.F. in the circuit until the recalescent point is passed; then reglow takes place behind the moving flame and the cooling effect in front. This thermal difference is, we believe, the cause of the resultant E.M.F., for it ceases when the flame ceases to move, and is absent in those metals where recalescence does not occur.

V. The thermo-electric position of iron undergoes a sudden change at the critical temperature. This was first noticed by one of us in 1875. Hot iron is thermo-electrically negative to cold iron, but at the critical point a large increase in the E.M.F. is suddenly developed. Mr. H. Tomlinson[16] has shown that iron at a bright red heat in contact with iron at the temperature of the air develops an E.M.F. of about one-twentieth of a volt, or upwards of twice that between a bismuth and antimony couple with a temperature difference of 100° C. between their junctions. Cumming was the first to notice long ago that the thermo-electric properties of iron changed at a red heat, but to Prof. Tait's classical Papers on thermo-electricity we owe the first exact investigation of the changes that heat produces in the thermo-electric properties of iron. "Iron," Prof. Tait remarks, "becomes as it were a different metal on being raised above a red heat; this may have some connection with the ferricum and ferrosum of the chemists, with the change

[9] *Phil. Mag.*, Feb. 1888.
[10] *Phil. Mag.*, Sept., 1887.
[11] Newall: *Phil. Mag.*, Nov. 1887.
[12] Barrett, unpublished laboratory notes, 1875.
[13] 'Transformations du Fer et du Carbone dans les Fers, les Aciers et les Fontes Blanches,' par F. Osmond, *Mémoires de l'Artillerie de la Marine.* A summary of M. Osmond's work is given in his paper read before the Iron and Steel Institute of Great Britain in the early part of the present year. M. Osmond has kindly lent us the specimens he has employed, and we hope to repeat some of his determinations shortly.

[14] Newall, *Phil. Mag.*, June, 1888.
[15] Trouton, *Proc. Royal Dublin Soc.*, 1887. Newall, *Phil. Mag.*, June, 1888. Mr. Trouton has found a similar but entirely transient E.M.F., caused by a moving flame to occur in other unannealed wires. This is an effect due to annealing by the flame, and disappears immediately, whereas the effect in steel is persistent.
[16] *Proc. Phy. Society*, Vol. IX. p. 105 (Nov., 1887). See also on this point a Paper by one of us (Newall, *Camb. Phil. Soc.*, Jan., 1888.

Digitized by Google

magnetic properties and of electric resistance at high temperatures."[17]

VI. *The electric resistance* of iron at this temperature also changes; Smith, Knott, Macfarlane,[18] and more recently Hopkinson[19] and Le Chatelier,[20] have published investigations on this point. Hopkinson finds a change in the temperature coefficient of the iron wire he used at 855°C., and of hard steel wire at a somewhat lower temperature. These temperatures he found practically coincident with the sudden loss of magnetic susceptibility of the metals. Le Chatelier finds mild and hard steel show two changes of curvature in their electric resistance, one at 850° C. and the other at 710° C., whereas manganese steel, in which we find recalescence to be absent,[21] shows no such change, the curve of increased resistance with temperature being perfectly regular. Le Chatelier also finds that pure nickel undergoes a sudden change in its electric resistance, the temperature coefficient altering at 340° C., which corresponds to the temperature of other changes in its physical properties.

VII. Some recent experiments made by Dr. E. Ball[22] appear to indicate that there is a still higher critical point than those observed by Osmond and ourselves. Dr. E. Ball has measured the tensile strength and roughly the magnetic state of iron and steel suddenly cooled down from different high temperatures. He finds that there are three critical points when a change in the tensile strength and magnetic character of iron and steel occur with sudden quenching: two of these points agree with Osmond's $a_1$ and $a_3$, but the third point is higher than either of these; he estimates it approximately as 1,300°C. More exact means of measuring the temperature and magnetic susceptibility are, however, necessary.

VIII. This higher temperature is near that at which M. Pionchon[23] has found a change in the *specific heat* of iron. Pionchon's results show that the specific heat of iron changes suddenly between 660° and 720°C., and again between 1,000° and 1,050°C., considerable absorption of heat taking place at these temperatures. The lower of these temperatures corresponds with the recalescent point and loss of magnetic susceptibility in steel. Mr. H. Tomlinson, as already noticed, has also observed two critical points in iron, one about 550°C., and the other at 1,000°C.,[24] when a sudden change occurs in the viscosity of this metal. No doubt these are the same points as those observed by Pionchon, for the variable composition of the iron also, and errors in determination of these high temperatures are probably sufficient to account for the differences observed.

The *amount of heat* given out during recalescence we have estimated from the observed expansion of the metal that occurs during recalescence. Taking Pionchon's determination of the specific heat of iron at a red heat, the heat liberated in the recalescence of a specimen of iron would thus appear to be somewhat over 100 times as much heat as would raise the same mass of iron 1°C. Dr. Hopkinson,[25] from the length of the break in the time curve of cooling, has estimated that the heat liberated in the recalescence of hard steel is equal to 173 times that liberated when the same material falls 1°C. The amount of recalescence in hard steel, as already stated, is considerably greater than that in iron.

IX. Here it may be mentioned that the hardening of steel by sudden quenching in water cannot be produced unless the metal be raised to the temperature of recalescence.[26]

X. We must now consider the general cause of these phenomena The secretary of this Committee long since suggested it was probably to be found in the carbon present in the iron, as recalescence was most marked in those specimens of iron and steel which contained larger percentages of carbon, and this cause Osmond has now, we think, satisfactorily established.

Recalescence in *steel* Osmond attributes to the chemical combination of the iron with the carbon present in a free state, and which has been liberated by heat. Thus the point of recalescence is that at which iron carbide, $Fe_3C$, forms; a body which is stable at ordinary temperatures but decomposed, with absorption of heat (producing the chilling effect observed on heating) at a red heat. Now the heat of combination we find to be about 3,000 calories per gram of carbon present in the iron, as deduced from Hopkinson's estimate of the amount of heat liberated during recalescence; further experiments on this part of the subject are necessary, and we hope to make them shortly.

Recalescence in *iron* Osmond attributes to an allotropic change which he believes iron to undergo at a temperature of about 750° C. Below this temperature iron exists in one molecular state, which Osmond designates $\alpha$ iron, between 750° and 850° the change is in process, and above 850° C. he asserts that iron enters the other molecular state, which he designates $\beta$ iron. It is, then, to the latent heat of allotropy that Osmond attributes the recalescence observed in iron, heat being absorbed to produce this change at the critical point during heating, and liberated during cooling at a somewhat lower temperature. Iron, according to this hypothesis, is a polymorphous element like sulphur, phosphorus, &c. Sudden cooling from a white heat, when the change into $\beta$ iron has occurred, should tend to preserve the iron in this allotropic state; but this is not the case, except to a small extent, and hence Osmond maintains that it is the presence of carbon in the iron which keeps the iron in the $\beta$ condition when suddenly cooled. Hardened steel would thus owe its properties principally to the presence of $\beta$ iron, which is hard and brittle at ordinary temperature: "both the iron and the carbon in hardened steel preserving more or less completely in the cold the condition which they possessed at a high temperature."

We think, however, that the evidence adduced by Osmond on behalf of his theory of recalescence in iron is as yet insufficient. No doubt iron does exist in an allotropic modification at a high temperature, but the electrolytic iron with which Osmond experimented contained 0·08 per cent. of carbon, very nearly as much as some of the pure steels with which we have experimented, which contained 0·1 per cent. of carbon. It is to the influence of this small amount of carbon present in Osmond's electrolytic iron that we are inclined to attribute the feeble recalescence which he observed in his specimen. The effect (*a*) of this residual carbon, and (*b*) of the mechanical treatment the specimen has received, such as hammering and wire-drawing, have yet to be investigated, and this we hope to undertake during the next year. If it be possible to keep iron in the $\beta$ condition when cold, it should not only be hard and brittle but *non-magnetic*, and this has not yet been proved. We have made some experiments on this point by suddenly quenching at a white heat fine iron wires in cold mercury, and here will merely state that their magnetic susceptibility was not destroyed. Manganese steel, it is true, is practically non-magnetic, and this Osmond attributes to the part played by manganese in fixing the iron in the $\beta$ condition, and Hopkinson has shown that whatever slight magnetic susceptibility is found in manganese steel could be accounted for by a few little bits of pure iron distributed through the mass.[27]

We believe that the difference in the temperature position of recalescence (and also of the jerk) on the up and on the down side of the curve of heating or cooling is analogous to what is found in the heating of water. In a clean vessel water may be raised above the boiling point, suddenly at some one point steam is formed, and the whole rapidly passes into steam, the change of state being accompanied by a *fall* of temperature and large absorption of heat. Similarly steam in cooling down may be lowered below the normal point of condensation, when from some cause, such as the presence of solid particles, condensation begins and rapidly proceeds, accompanied by a *rise* of temperature.[28] The retardation of this change Mr. Tomlinson[29] considers to be due to the great internal friction which exists in iron at a red heat; in consequence of this the change takes place at a lower temperature than it otherwise would, until at last a sort of explosive action occurs, and the change rapidly runs throughout the whole mass, analogous to what takes place in supersaturated solutions.

This is what we may expect to occur in the magnetic metals which exhibit the phenomena of hysteresis when under stress.[30] The recent paper of Prof. Ewing's on the Molecular Theory of Induced Magnetism,[31] to which we have already referred, throws remarkable light on the various phenomena we have been studying. By means of his beautiful experimental model, Prof. Ewing has shown that the intermolecular magnetic forces alone are sufficient to account for the known facts of magnetisation, and that magnetic hysteresis is not due to anything in the nature of frictional resistance to the rotation of the molecular magnets, but simply to the molecular instability which results from these intermolecular magnetic actions. And, further, that the same cause explains why there is "in magnetic metals hysteresis in physical quality generally with respect to stress, apart from the existence of magnetisation." We shall probably have occasion in our next report to deal more fully with Ewing's explanation, and here can only congratulate the author on the value and beauty of his suggestive experiments.

Connected with this part of the inquiry, we may refer to the interesting results Hopkinson has obtained with an alloy of iron

[17] *Nature*, June 12, 1873. *Trans. R.S.E.*, Dec., 1873.
[18] *Proc. Royal Society of Edin.*, Feb., 1875.
[19] *Phil. Trans. Roy. Society of London*, May, 1889.
[20] *Comptes Rendus*, Feb. 10, 1890.
[21] Barrett, *Proc. R. Soc., Dublin*, Dec., 1886.
[22] *Proc. Iron and Steel Institute of Great Britain*, 1890.
[23] Pionchon, *Comptes Rendus*, June, 1886.
[24] *Phil. Mag.*, Feb., 1888.
[25] *Phil. Trans.*, May, 1889.
[26] J. H. Brinnell, *Jernkontorets Annalen*, 1885, and *Stahl und Eisen*, November, 1885. Independently observed by one of us, Newall, *Camb. Phil. Soc.*, January, 1888.

[27] *Phil. Trans.*, April. 1885.
[28] Newall, *Camb. Phil. Soc.*, Jan., 1888.
[29] *Phil. Mag.*, Feb., 1888.
[30] In a Paper by one of us (Newall), we pointed out some time ago that the phenomena observed in recalescence "were really signs of something of the nature of what Professor Ewing calls hysteresis."
[31] *Phil. Mag.*, Sept., 1890.

Digitized by Google

and nickel. This alloy Hopkinson finds to have two stable conditions, one being magnetic and the other non-magnetic; a high temperature destroys the magnetic state, which can only be resumed by lowering the temperature considerably below the freezing point. The remarkable fact, now explicable by Ewing's experiments, being that this iron-nickel alloy may be either magnetic or non-magnetic at the ordinary temperature, its previous history determining the state in which it remains.

Here we must leave the subject at present; we are well aware that many matters of interest have necessarily been omitted, and that we have inadequately dealt with those that have come under consideration. So many issues of importance, both to the chemist and metallurgist, as well as the physicist, have been opened up by this inquiry that we trust the Committee, which will be enlarged, may next year present a fuller report.

## AN OLD TELEPHONE SWITCHBOARD.

The accompanying illustration and diagrams of connections relate to an old telephone switchboard erected in the first week in February, 1878, at Meriden (Conn.). The illustration and description are taken from an article by Mr. Morris F. Tyler, which appeared in the *Electrical Review* of New York of January 24th :—

Across the top (see Fig. 1) is a row of 16 binding posts; below appear four circles of metal buttons; in the centre of each circle brought off the annunciator point by turning to the right, and the subscriber's line carried to the office telephone and ground by coming into contact with the bar (Fig. 3). After it was learned whom the subscriber wanted, this connection was thrown off and the switch corresponding to the line of the party wanted was turned down to the bar and call was made. After that subscriber was raised, the switch in circle No. 1 was put on No. 1 pin and the

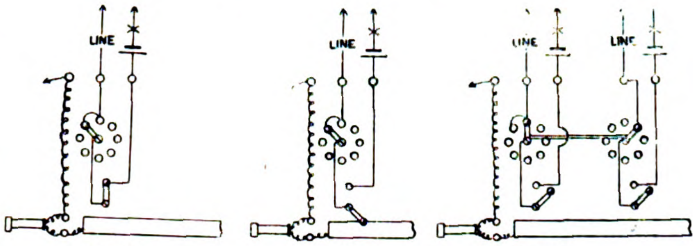



FIG. 2. FIG. 3. FIG. 4.

Diagrams of Connections.

switch in circle No. 2, if it was subscriber on line 2 that called, was put on the second pin, and the ground switch in both instances turned open (Fig. 4). The switches of these circles were connected in pairs; that is, the first and second and the third and fourth circles were connected together. This left the two subscribers' lines connected with one another, but cut out of office telephone, of ground, battery and annunciator, so that the subscriber could

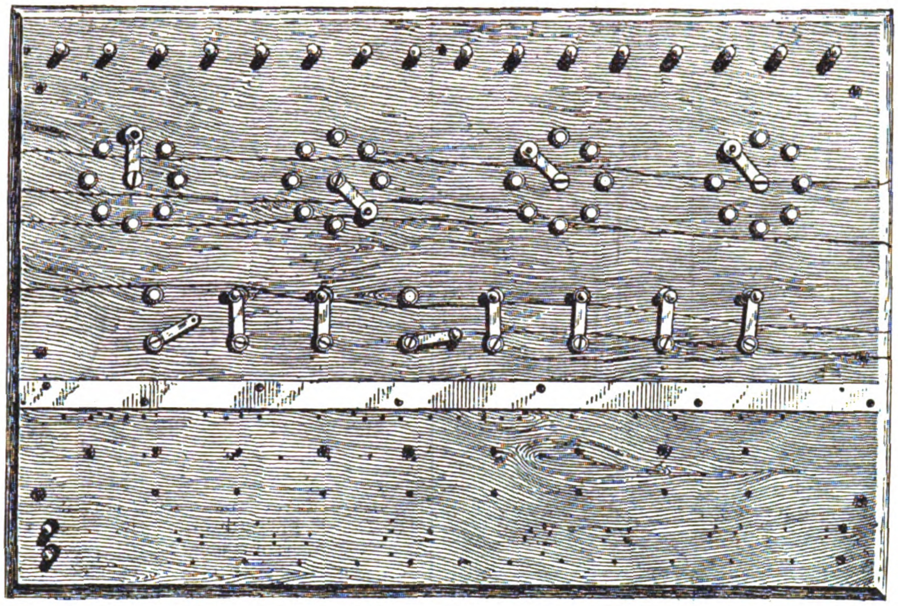


FIG 1.—An old Telephone Switchboard erected at Meriden (Conn), February, 1878.

is pivoted an arm, which can be brought into contact with any one of the buttons. There are eight buttons in each circle. Next below these is a row of two-point switches, playing between a button similar to that in the circles and a continuous strip of metal which is seen across the board below.

In the lower left hand corner are two binding posts, and when the board was in use there was a similar pair in the lower right hand corner. To these two lower pairs of binding posts telephones were attached, the telephone wire running from the upper part of the pair on each side to the end posts on each side of the upper row and thence to ground, and from the lower post to the metal strip. The 14 posts across the top between the two terminal posts are alternately line and annunciator posts. Subscriber's line No. 1 came in, for instance, in the second post of this upper row, then it passed to the top button of the circle immediately under it, and from there was legged across to the top button of each of the circles. From this button in the first circle it passed to the switch below the circle. The button above this switch is connected with the annunciator and battery through the third post in the row. The other point of this switch, or the bar, goes to the telephone and ground in that direction. The next pair of wires was appropriated to button No. 2, or the next right hand button of each circle and went through a similar course of wiring. The button No. 8, or the one to the left of the top button of each circle, is zero point.

When no wire was in use each of these switches rested upon that button, as is shown in the diagram (Fig. 2). That left the subscriber's wire connected with the annunciator by means of the lower switch. When the call was made, the lower switch was not call the central again until the operator, by turning one of the lower switches, threw him on to the office telephone. The switch, as it stands in the illustration (Fig. 1), is set for conversation between parties on lines 1 and 4, with the other lines in calling condition. This switch accommodated seven wires, on which were 50 subscribers, but only two conversations could be carried on at the same time. The whole system was operated on closed circuit.

The primitive character of construction will be recognised from the fact that the buttons in the circles are the heads of carriage bolts, which have been slightly turned down, and were once nickel-plated, and the knobs upon the switches in the circles are knobs used upon tin teapots. The wiring on the back of the switch was of ordinary office or paraffined cotton wire.

## ON THE ALTERNATING ELECTRIC ARC BETWEEN A BALL AND A POINT.*

BY EDWARD L NICHOLS.

The attention of Prof. Nichols was first directed to the phenomenon forming the subject of this paper, by Mr. E. G. Acheson, whose observations may be thus described:—When the secondary terminals of a transformer are metallically connected with a ball and point, placed near enough to admit of a discharge between the

* Abstracted from the American *Journal of Science*, Vol. XLI., January, 1891.

Digitized by Google

two, it is found that a galvanometer shunted around the ball and point indicates a considerable flow of continuous current.

The phenomenon has been recently investigated by Messrs. Archbold and Teeple in the Physical Laboratory of Cornell University. The apparatus employed consisted of a Ruhmkorff coil of moderate size, the interruptor and condenser of which had been thrown out of circuit. The primary coil consisted of a few turns of heavy wire, surrounding a core of iron wires, and was fed from a small alternator with currents reversing 14,000 times per minute. When the terminals of the secondary were brought into position, a brilliant discharge took place which, although appearing continuous to the eye, disclosed its intermittent character by emitting a note corresponding in frequency with the period of alternation.

The terminals of the secondary coil were subsequently connected with a brass ball, about one centimetre in diameter, and with a point consisting of a steel sewing needle. These were mounted horizontally in well insulated bearings, the centre of the ball in line with the axis of the needle. The distance between the ball and the point of the needle was capable of adjustment by means of a micrometer screw. A mirror galvanometer of 2,000 ohms, having in its outer circuit about 100,000 ohms, was shunted around the ball and point (in parallel circuit with the air space between them). When the induction coil was put into operation, the ball and point being too far apart to admit of a visible discharge, the galvanometer needle remained at zero, but when they were brought within striking distance, a large and constant deflection was produced. When the ball and point were interchanged, the deflection was reversed, its direction always being that which would have resulted from a current flowing from the ball to the point. Under the influence of the discharge, which was intensely luminous, the steel needle was fused at the point and rapidly wasted by oxidation, so that it became necessary to find some more refractory material. It was finally supplanted by a pointed platinum wire, which although rendered highly incandescent withstood the temperature of the arc much better than steel had done.

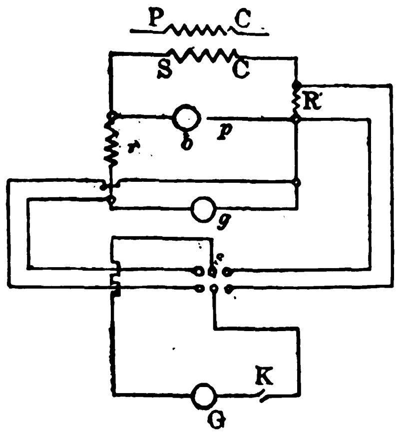



FIG. 1.

As the sparking distance is increased the arc at first forms and sings with an even tone, the point becomes of a dull red colour, while the galvanometer gives a small but quite steady deflection. As the arc is drawn out further it sings louder and more harshly, the point becomes redder, while the galvanometer deflection increases and becomes very unsteady. At a certain critical length the tone becomes smooth and even, the point brightens almost to a white heat, while the galvanometer deflection becomes much greater and very steady. The explanation suggested, and which subsequent experiments seem to confirm, is as follows: At first the arc forms both ways, the rapid succession giving the tone. As the arc lengthens the arc still forms from ball to point, but is only intermittent (occasional) from point to ball, giving the unsteady tone and deflection. Finally the distance becomes too great for the arc to form from the point to the ball, while it still passes freely the other way, and the tone and deflection become steady.

Attention was chiefly directed to the conditions existing when the critical length of arc above mentioned had been reached. In order to do this the length of the arc had to be maintained between very narrow limits, and as small changes in the speed of the alternator destroyed the adjustment, the necessary steadiness was only obtained when the dynamo was driven by a motor supplied from storage cells. The measurements made were such as to determine the periodic changes in voltage and current during a complete cycle—first when no arc existed, and afterwards when modifications were introduced by the discharge. In all the experiments the striking distance was greater than the critical value already defined.

The voltage was measured by a mirror galvanometer of ten thousand ohms resistance. The circuit was completed through an instantaneous contact device, consisting of a wooden disc mounted upon the shaft of the machine. A single bar of brass, on the periphery of the disc, passed under a brush once every revolution. This bar was connected with a brass collar turning under a second brush. By thus closing the circuit for an instant once in a revolution, the voltage of the secondary circuit at that particular time could be measured, and by adjusting the brush the entire cycle could be explored.

The arrangement of apparatus is shown diagrammatically in Fig. 1. P C and S C are the primary and secondary coils of the induction coil, *p* and *b* are respectively the point and ball. R is a non-inductive resistance, *g* the indicating galvanometer, in parallel with the ball and point, *r* a non-inductive resistance, *s* a switch by means of which the Thomson galvanometer could be shunted at will around R or *g*. K is the instantaneous contact device, and G is the Thomson galvanometer. When the Thomson galvanometer was shunted around R, which was placed in the main circuit leading from the induction coil, it served to indicate the current flowing in that circuit during that portion of the cycle for which contact was being made; when connected in shunt with the galvanometer *g*, it measured the fall of potential through the coils of the latter instrument. The function of the indicating galvanometer during this part of the investigation consisted in showing, by the size and direction of its deflection, whether the discharge between the ball and point continued to maintain its proper character.

The result of the experiments is shown in Fig. 2. Curve A shows the variation of current when the arc is extinguished. It is of the usual sinuous character. Curve B shows the cyclic charges of current when the arc was playing.

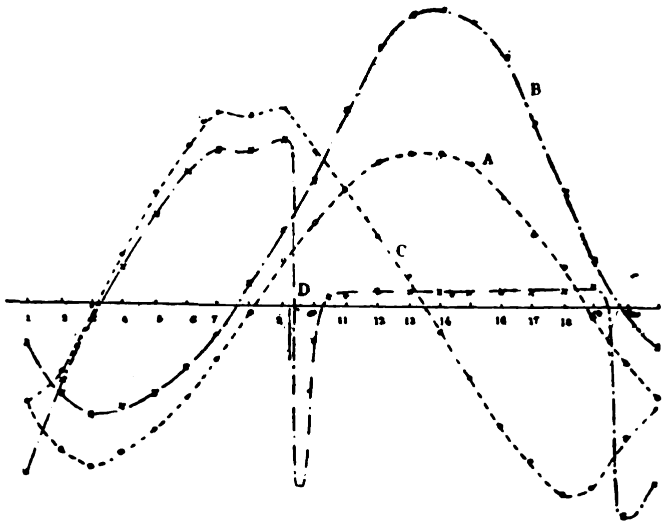



FIG 2.

Abscissæ represent portions of a complete cycle, the period being divided into 20 equal parts, ordinates the relative amounts of currents through the resistance R, or the total current in the secondary circuit. Deflections, when the current flows from ball to point, are plotted above the base line, as may be seen from the curve B. The current flowing in the positive direction during each cycle was greatly in excess of that flowing in the negative direction, when the discharge was taking place between ball and point; whereas when no arc was formed (curve A) the areas enclosed by the positive and negative branches of the curve were equal. Now there were two paths offered to the current, that through the galvanometer *g*, and the resistance *r*, which consisted of a column of copper-sulphate solution between copper poles (approximately 112,000 ohms), on the one hand, and the parallel circuit between the ball and point on the other. The resistance of the latter path was infinite whenever the arc was interrupted, falling to finite values during each discharge. Increase of current through R indicates, therefore, the formation of the arc. Such increase is found to exist during the second half of each cycle, that is to say, during that interval in which the ball is positive; and it might be inferred from these curves alone that the discharge was an intermittent one taking place always from ball to point. Other curves, taken simultaneously with A and B, the Thomson galvanometer being shunted around the indicator galvanometer, lead to the same conclusion. The curves marked C and D (Fig. 2), show the results obtained. Owing to the high self-induction of the galvanomer, and to the frequency of the current, the fluctuations in voltage do not correspond in time with the fluctuations in the current flowing through the resistance R. The lag in fact amounts to nearly 90° of phase. The curves are, however, of some interest and show that when the arc is extinguished (curve C) the positive

Digitized by Google

and negative fluctuations are of equal amount, while when the arc is playing (curve D) the positive predominates. To obtain the voltage curves between ball and point directly, a noninductive resistance was substituted for the indicating galvanometer, and the measurements from which curves C and D had been drawn were repeated. Of the two curves thus obtained, that taken when the arc was not playing (E. Fig. 3) is a sine curve closely coinciding in phase with the simultaneous current curve (A. Fig. 2); and the corresponding curve F, taken while the discharge was passing, is in its essential features of the same character as curve D.

The results exhibited graphically in these six curves afford abundant verification of the theory of the ball and point phenomenon, given in a previous paragraph; and they establish the fact that in the secondary circuit of a transformer, such as that made use of in these experiments, the striking distance from ball to point exceeds that from point to ball. It follows that whenever the space between the ball and point is less than the former and greater than the latter distance, discharge will occur only during that portion of each alternation for which the ball is positive, and that under such circumstances a galvanometer placed in the circuit will show a constant deflection.

Complete corroboration of the foregoing conclusion was obtained by studying the image of the arc in a revolving mirror. With a discharge of less than the critical length, the discharge was seen to

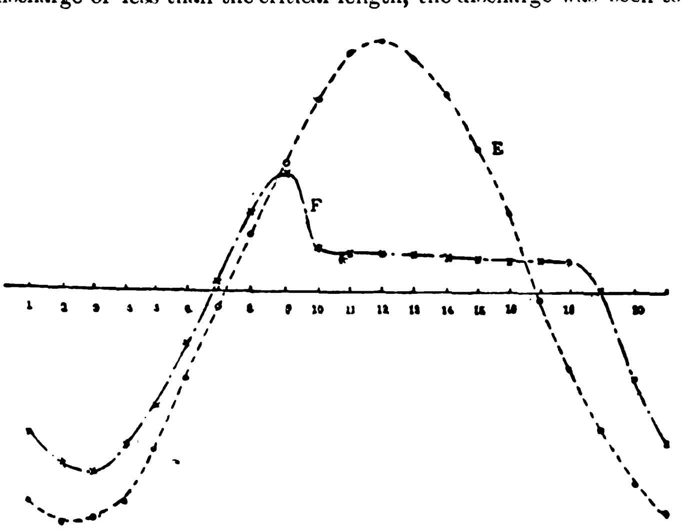



Fig. 3.

consist of two distinct sets of sparks, all of the same duration, but differing in colour. Each alternate discharge was purple, the intermediate ones being of a greenish cast. The spark-images were everywhere equidistant, and their duration was about four times as great as the intervening intervals of darkness. The extension of the sparking distance beyond the critical point resulted in the complete suppresssion of the series of purple images, the intermediate ones remaining undisturbed in position, duration, and appearance.

## THE APPLICATIONS OF GEOMETRY TO PRACTICAL LIFE.*

BY PROF. KARL PEARSON.

There is scarcely any branch of modern science which has of recent years made such progress as geometry; there is certainly no branch over the purport of which there is so much obscurity or has been so much discussion. On the one hand, geometry, like most sciences, was born of a practical need. The Egyptians, an eminently practical people, were not interested like the Greeks in the properties of the circle for the circle's own sake, but they wanted an art to measure the capacity of their barns and the size of their haystacks, and to plan out their pyramids and great buildings. But, above all, they were landowners, and to sell property they required to measure land—to measure it in square feet, and not by the time that a yoke of oxen would take to plough it, which was not always an exact or convenient test. So the Egyptians invented land-measuring or surveying, and termed it *geometry*, and the geometricians they called *rope-stretchers*.

On the other hand, the Egyptians, having satisfied their immediate wants, left geometry uncultivated, and by not pursuing it on purely theoretical grounds failed to convert it into that great instrument of investigation which in the end was to master the mystery of the heavens, guide the mariner, or help the engineer.

The next stage in the development of geometry was left to the Greeks, for whom to apply geometry to practical purposes would have been to debase it. They studied geometry for its own sake, much as some of our friends to-day study metaphysics, only, it seems to me, they did it to more purpose. They recognised in geometry a great instrument for sharpening the intellect, and they made it the basis for a sound education. A proposition was to them a delight in itself, and to deduce a new one a distinct intellectual advance. Thus they had the proverb, "A figure and a stride: not a figure and sixpence gained."

I have said enough, perhaps, to indicate how the two tendencies of modern geometry, and, indeed, of the whole of modern science, date back to the very beginnings of scientific activity—to the practical Egyptians, whose horizon was bounded by the immediate needs of life, and to the dreamy, metaphysics-loving Greeks, who despised practical applications. There are few teachers of geometry who will not have felt at times the burden of these two tendencies. The great mass of material in the form of published papers on higher geometry, many of which can only be understood by the initiated few, and some of which have probably never been read except by their writers—this weighs at times upon the mind and makes one, without despairing of science, cry, "*Cui bono?* For whose good? How can this help the progress of mankind?" On the other hand, how the listless student, bent on struggling through life with the least expenditure of intellectual energy—how he calls up the spirit of the Greek, when he languidly asks his teacher after lecture, "What is the *use* of this? I've got the result in 'The Engineer's Pocket-book.'" For *him* the insight to be gained by seeing the *how* and *why* of a process is of no importance, and the fingers tingle to hand him threepence that he may at least gain something by attending our lectures.

It is not my purpose now to trace these practical and theoretical tendencies through the history of geometry down to the present day. Neither do I intend to emphasise one tendency at the expense of the other. But of this fact I feel clearly and absolutely certain, that a divorce between the two—such as has existed in some of our great mathematical schools—is wholly unnatural, and tends sadly to retard the efficiency of both. What we are slowly but surely learning in this country, owing to the pressure of foreign competition, is that education and theory are needed in all branches of practical life if we are to maintain our industrial position. But it must be education and theory which is sympathetic to practice, can indeed be wedded to it, and takes upon itself no cynical and superior airs. When we compare on the one side the vast amount of mathematical talent out of touch with all human needs, and on the other the amount of practice which limps along for want of theoretical support, we cannot but be grateful for any institution or foundation which tends to promote a better fellowship between the two. This union of theory and practice, with its offspring the applied sciences, has nowhere in recent times met with more cordial support than in the City of London. Within the last 20 years the science of engineering has been revolutionised; from an empirical and mechanical craft, engineering has been raised to the rank of a learned profession. The introduction of theory into engineering practice has been largely due to the progress of modern geometry and the geometrical methods of calculation.

Problems, which when clothed in mathematical symbols only served to appal the practical man, became intelligible to him when hieroglyphics were replaced by curves upon the drawing-board. The success of this particular union of practice and theory is largely, I believe, due to the choice of a geometrical method, to the recognition that form and figure are more easily realisable by the average mind than symbol and numeric quantity.

I have referred to the union of theory and practice which has been so largely realised of late years in engineering construction because it offers us a striking example, not only of the success of theory as applied to practice, but also of the manner in which that theory, in order to be successful, must be applied. The theory does not need to be superficial, but it must be of a kind which the practical man can grasp; the calculations must be made in a form which appeals to his imagination, and in the particular sciences preliminary to the engineering profession this has been largely done by the aid of geometical and graphical methods. Twenty years ago these methods were scarcely discovered, or the few known were neglected or scouted. To-day the most scientific Government in Europe permits the calculations and plans of the largest engineering structures which are submitted for its approval to be made by purely graphical processes. Here, then, we have an instance of theory placing at the disposal of practice one of the most efficient instruments of modern calculation and investigation, and this, indeed, is peculiarly the light in which, owing to early tradition and present needs, geometry ought, I think, to be dealt with. The Renascence, with its revival of learning, had resuscitated the knowledge of the Greek geometry. But the minds of men

* Abstract of a probationary lecture delivered at Gresham College, on Friday, December 12, 1890. The historical facts of this lecture are chiefly drawn from two excellent books—Gow's "History of Greek Geometry," and Ward's "Lives of the Professors of Gresham College."

Digitized by Google

were not content with pure theory; they were anxious to understand the laws of the physical universe—astrology was being replaced by astronomy, chemistry was deposing alchemy. The old forms remained, but they were filled with a new life. Sir Thomas Gresham, indeed, when he founded his College established his seven professorships on the lines of an old mediæval University, in which all knowledge was forced into one of the seven divisions—divinity, astronomy, geometry, music, law, physic, and rhetoric. But what a very different view the early science professors—those of astronomy and geometry—took of their subjects to what would have been possible a hundred years earlier! Geometry for them meant the application of mathematical knowledge to all the branches of physical science. It was not for them the pure theory of lines and circles and curves, but a process of calculating and investigating the facts of Nature. Thus the revival of geometry in the sixteenth and seventeenth centuries was on Egyptian rather than Greek lines. Newton, with astounding ingenuity, used geometry as his main instrument for investigating the motions of the moon and planets.

I have no wish to minimise the educational value of purely theoretical science. I recognise how great a factor it has been and is in the intellectual and spiritual growth of the nation. Investigations like those of Darwin and Maxwell, which appear at first sight to have no practical applications, may profoundly alter our whole view of human life, or of the physical world which surrounds it, and in doing this may modify indefinitely our practical conduct or our command of the forces of nature.

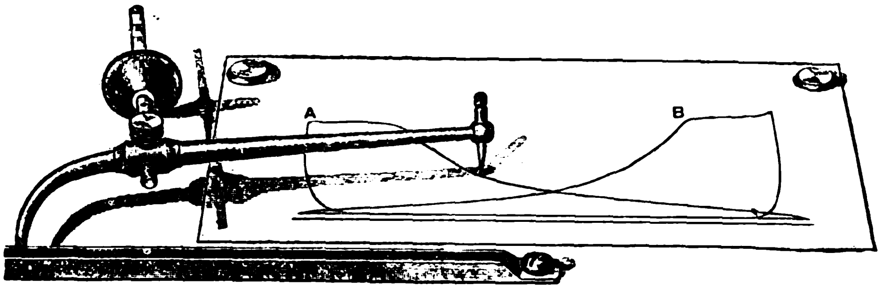
Even geometry in its more abstruse speculations, when it transcends the space in which we live and theorises of another, of which ours is as poorly representative as a landscape painted on flat canvas is poorly representative of the wealth of form and distance in the scene it depicts—even this abstruse geometry may some day react on practical life, by the modifications it is capable of producing in the current ideas of space and force. I recognise to the full this educational value in geometry, and in all forms of pure science; but I believe that there are other institutions—notably the great Universities—which sufficiently emphasize this side of learning.

In particular, it seems to me that the lectures on geometry can be made especially serviceable in this direction, if geometry be interpreted in the wide sense current in the seventeenth century, and which it retains to this day in France. The modern development of graphical and geometrical methods has placed a powerful instrument of calculation and investigation in the hands of those who have neither the time nor opportunity of learning to handle the abstruse tools of analytical mathematics. Wherever quantity of any sort has to be measured and reasoned upon, there these geometrical methods find their applications. Their applications are, indeed, so manifold that it is difficult to enumerate them; to questions of force and motion, to problems in the strength of materials, in the structure of bridges and roof-trusses, of machinery in motion, of cutting and embanking—they have been long applied, and form the basis of much of modern engineering practice. But there are other fields, the graphical representation of statistics at once suggests itself. Mortality, trade, goods and personal traffic, furnish statistics which if dealt with in a graphical manner very often suggest conclusions which are of the greatest interest to those dealing with problems of insurance and commerce—conclusions more readily deducible from the geometrical than from the numerical representation of statistics. The like geometrical methods have in recent years been applied to the principles of political economy, till the theory of prices has become almost a branch of applied geometry.

But it is not alone in these very specialised subjects that we may reason geometrically. The whole field of physical science is occupied with the investigation, representation, and reasoning upon *quantity*, and therefore is essentially a field for the application of geometrical methods, but the bearings of physical science on practical life are too wide and too well known to be enlarged upon now.

## HINE AND ROBERTSON'S PLANIMETER.

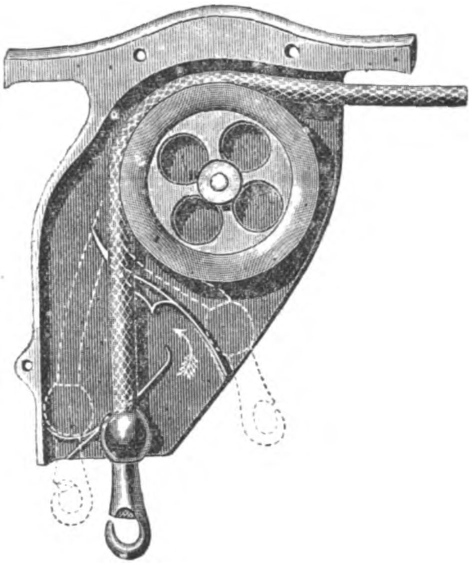
**A novel integrating instrument of great simplicity, designed for the special purpose of furnishing a ready means for measuring indicator diagrams simply and rapidly, is described in the *Electrical World* of New York. From its construction, it will be observed that the slipping motion of the wheel in running over or on to the card, which is a source of error in the Amsler planimeter, is in a very large measure avoided. The record wheel is knife-edged and free to move on its spindle, and reads by the distance it has travelled along its axis, instead of with a vernier as is usual. In operating the instrument it is only necessary to slip the wheel against the shoulder which forms the zero point on the scale, and then trace the diagram with the tracing point from the upper left corner of each card, in the direction in which the hands of a clock move. The scale engraved on the spindle gives, on completing the tracing, the number of square inches in the card. This new instrument is said to work very satisfactorily for the purpose intended. Its merits are simplicity, and the ease and rapidity with which it can be manipulated, without special delicacy in adjustment.**



Hine and Robertson's Planimeter.

## THE CUTTER ARC LAMP SUPPORTING PULLEY.*

In this ingenious device the arc lamp is hung on a hook, whose large knob is engaged by projecting ridges, which automatically support the lamp when raised, or release it again when about to be lowered. This is accomplished without the addition of any moving parts, in the manner shown in the accompanying illustration. On raising the lamp the knob is guided by the raised ridges until it strikes the curved stop; then on slackening the hoisting rope, the knob is pulled down by the weight of the lamp into the recess in the lower corner of the pulley. The lamp is then supported entirely by the pulley, so that the hoisting rope may be loosened, or even cut, without letting the lamp fall. To release the lamp, it is raised until the knob has passed the corner of the upper ridge, when it will


Interior of the Cutter Pulley.

* From the *Electrical Engineer* of New York.

Digitized by Google

be guided out (as shown by the dotted lines in the cut) and the lamp can be lowered.

Both the engaging of the hook and the releasing are accomplished in turn by raising the lamp till the knob strikes a solid stop, and then slackening the rope. This leaves no time to be wasted in trying to stop at some exact point, or to disengage a series of interlocking cams, but makes the action as positive as it is simple. The method of fastening the pulley to the suspension wire is also new, and requires no bolts or screws to keep the pulley in its place. The suspension wire rests in the grooved upper edge of the pulley and is held there by two wires wrapped around the ends of the pulley. The kink put into the suspension wire by this method of fastening effectively keeps the pulley from slipping along the wire, the more so as there is no tendency for this, excepting while the lamp is being raised or lowered.

## AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *January* 23, 1891.

**The Lapse of the American Telephone Patents.**—There is a possibility of some interesting moves in telephonic matters before long. The original Bell telephone patent expiring, as it does, in 1893, cannot much longer afford protection to the Bell Telephone monopoly. Besides this the important transmitter patent, patented in this country after its appearance in England, will soon expire, and the Bell Telephone Company consequently is undoubtedly casting about for means to prolong its monopoly. It already controls the Edison carbon telephone patents, and a very large number of other important claims, but these are not enough to secure any considerable prolongation of its life as a monopoly. Rumour has it that there is a possibility of the notorious Daniel Drawbaugh appearing in rather a new *rôle*. As his patent was applied for in July, 1880, it stood no sort of chance against the early Bell patents by reason of their having been for two years in public use. But among the numerous claims made by Drawbaugh was one for the invention of a carbon transmitter; the application in question is antedated by something more than two years by Edison, but, inasmuch as the Edison carbon transmitter had not perhaps been in public use for the legal period of two years, Drawbaugh's contention could be revived if it became necessary to do so. A patent for the carbon transmitter granted to Daniel Drawbaugh, and bearing date from 1891 or 1892 would be most convenient for the Bell Telephone Company, and inasmuch as it controls the only claims with which the redoubtable Daniel would be likely to come in conflict, it has been suggested by some electrical gossips that an effort may be made to deck out Drawbaugh in in the garb of a prior inventor. It is understood that the Drawbaugh Company, notorious through litigation a few years ago, has been approached with reference to the subject. Another interesting rumour is to the effect that the Western Union Telegraph Company is about to make an onslaught upon the Bell Telephone Company, based on the agreement entered into between the two by which the latter was not to enter into active competition with the former. With the present state of the long distance telephone service, and the great additions to it that are likely to be made, the telegraph company is beginning to feel that its privileges are being encroached upon.

**The Rapid Transit Problem in New York.**—Vigorous efforts are being made to push a Bill through the New York Legislature to facilitate rapid transit work in New York. This subject is now being actively discussed, and the chances are that some sort of a Rapid Transit Bill will be passed ere long. There is some danger, however, that it may be passed in such form as to play into the hands of the elevated roads, which, however useful they may have been, and still are, for certain purposes, give very feeble promise of anything like adequate rapid transit. Engineers with arcade schemes, viaduct schemes, and tunnels are becoming as plenty as primary battery inventors, and the time of the Rapid Transit Commission is largely taken up with meditating on their respective proposals. It is too early yet to venture any prediction as to what the outcome will be, but the public is thoroughly aroused, and something will have to be done, and done quickly.

## CORRESPONDENCE.

### ELECTRIC AND MAGNETIC THEORIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have read with interest Mr. Sprague's letters in *The Electrician* and elsewhere. It seems to me that he has confused several points, and thus included under his sweeping condemnation many things which are quite beside the point at issue. Leaving out the question of electrolysis and discharges through gases, we may divide the subject into three heads.

1. Faraday's experiments and theories on electrostatic and electro-magnetic induction, and Ohm's law; these were expressed by Maxwell in mathematical language, and together with the work of such men as Coulomb, Gauss, and Ampère constitute the whole of his first volume and about half of the second. The relations between the different quantities which Maxwell deduces are the direct expression of experimental facts, and can only be doubted by those who are prepared to doubt Faraday. As yet it must be noticed there is very little, if any, mention of a medium which may not be ordinary matter, and what mention there is does not in any way involve the accuracy of the expressions, since they rest in the firm basis of Faraday's researches.

2. Maxwell's theory of the nature of displacement currents and the electro-magnetic theory of light.

This theory *assumed* that the true electric current consisted not only of currents in conductors, but also of the rate of variation of electric "displacement" in dielectrics, and that this latter part produced the *same* magnetic effect as the part in conductors. (*See* Maxwell's "Electricity and Magnetism," Vol. II., page 234, § 610.) This was an assumption, and could only be proved by the manner in which experiment verified predictions based on this theory. For a long time this proof was wanting, and other theories not involving this assumption were proposed. From his theory Maxwell developed the electromagnetic theory of light, and calculated what the velocity of electro-magnetic waves, if they exist, depends on; and what is more, he proceeded to determine this velocity by experiment, and found that it is very much like that of light.

It is well known that the existence of electro-magnetic waves has been demonstrated by Dr. Hertz, of Bonn. As yet there is no positive assumption of anything beyond ordinary dielectric, and Maxwell's theory need by no means be false if there be no such thing as ether. The existence of waves was predicted as a direct consequence of Faraday's discoveries, with *one* assumption. Calculations have been based on Maxwell's theory, and have been the means of predicting many phenomena which have been verified by experiment, notably Mr. Heaviside's investigations, at which Mr. Sprague seems to stumble very much. In these the word "ether" certainly occurs, but it by no means follows that the results would be false if there be no ether.

3. We next come to the attempts which have been made to give a mechanical explanation of the phenomena of light and electricity. It is to these, I gather, that Mr. Sprague particularly objects.

First, Green proposed to explain light by the existence of an elastic solid ether which seemed to give a very fair account of many of the phenomena observed, and was by no means an unpromising proposal; but yet there were great difficulties in the way of its unreserved acceptation; for instance, that it introduced the necessity of a longitudinal wave in addition to the transverse waves, and the difficulty of accounting for the motions of the planets, if space were filled with such a substance. Then there was Sir William Thomson's attempt to get rid of the necessity of a longitudinal wave by a peculiar relation between the rigidity and compressibility of the ether (*Phil. Mag.*, November, 1888). This has given very satisfactory results on many points; and may be regarded as an advance towards the true explanation. It must not be forgotten that the proof of such theories lie in their ability to explain *all* the phenomena.

Digitized by Google

Then since many electric and magnetic phenomena are not such as we are accustomed to connect with matter as we know it, it became a question as to whether they could be explained by the action of an ether; and since, as Maxwell remarks, it is unphilosophic to fill space with two or three ethers, it seemed necessary that both light and electric actions should be caused by the *same* ether, and this is further confirmed by the velocity of electro-magnetic waves. To explain electric and magnetic phenomena something of the nature of a whirling motion appears to be necessary, hence it became a question whether an explanation could not be given by means of fluid motion; this would escape the difficulty of the motion of the planets to at least a great extent.

The attempt has been made by Sir William Thomson and Fitzgerald, who have shown that if space were filled with a certain arrangement of vortices in a perfect fluid light could be propagated, and that there was some hope of explaining electric and magnetic phenomena as well. There the matter apparently rests at present, and cannot be decided one way or the other till it has received a great deal of close study, and has been verified, or otherwise, by experiment.

The above is some, though doubtless very imperfect, statement of the matter at issue, and may, I hope, tend to render Mr. Sprague's objections a little more definite in their form, as it is difficult to meet objections of a very general and hazy character.

Mr. Sprague and Prof. S. P. Thompson appear to be at variance about Ohm's law only through not understanding the meaning of each other's language, so that there is no necessity to discuss that question further.—Yours, &c.,

R. S. Cole.

Emmanuel College, Cambridge, January 31, 1891.

---

TO THE EDITOR OF THE ELECTRICIAN.

Sir: To avoid any confusion in discussing the subjects indicated by Prof. S. P. Thompson, it will be well to commence with a few definitions and explanations. The fundamental point is whether electricity, or electric energy, is transmitted by ether or by ordinary matter. I define ether as a hypothetical substance (in the metaphysical sense of the word), the existence of which would never have been suspected but for the fact that light traverses space; when action at a distance was seen to be hardly conceivable, it was necessary to conceive that there was *something* in space to transmit action. But we know that there are properties which it cannot possess, those very properties by which we define matter, viz., gravitation force, internal friction, which would cause loss of energy in transmission, and external friction or resistance to the motion of matter. Now, it appears to me that with these properties vanish the whole of the mathematical reasonings about the properties of the ether; because, as it can possess no momentum, and can take no structure, as this depends on friction, it does not come within the range of mechanical laws. All the notions about density, rigidity, elasticity, &c., are simply the result of treating this imaginary (though probably existent) substance as though it possessed properties which we are quite sure it does not possess.

Matter I define as substance, in the usual sense of substantial, affecting our senses, and capable of measurement and of experimental examination and consisting of the elements discovered by chemistry, possessing a structure based upon its own existence in the forms of molecules, atoms, and probably sub-atoms, and being the agent which manifests the existence of energy or forces.

To avoid any cacophony about mere words, I repudiate all ideas about what is called the "essence" of matter, or any interest in the question of what it really is. All this is of no concern to us. It belongs not to science, but to metaphysics. For the same reason I pay no attention to a fashionable notion that the imaginary ether is capable of being condensed into or combined with matter, and is the real cause of the properties of matter, or some of them. That also is no concern of ours. All I say as to it is, that if "ether" forms part of the constituents of matter, and if an atom of matter has, as part of its essence, some ether, then that atom is what I mean when I speak of matter. I use the term purely as the expression of observed facts, apart from any notions as to the cause of those facts, which it is very certain no one knows anything at all about, and it is most probable no one ever will know anything. Longfellow may be right when he says, "things are not what they seem;" but our business is with what seems. Our cognisance is of phenomena and their relations, not of essences and ultimate causes.

Dr. Lodge spoke of what I have done by "my own methods;" as far as they are merely personal they would be of little interest, but if they involve a fundamental principle, they are of great importance, and I will state what my method is. The definition is clear and simple. I look at all natural phenomena with the eye of a chemist, and examine them with the means and by the principles of chemistry. Now chemistry is the most exact of all the sciences, and the most definite in its working; but of all the sciences it is the least influenced by mathematics: it deals with *things*, not with *abstractions*. On the other hand, most electricians, practical and theoretical, study electricity from the mechanical point of view; all the systems of measurement are based upon abstractions, mass, time, and space, which are indefinite because arbitrary. In other words, the mechanical or mathematical mind is directed to the functions of energy, while that of the chemist is directed to the functions of matter and its structure, and compelled to work on lines laid down by nature. Now energy and its relations are the legitimate field of mathematics, and are capable of being dealt with in endless abstractions. And let me say one thing as to the functions and effects of mathematics: they are to the mind what the cart and the harness are to the horse; they enable him to do much valuable work, but they enslave him. It will be seen, then, that what Dr. Lodge calls my methods are no mere peculiarity of my mind; the same mode of working can be seen in all who are chemists, rather than mathematicians; it is very strikingly shown in the methods of Faraday and of Prof. Crookes, and in the result of their thoughts. I am quite sure that Mr. Heaviside has (very naturally as a mathematician) quite misunderstood the nature of mind, when he said, p. 331, "Unfortunately, in my opinion, Faraday was not a mathematician." No, had he been one, he could not have been what he was; his natural energies would have been "cribbed, cabined, and confined." He would have been Pegasus in harness; he would have been like David, mighty to conquer with his own simple weapons, helpless in the armour of Saul, valuable as that might be in itself.

The specific subject which I propose to examine is the mode in which what we call an electric current is propagated, and in what manner energy is related to it, and transmitted in connection with it. I assume that we are all agreed that the current and the energy originate in what we may call "the source," be it a battery, a dynamo, or thermopile, where energy is, by some agency which we are not now concerned with, in some way related to and impressed upon what we may agree to call a "circuit," because definite in space and direction. I assume also that no one will dispute that there are two orders of circuit, the *inductive*, in which stresses can be set up electrically, and the *conductive*, in which the phenomena which we call the electric current are produced. In my next letter I shall start from these to see how Ohm's law deals with them.

Meanwhile, I wish to suggest to Mr. Heaviside, as our chief term coiner, to adopt a word from me. He has given us inductance instead of induction, which was too general, conductance instead of conductability, and so on, with many useful modifications. I think we might take a hint from chemistry and make prefixes and terminals indicate orders of facts, and the terminal "ance" is being so used. I wish we could get rid of "resistance," and especially that dreadful "magnetic resistance," and substitute something else for the reciprocal of conductance and permeability; in fact, ought not this last to be *permeance*, as being a passive property, not an action? What I want, however, and mean to use, is a term corresponding to inductance, the electric reaction, say *magnetance* for the magnetic reactions of electric circuits. They are both, in my views, temporary storages of energy, effected by specific properties of matter.—Yours, &c.,

John T. Sprague.

Digitized by Google

## RESISTANCE COILS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: On page 649 of your issue dated October 10, 1890, the following words occur:—"The series resistance is not wound with a looped wire, as is usual in resistance boxes, because this method is not good, the insulation being apt to break down. A single wire, therefore, was used. When one layer was wound, the bobbin was reversed in the lathe, and the next layer wound in the opposite direction, a thin layer of insulation being put between the layers. This method secures absence of self-induction, and good insulation, as the beginning and end of the coil are kept well apart."

In your Editorial Notes on page 1 of the present volume, dated November 7, 1890, you draw particular attention to this mode of winding in connection with the work of M. Chaperon, and further remark:—"This method has already been used by Mr. Swinburne in the construction of non-inductive resistances for wattmeters."

Permit me to draw your attention to my Patent, No. 2,263, May 24, 1881. On page 5, beginning at line 35, you will find—"I will now explain the manner in which I construct my resistance bobbins. Hitherto in winding resistance coils the wires have been wound on double in order to obviate inductive effects, but this mode of winding has the disadvantage of not securing good insulation. I now propose to wind the coils with a single wire helically, and reverse the direction of the winding in every layer, placing between each layer of wire a layer of insulating material."

This Patent embraces some other considerable improvements, and a resistance box, constructed in strict accordance therewith, was shown in the Electrical Exhibition at Paris in 1881. It was also included in the exhibit of the Eastern Telegraph Company at the Crystal Palace in 1882, and I still have it in almost daily use. An illustrated description of this box will be found in *Engineering*, July 28, 1882, pages 79 and 80. Since then we have made several such boxes which give greater satisfaction, and stand this climate far better than boxes made in England in the old way.—Yours, &c., J. Clement Cuff.

Eastern Extension Telegraph Company, Singapore,
January 1, 1891.

## CONDUCTIVITY OF STRANDED WIRE.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Referring to your review of Mr. W. S. Boult's wire-table and the question raised in it regarding the comparative conductivity of strands, I have always found them to be of lower resistance than that of the single wire divided by the number of strands, but hitherto have not considered the exact difference.

To test the point, I have made about 190 yards of 7/20 out of one coil of wire with a special short lay in order to enhance the difference, if any, and measured an equal length of single wire off the same coil in order that no question of conductivity or diameter might enter into the question.

The resistance of these two were balanced carefully against one another by a modified form of Wheatstone Bridge. The resistances were found to be in the proportion of 1 : 7·052. The weights, both by actual weighing and by calculation, were as 1 : 7·142.

You will see from this that the resistance is approximately midway between that of seven straight wires and that calculated from the actual weight. I expect in a 19 or 37 strand the conductivity will be much nearer the proportion of the actual weight, as the wires touch at so many points in crossing one another.

The average weights of strands for ordinary telegraph and electric light work, as made by our firm, are about 7·07, 19·35, and 37·9 times the weight of the single wire for 7, 19, and 37 strands respectively, and these may be taken as good averages for most makers.

Hoping the above may prove of interest.—Yours, &c.,
James Connolly,
Electrician to the Okonite Company.

Newton Electric Works, Newton Heath, Manchester,
February 3, 1891.

# TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

Tenders Wanted.—It will be seen by our advertisement columns that tenders are invited for providing and fixing the engine and all necessary plant and appliances complete for lighting the Ipswich Borough Lunatic Asylum by electricity. The premises can be viewed, and further particulars obtained, on application to the Medical Superintendent at the Asylum. Tenders, endorsed "Tender for Electric Lighting," are to be sent to the Chairman of the Committee, at the Asylum, before March 1 next.

Mr. Crompton's Laboratory.—We learn that this laboratory is now complete and fitted with modern electrical appliances. Tests can be made and reports given upon conductivity of copper and magnetic qualities of iron and steel, insulation resistance of various materials used for covering electric conductors and other purposes, arc light carbons, quantitative tests of accumulators, calibration of direct current indicators to 3,000 amperes, calibration of direct current potential indicators to 2,000 volts, certification of registering or coulomb meters. In addition to the above, photometric and other tests can be made.

Humboldt Electric Power and Mining Company (Limited).—At a meeting of this Company, held on the 14th inst., a resolution passed at a previous meeting that the Company be wound up, and that Mr. W. F. Gardner, the secretary, be the liquidator, was confirmed.

Electric Light Installation near Ascot.—Sunningdale Park, near Ascot, which has recently been acquired by Major Joicey, is to be electrically lighted throughout. It is estimated that about 350 lamps will be required to light the house and stables, and the generating plant will comprise two "Cornish" boilers and two "Parsons" steam turbine dynamo machines of the new improved type. The installation is being arranged by Mr. A. A. Campbell Swinton.

Messrs. Blakey, Emmott and Company (Limited).—We have received from this firm their newly issued illustrated catalogue and price list, giving full particulars of the Blakey-Emmott continuous current, and the Blakey-Emmott alternating current dynamos, the B.E. transformer, their special engine and dynamo combination, and the various specialities manufactured by the firm, including main and branch switches and fuses, lamp holders, measuring instruments, &c. Illustrated particulars are also given of the Blakey-Emmott diferential arc lamp, and of complete lighting sets for dyers, &c. Not the least conspicuous illustration is that of the Company's large works at Halifax.

Jensen Electric Bell and Signal Company.—We have received from this Company a number of advanced sheets of a new catalogue in preparation, giving illustrated particulars and prices of the firm's various manufactures, including the Jensen electric church bell, indicators, &c., and also of Lacombe's patent central zinc battery. Several handy sets of bells, batteries, &c., are shown.

Stone Discs for Switch Bases.—We have received from Messrs. F. A. Richter and Company some excellent samples of stone discs, bases, &c., made from their patented material "real stone." They are made with great accuracy and care, and compare favourably with similar articles made from earthenware, porcelain, &c. They appear to be porous, but would doubtless be very easily saturated with insulating material.

Mills Sectional Steam Boiler.—We have not yet been convinced of the complete superiority of water-tube boilers over the old-fashioned Lancashire which are so popular among electrical engineers, but there are doubtless many situations for which they are very well adapted. Those who intend to put down a water-tube boiler should carefully examine the merits of the Mills Patent Excelsior Boiler, which claims a very remarkable economy, and supports its claims by the results of tests made by Mr. Longridge. The chief feature is a cylindrical water-cased furnace. The arrangement may be briefly described as a miniature Cornish boiler inside a Babcock Wilcox.

# BOOKS, &c., RECEIVED.

"Journal of the Institution of Electrical Engineers," Vol. XIX., No. 90. (London: E. and F. N. Spon.)

"Directory of Technical Literature." Edited by Fritz von Szczepanski. (London: Sampson, Marston, Searle, and Rivington.)

"Theoretische und Praktische Untersuchungen zur Konstruktion Magnetischer Matchinen." By Dr. Max Corsepius. (Berlin: Julius Springer. Munich: R. Oldenbourg.)

"An Explanation of the Phonopore." By C. Langdon-Davies. (London: Kegan Paul, Trench, Trübner and Company.)

Digitized by Google

# PATENT RECORD.

## APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

December 16, 1890.

20,493. J. P. BAYLY. London. Improvements in connectors applicable to joining electrical or other wires, or for any similar purpose. (R. T. Moore, Ceylon.)

20,510. H. H. LAKE. London. Improvements in apparatus, chiefly designed for reducing the burr on electrically welded metal articles. (W. M. Wood, United States.)

20,538. A. J. BOULT. London. Improvements in or relating to electric lamps. (D. Tommasi, France.)

20,540. W. P. THOMPSON. Liverpool. Improvements in welding metals electrically. (C. L. Coffin, United States.)

20,541. W. LE GRAND BURDY. Liverpool. Improvements in and relating to electrically actuated cash drawers or registers.

December 17, 1890.

20,571. A. McDONALD, J. P. McDONALD, J. C. and J. McDONALD. Manchester. Improvements in the arrangement and simplifying the mechanism of an electrically controlled arc lamp.

20,612. W. WHITE. London. Improvements in socket holders for incandescent electric lamps.

20,632. S. O. COWPER-COLES. London. Improvements relating to the manufacture and coating of metallic articles by electro-deposition, and to apparatus therefor.

20,639. C. LE BLON, A. OBLASSER, and A. GODDYN. London. Improvements in and relating to electric arc lamps.

December 18, 1890.

20,651. Sir H. C. MANCE. Bedford. An improvement in electrical transformers.

20,712. E. ORTELLI. London. Improvements in and relating to electric batteries.

December 19, 1890.

20,743. W. J. FARR. Reading. An automatic releasing and electrical resetting signal.

December 20, 1890.

20,784. W. J. ENGLEDUE. London. Improvements in metallic elements for galvanic batteries.

20,817. C. VAN DER ELST and B. LOEWENSTEIN. London. New or improved means (dynamo multiplex) for utilising the centrifugal or projecting force of a rotary body.

20,821. F. G. COMING. London. Apparatus for transferring electric car batteries. [Date applied for under Patents Act, 1883, Section 103, May 21, 1890, being date of application in United States.]

20,830. H. BAYLEY. London. Improvements in and connected with electric ceiling roses and electric wall connectors.

20,831. W. H. OAKLEY and C. E. SPURRIER, London. Improvements in electric ceiling roses and wall connectors.

20,838. H. BIRKBECK, London. A new or improved dry couple or element for electrical purposes. (O. Henrichsen.)

December 22, 1890.

20,896. A. GAY and R. HAMMOND. London. Improvements in apparatus for regulating electric currents or electric potential.

20,898. H. H. LEIGH. London. Improvements in dynamo-electric machines. (E. Léon Desroziers, France.)

December 23, 1890.

19,272A. C. E. CARPENTER. London. Improvements in electric soldering irons. [Date applied for under Patents Act, 1883, Sec. 103, June 21, 1890, being date of application in United States.] [This application having been originally included in No. 19,272, dated November 26, 1890, takes under Patents Rule 23, that date.]

20,927. H. G. LESTER. London. Improved insulated circular cut-out box for electric lighting.

20,940. W. H. BECK. London. Improvements in electrical indicating apparatus for range or location-finding instruments. (The American Range Finder Company, United States.)

20,983. M. H. HURRELL. London. Improvements in electrically-controlled long-range torpedoes.

20,986. H. H. LAKE. London. Improvements in apparatus for electrically welding, and otherwise working metals. (H. Lemp, United States.)

20,992. G. H. JONES. London. Improvements in electric bells.

December 24, 1890.

21,017. F. PROTZ and J. JUCKER. Manchester. Improvements in electric arc lamps.

21,026. A. W. BERNE and C. A. FISH. Liverpool. Improvements in electrical attachments for railway switches or points, applicable for ringing an audible signal on the locomotive of a train which is approaching a switch which has been misplaced.

21,031. P. J. DAVIES. London. Improvements in the production of lead plates or electrodes for secondary batteries and the connection straps or lugs to the same.

21,032. W. W. HORN. London. Improvements in covering and protecting electric wires and other conductors. (W. E. Oehrle, United States.)

21,045. F. WALTON. London. Apparatus for armouring insulated electrical conductors.

December 27, 1890.

21,116. A. GAY and R. HAMMOND. London. Improvements in electric arc lamps.

December 29, 1890.

21,142. O. Y. RHODES. Halifax. Improvements in miners' safety lamps, and in the method of lighting the wick thereof by an electric current.

21,143. O. Y. RHODES. Halifax. Improvements in electric batteries for lighting miners' safety lamps.

21,147. A. J. BOULT. London. Improvements in or relating to the insulation of electrical conductors. (J. B. F. Frédureau, France.)

December 30, 1890.

21,183. B. J. B. MILLS. London. Electric protective and signal systems and apparatus. (C. E. Ongley. United States.)

December 31, 1890.

21,254. MORRIS BROTHERS, Limited, Birmingham. Measuring electromotive force and current of electricity in one instrument.

21,301. J. G. MURDAY. London. An electrical signalling device for indicating the overheating of journals, bearings, and other parts of machinery; also applicable as a fire alarm, and for indicating the rise and fall of temperature in greenhouses, buildings, and for similar purposes.

January 1, 1891.

40. G. HOOKHAM. Birmingham. Improvements in electricity meters.

49. W. WENSKY. London. Element and process for producing constant electric currents.

January 2, 1891.

83. W. P. THOMPSON. Liverpool. Improvements in or relating to electric guest calls or the like. (A. Striemer, United States.)

100. W. C. JOHNSON and S. E. PHILLIPS. London. Improvements in suspension insulators for electrical conductors and electrical apparatus.

105. F. HASELWANDER. London. Improvements in lightning arresters for electric conductors.

January 3, 1891.

128. J. L. LEE. London. An improved means of and apparatus for regulating automatically the flow of electric currents.

January 5, 1891.

176. W. J. GARNETT. Bradford. Improvements in electric dynamos and motors.

184. R. E. B. CROMPTON. London. Improvements in dynamo machines.

185. R. E. B. CROMPTON. London. Improvements in dynamo machines.

200. L. BRIANNE. London. Improvements in or connected with electric arc lamps.

January 6, 1891.

223. W. H. TODD. Manchester. Improvements in primary electrical batteries.

230. F. SCHWARTZ. London. Improved mechanism for actuating clocks by electricity.

244. C. HARRISON. London. A wire guard for electric lamps.

248. F. G. CORNING. London. Improvements in mechanism for transferring electric car batteries. [Date applied for under Patents Act, 1883, Section 103, June 9, 1890, being date of application in United States.]

258. A. GAY and R. HAMMOND. London. Improvements in electric arc lamps.

271. A. SCHENERSTEDT. London. Improvements connected with electric arc lamps.

284. E. L. MAYER. London. A new or improved telephone transmitter.

285. E. L. MAYER. London. A new or improved method of telephonic transmission and apparatus therefor.

January 7, 1891.

303. C. K. HARDING. London. Improvements in electric railway systems. [Date applied for under Patents Act, 1883, Section 103, June 9, 1890, being date of application in United States.]

January 8, 1891.

361. F. W. WEBB and A. M. THOMPSON. Crewe. Improvements in dynamo electric machines.

389. F. TEAGUE. London. Improvements in electricity meters.

394. W. T. GOOLDEN and S. EVERSHED. London. Improvements in electric measuring instruments.

January 9, 1891.

439. B. J. B. MILLS. London. Improvements in torpedoes propelled and steered by electricity. (W. S. Sims, United States.)

January 10, 1891.

475. A. E. D. WALTERS. Southsea. The absolute silence of telephone telegraph, and other wires, whether attached to chimneys buildings, iron standards on roofs, or wooden poles placed in any position.

476. W. E. BANTA. Glasgow. Wire coupling for electrical conductors. [Date applied for under Patents Act, 1883, Section 103, June 11, 1890, being date of application in United States.]

Digitized by Google

490. S. A. ROSENTHAL and W. SMETHURST. London. Improvements in the construction of electric batteries for application to the firing of fire-arms and other explosive appliances.

492. R. WILLIAMSON. London. A jointed bracket for electric lamps.

508. W. H. MUNNS. London. An improved underground electric conduit. (H. Young, United States.)

536. C. W. ATKINSON and L. B. ATKINSON. London. Improvements in dynamo electric generators and motors.

January 12, 1891.

573. W. J. RUNDLE, F. B. LEA, and A. G. NEW. London. Improvements in devices for hanging pictures, especially applicable to the casing of electrical conductors.

584. M. HAUTIN and M. LEBLANC. London. An improved construction of alternate current dynamo electric motors.

587. F. H. P. BERLYN. London. Improvements in or connected with incandescent electric lamps.

593. T. COAD, London. Improvements in electric primary batteries.

January 13, 1891.

608. I. PARKER. Wolverhampton. Improvements in construction of channels for the use of electric conductors in streets.

616. H. J. ALLISON. London. An improved carbon stick or pencil for arc lamps. (B. B. Ward, United States.)

617. H. J. ALLISON. London. Improvements in the construction of electric arc lamps, and appliances used therefor. (B. B. Ward, United States.)

624. AMERICAN ELEVATOR COMPANY. London. Improvements in Electrical elevator apparatus. (Otis Bros. & Co., United States.)

641. E. G. HAMMER. London. Improvements in electric clocks.

647. H. H. LAKE. London. Improvements in electrical measuring instruments. (E. Weston, United States.)

649. H. H. LAKE. London. Improvements in and relating to electric elevators or lifts. (R. Eickemeyer, United States.)

657. H. H. LAKE. London. Improvements in conduits for electric conductors. (A. Lord, United States.)

667. W. P. THOMPSON. Liverpool. Improvements in electrodes for voltaic accumulators. (The Hess Electric Storage Battery Company, United States.)

668. W. P. THOMPSON. Liverpool. Improvements in or appertaining to voltaic accumulators. (The Hess Electric Storage Battery Company, United States.)

669. J. PULUJ. London. Improvements in electrical cut-outs or safety fuses.

January 16, 1891.

846. W. V. MORTEN. London. Improvements in electrical cables.

January 17, 1891.

860. A. H. BAGNOLD. Rochester. An electric bell repeater. An electric bell and receiver for electric signals.

861. G. L. ANDERS and C. H. ELLIOT. London. Improvements in the insulation of metals for electrical purposes.

## SPECIFICATIONS PUBLISHED.

1889.

20,974. VAN RYSSELBERGHE. Electric Supply. (Price 8d.)

1890.

135. ATKINSON. Alternate current motors. (Price 8d.)

1,246. FITZGERALD and FALCONER. Electrolytic generation of chlorine, &c. (Price 4d.)

2,241. ROBINSON. Electric vote indicator, &c. (Price 8d.)

2,527. CORNWELL. Electric arc lamps. (Price 8d.)

3,133. BOARDMAN. Incandescent arc electric lamps. (Price 8d.)

3,163. ALEXANDER. Electric switches. (Price 6d.)

4,000. PIEPER. Electric regulators. (Price 8d.)

4,028. FITZGERALD. Electric telephone transmitters. (Price 6d.)

7,044. LAKE (Brooks). Electric conductors. (Price 6d.)

7,186. THOMPSON (Coffin). Welding metals electrically. (Price 6d.)

9,668. HEBENDAHL and Others. Elevating, &c., electric lights. (Price 6d.)

9,797. ALEXANDER. Electric circuit controlling apparatus. (Price 8d.)

10,122. DEWEY. Electric railways. (Price 8d.)

12,997. BRAIN and Others. Electrical rock drill, &c. (Price 6d.)

13,009. ODELL. Printing telegraphs. (Price 1s. 1d.)

13,362. EDWARDS (Cassalette and Another.) Automatic telegraphs. (Price 1s. 6d.)

14,634. INGLEFIELD. Electric light signalling. (Price 6d.)

15,043. LAKE (Abshagen). Electric heating apparatus. (Price 8d.)

15,084. VAN DEPOELE. Electric railway conduits. (Price 8d.)

16,346. CURRIE. Distributing electricity by storage batteries. (Price 8d.)

18,292. DRAKE and GORHAM. Electrical switches. (Price 6d.)

18,576. NEVILE. Controlling electric currents. (Price 8d.)

18,625. LAKE (Lemp). Electric welding, &c. (Price 8d.)

18,631. LAKE (Thomson). Welding metals by electricity. (Price 6d.)

19,057. THOMPSON BEACH. Electric Arc Lamps. (Price 6d.)

19,097. CLARK (BORNHOLDT & GLATZ). Incandescent Electric Lamps. (Price 6d.)

19,162. DEWEY. Electric welding and metal working. (Price 8d.)

# COMPANIES' MEETINGS & REPORTS.

## The Anglo-American Telegraph Company (Limited).

The ordinary half-yearly meeting of the proprietors in this Company was held at Winchester House, Old Broad-street, on the 30th ult., under the presidency of the Marquis of Tweeddale.

The SECRETARY (Mr. T. H. Wells) having read the notice convening the meeting, the report of the Directors, which has been published in *The Electrician*, was taken as read.

The CHAIRMAN: Gentlemen, in the first place I desire to refer to the loss which the Company has sustained through the resignation of our chairman, Lord Monck. Lord Monck joined this Company in the position of Chairman seventeen years ago. He brought to bear on our deliberations great knowledge of business and public affairs. He was a very good man of business himself, and he won from the first and retained to the last the regard and confidence of his colleagues, of the officials of the Company, and, I think, of every member of the proprietary. No one who remembers Lord Monck in the chair can have forgotten the dignity and uniform courtesy with which he conducted the affairs of the meetings. I ask you to join in a cordial expression and wish that he may long live to enjoy the repose which a long, active, and useful life renders him so worthy of. I believe that the manner in which the vacancy on the Board caused by his resignation has been filled will meet with the approval of everyone present. We believe that in appointing Sir Albert I. Leppoc Cappel as one of our Directors, we have chosen the best man we could get. The distinguished career he led in India, crowned by occupying the highest position in connection with the telegraphs in that country, both submarine and land, and the honour which was bestowed upon him on retiring from the service, offer, I think, ample evidence that he will be a valuable acquisition to our Company. With regard to the honour which has been done to me by my colleagues, I shall not say a word more than that if you renew your confidence in me later on I shall do my very best to justify the position which my colleagues have been good enough to bestow upon me. Turning now to the accounts and the report, you will observe that the gross receipts have amounted to £161,986, and that the total expenses were £56,142. The gross receipts are somewhat larger than they were this time last year, and the total expenses are somewhat less. For instance, the traffic receipts show an increase of £3,027, and the total expenses show a decrease of £2,470. We had a sort of windfall in the shape of the hire of the "Minia," which enables us to add £1,500 to our receipts, and we carry forward rather less than we brought forward from last year. These sums added together enable us to recommend the payment of a dividend somewhat in excess of what was paid last year; that is to say, we recommend a dividend of ½ per cent. more than we had last year, making £2. 17s. 6d. for the whole year. I think the reduction in the total expenses must be regarded as a highly satisfactory feature, because you find that under the heads, both of repairs and renewals of cables there is a very large decrease as compared with last year. The ordinary repairs are less by £6,919, whilst almost the whole of the interest on the renewal fund is appropriated to increasing that fund, which now amounts to £980,000, and if we chose to add the increased value of our securities over their cost price we should raise this amount to something over a million. The working expenses, under Tables B and C, are higher than they were at this time last year by £4,449. This increase is mainly due to the offices which we found it desirable to open in New York and other places of a less important character, and agencies which have been established in other parts. You are aware that we are exposed to a very active competition for the traffic between this country and the United States, and when the competition takes the shape of establishing offices in different parts of the United States, of this country, and abroad, it becomes indispensably necessary to pursue the same policy. It is proved beyond doubt that if any company establishes an office in any particular town the traffic goes to that company, so that if we wish to maintain our present traffic and improve it, we must at least do what our competitors are doing. I dwell upon this because I think it is not impossible that the increase to which I have just referred may be further increased during the present half-year. The increase in our traffic does not appear to be a very large figure, but it is an increase on a very considerable increase at this time last year. The increase then amounted to something like £23,000, so it is not, from that point of view, so insignificant as it might appear. At the same time we all admit on this side of the table that we should be very glad if that increase had been larger. We should have been very glad to have obtained a larger share of the traffic between this country and the other side, but I do not think we can lay to ourselves any blame for not having done our best to increase that share. What we have to do is to render our service as efficient as possible. I believe when our lines are in order we are unrivalled with respect to regularity and speed; but there are times when we are exposed to interruptions on our land lines both on this side and the other through the storms which prevail in the winter months, and these interruptions are a source of annoyance to ourselves and to those who favour us with their traffic. With regard to these interruptions, I may say they are far more numerous on the other side than on this, and we have been for some time endeavouring to find a remedy for this drawback to our system. I hope before we meet you again to be able to report to you that the interruptions on the other side have become less, and that the means we hope to adopt to reduce them will have been carried into effect. Although, no doubt, causes operate in favour of certain lines, apart from the efficiency of those lines, I think we may lay it down as a general maxim that in the long run the traffic will flow over the lines where the service is

Digitized by Google

best performed, and, therefore, I hope we may look forward in the future to an improved traffic—an improvement which has existed during the last six months, and which I hope will characterise the current six months. There is one other matter to which I must refer, and that is with regard to the position of our lawsuit in Paris. It was suggested at the meeting the other day of the Direct Cable Company that we had not been as active as we might have been in seeing that this suit was carried to a conclusion. I do not think that there is any justification for such an idea. The suit was instituted in 1886, and the first decision, a judgment in our favour, was given on January 9, 1888. The judgment was appealed against, and on March 19, 1889, a judgment adverse to us was given. We lodged our appeal with the Conseil d'Etat on July 3, 1889, and on March 28, 1890, the French company's defence was entered. The record of the case has been before the Conseil d'Etat in various shapes ever since that time, and we are informed that in all probability it will come up for judgment within a reasonable time. It has not been put on the roll yet, but the moment it is, we understand there will be no delay in the hearing and judgment. I think I have touched upon all the more important matters referred to in the report, and I shall conclude by moving the adoption of the report of the Directors and accompanying statement of accounts to December 31, 1890, and the payment of the dividends as recommended in the report.

Sir JAMES ANDERSON seconded the motion.

The CHAIRMAN then expressed his readiness to answer any question, or to supply any information that might be required.

Mr. WREFORD said he did not desire in any way to oppose the motion, but perhaps the Chairman would be good enough to let them know whether any "crumb of comfort" could be offered to the Deferred shareholders, of whom he was one. They had waited for a considerable time, and with patience, in the hope that they might have some dividend; and he had taken note of what the Chairman had said—that if the increased value of the securities they held was taken into account there would be over £1,000,000 at the credit of the renewal account. This being so, did it not occur to the Directors that some portion of the benefit arising from the renewal fund might be divided among the Deferred shareholders?

Mr. LEON: Mr. Chairman and fellow-shareholders, I have no resolution to propose, but I should like to offer a few remarks, in quite a friendly way, not in any hostile spirit, but with the ordinary authority of a large moneyed interest in the Company, and with the knowledge I possess in being one of the largest customers of this Company. I think, gentlemen, that we have very little reason to congratulate ourselves upon the working of this Company for the last year, and I will give you several reasons for this statement. First of all, our worthy Chairman remarked that we are unrivalled as regards regularity and speed. I may say, gentlemen, that my experience as a very large customer is quite the contrary.

The CHAIRMAN: Allow me to say that I refer to the lines when not interrupted.

Mr. LEON: When there is no interruption; gentlemen, our worthy Chairman is quite correct. I want to lay down as an axiom, gentlemen, that the interest to be paid to the stockholders depends very much on the attention paid by the management to the customers, and owing to this very strong competitive element that we have to face—I allude to the Commercial Company—the individual customer—my custom, for example—is of much more importance to this company than this company is to me, for at any moment I can move, and get another very large customer to move off bag and baggage to the enemy. I do not want to do this, gentlemen, because I have a very large moneyed interest in this concern. I don't want to make any idle threat as to what we should do, but I only want to diagnose the disease that is rapidly spreading in the management of this Company. I hear on good authority that the Commercial Cable has opened offices in Dundee and Bradford, and probably in other places. I want to know, Mr. Chairman, from those who have the management of these details, why we did not do the same. You must know that my business is on the Stock Exchange, and it is of the very greatest importance to me that my messages are received and despatched very promptly. We employ the Anglo-American Company to carry our messages for New York, and if we do not get these messages delivered immediately our business is absolutely worthless. In the management of my business I stand on the Stock Exchange, and my clerk has a seat in the office of this Company in Throgmorton-street, and he sends me the price of stocks from New York, and also any remarks he may have to make as to the working of the cable. These remarks are by no means of a satisfactory character, and I do not think there can be any difference of opinion about that. Now, I believe I have diagnosed the disease. The question is, gentlemen, to find out the remedy. As I said before, I do not speak in any way hostile to this Company; I am only speaking for the benefit of the stockholders, and also for benefiting indirectly their customers. I ask you, therefore, Mr. Chairman, whether it is not advisable to spend some of our large reserve fund in doing away entirely with land lines, and laying a direct cable, in direct opposition to the Commercial Company, right up the Hudson River to New York; then, also, in opening offices where the Commercial open them, and even in some of the numerous places where the Commercial have not opened them, so that we may now enter into active competition, not in the way of a decrease in the rates, which is a bad way of competing for both sides, but by giving, if possible, more facilities to the public, so that they may prefer our cables to those of our opponents. I have nothing more to say, sir, except I believe that if this is not done by the Company, my friends—that is, myself and another large firm, I won't mention their names—will leave altogether; and I may tell you more, that we believe that if you lose our custom it means something like a ¼ to ⅜ per cent. on the dividend of the entire Anglo stock. I have the figures here, and they will show you the amount of money we spend in one year in cabling alone to New York. I believe it will also affect the proprietary, because the stockholders will enter into a canvass of the members to put new blood on the Board. I do not mean to say that new blood is absolutely necessary, but it is advisable, after a course of years, to change the blood of every organisation and public company. That is all I have to say, and I should like to hear any remarks you may make as to what is to take place in the coming year as regards an improvement in the management of the Company.

Mr. WOOD inquired whether, if the lawsuit about which they had heard did not come on for hearing in a short time, the Directors could do nothing to expedite the matter. Many of the shareholders were getting rather tired of seeing that the lawsuit was still pending. There seemed to be no end to it; and was it possible that it was being put off for a set purpose?

Mr. JACKSON said he believed that he was expressing the general opinion of the proprietors when he said he agreed with the eloquent eulogium which the Chairman had bestowed upon Viscount Monck. He was sure that those who had been attending the meetings of this Company would agree with everything that the Chairman had said respecting Lord Monck, and would join in the hope that their late Chairman might be spared for many years to enjoy his retirement. He had no doubt that Lord Monck regretted as much as they themselves did the low state comparatively into which the Company had fallen. He said "comparatively," because he remembered when they paid handsome, but in no sense excessive dividends, considering their risks. He thought that these risks had been well illustrated by the gentleman who had brought a sort of charge against the Company by showing how frequently their communication was interrupted. He wished that he could feel confidence and hope in what the Chairman had told them about the little increase paid on the present occasion in their dividend, but he was afraid that it was owing more to the immunity which they had enjoyed from accidents than to an increase in their traffic. The Chairman had pointed out that they had had an increase of revenue of £3,000, and that their expenses had shown a decrease, but they did not show a decrease.

The CHAIRMAN: Not the working expenses, but the total expenses.

Mr. JACKSON, continuing, said that the expenses did not show a decrease in the essential direction. The decrease was owing to the smaller amount of damages to the cables. The absolute increase in the working expenses compared with those for 1889 was more than the difference in their income. The working expenses at the head office and at the stations—the permanent working expenses—were £39,300 in the December half of 1889, while in the half-year under review they had amounted to £43,700, owing, as has been said, to the establishment of offices in New York and elsewhere. With reference to Mr. Leon's remarks they might be met with the answer that if he depended entirely on the two cables of the Commercial Company he might suffer still greater inconvenience from interruptions, owing to the amount of business passed over those lines, than he had been subjected to by using this Company's cables. There were something like seven "pool" cables, and it was inconceivable that these seven cables could not do the work more satisfactorily than the other two. He did not know whether Mr. Leon referred to the Direct and the other associated Companies; but surely seven cables must be more reliable than the two of the Commercial Company. However, this was a matter for the Manager to reply to. They knew that they had gentlemen conducting their business who had extraordinary ability, great experience, and unequal knowledge which had been acquired over a long period of years; and he would merely impress upon Mr. Leon, before he withdrew his custom, that he would probably find that he would suffer more inconvenience in his business than he would if he continued to employ the "pool" cables. He regretted, and he was sure the Directors regretted, the poor return of profit now obtained by the Company. He knew that competition was put forward as explaining this; but it was no answer to the gravamen of his charge. He thought that the Board, as Mr. Leon had said, did require an infusion of "new blood" in some sense. One of the highest authorites on telegraphy observed lately that it was a question of "new brooms." He did not know whether the authority meant it to be inferred that the "old brooms" were worn out when he said that the cleverest man would win. Mr. Leon's remarks ought certainly to be taken to heart, because he (Mr. Jackson) maintained that there was great dissatisfaction at the absence of anything like real improvement in the Company. With regard to the appointment of the new Chairman, he desired to speak with every possible respect of Lord Tweeddale's great knowledge, business experience, and high character; but he desired to express his opinion—he meant nothing in the way of offence—that a protest was due from the shareholders' side of the table against the practice of pluralism of directorships. How could they hope to get out of their difficulties arising from the state of stagnation which had come over their affairs when, notwithstanding his great abilities, they had a Chairman who was a member of the Board of 16 different companies, of several of which he was the head, including the North British Railway Company? He hoped in any case that their Chairman would do what he could to introduce an element into the Company which would prove beneficial to them, and he trusted that the views which he had just expressed would receive the honest, unbiassed support of other shareholders. With the fact that the last competitor who had come into the market to do business was paying a dividend of 7 per cent., and putting by 5 per cent. or 6 per cent. to redeem debentures—that was to say, earning 12 per cent., he thought the shareholders of this Company were entitled to ask why they were not in a better position.

Mr. HUMPHREYS said with regard to 40 per cent. of the capital of the Company, the Deferred, the holders of which were receiving no dividend, they were an important body, holding, as they did, £2,800,000 of the capital. They were receiving nothing, and yet another section of the proprietors was receiving 5½ per cent. In these days of conversion, which seemed to him to be all the fashion, he would like to ask

Digitized by Google

why the Directors had not given consideration to this subject, when he thought the holders of the large amount of capital which he had mentioned would receive some return. Their reserve fund now amounted to £980,000, and a portion of the current half-year's interest derivable from the investments would complete that sum up to £1,000,000. He asked, in justice to the long suffering, patient, and very quiescent holders of 40 per cent. of the capital, might they not have the interest earned by the reserve fund appropriated to their benefit in the coming half year? He hoped, with the changes which had occurred on the Board, that the Directors would apply their energies to considering the Deferred shareholders of the Company. Let them, either by conversion or by purchase, or by some other means, get rid of the Six per Cent. Preference Stock.

The CHAIRMAN, in reply, said Mr. Wreford asked me if we could hold out any hope on this side of the table for the Deferred shareholders. That is a very delicate subject, and involves the question of dealing with the renewal fund. It has always been in my mind that £1,000,000 was the very least we should have standing at our credit, having regard to the age and condition of our cables, and the necessity some day or other of renewing them. At the same time if we were to go on putting by as much as we have done during the past year to the reserve fund, I have no doubt that the Directors would then take into consideration the possibility of placing less to the renewal fund. This last year we added to that fund £27,894 out of interest, which amounted to about £31,500. Now, if we could hope to go on at that rate for a year or two more, I have no doubt that the matter would be open to consideration. Beyond that it is impossible for me to go, and I am saying even that only as my own personal opinion. I must acknowledge the reasonable spirit in which Mr. Leon spoke. His grievance is a perfectly legitimate one. He is a large holder of our stock, and a very excellent customer. I am glad to be able to say, with respect to one of his criticisms, that we have given orders for offices to be opened at two of the places he named—Bradford and Dundee—and that we contemplate establishing offices in several other places where we are likely to obtain custom which will repay us for so doing. I said that he has a legitimate grievance, and I think that the remarks which fell from me in proposing the adoption of the report must have convinced him that the grievance is one that is attracting our serious attention. I have no doubt that the cure will be the one suggested by Mr. Leon, which is perhaps the only cure—the substitution of submarine for land lines. We are, however, of opinion that the land lines might be more carefully looked after than they are at present, and we found that opinion upon the fact that our own lines in this country and other places, where we have them exposed almost as much, if not quite as much, as are those of the Western Union, are rarely interrupted. From that we conclude that the same amount of vigilance which is exercised on this side, if exercised on the other, would very largely reduce the number of interruptions on the land lines. I may, however, tell Mr. Leon that we have before us the question, if not altogether of running a cable into New York, as he suggested, of coming to some arrangement by which we should have an uninterrupted cable communication with New York. I suppose Mr. Leon will be quite satisfied with that if we can bring it about. What I said with regard to the unrivalled speed with which our business is done when interruptions were not taking place owing to the weather is, I believe, strictly and literally true—that no company comes near us with respect to the rapidity and despatch of our cables. I should have no difficulty in submitting data which would satisfy all present as to the truth of that statement. Mr. Jackson, who followed Mr. Leon, referred to the expenditure, and said it was larger than the corresponding increase in the receipts had been. That may be true, but it does not in any way justify any adverse criticism upon the expenditure which we have incurred in establishing offices, &c., because if we had not established those offices we might ask whether we should not have been worse off than we are now. The New York office, which was established a short time ago at considerable expense, has entirely justified our expectations. Then Mr. Jackson complained of the small amount of our receipts, and he told us that competition is no answer as explaining it. But surely competition is the whole answer. If we had enjoyed anything like a monopoly—a semi-monopoly, which it is said we enjoy to the East—a very different state of things would be realised. Mr. Jackson knows very well that not only is this traffic free to competition, but competition of the most remarkable character—competition by private individuals, not even by a Company. Surely that is the real answer. As long as that is the case, the property of this Company is and must be regarded as of more or less precarious character. Then Mr. Jackson did what he was perfectly entitled to—criticised the Directors in having appointed me as their Chairman; and he denounced what he described as pluralism. He is perfectly entitled to his opinion on that matter. I can only say for myself that I have never sought for any one of the positions which I hold. I have been invited to occupy similar positions with a great number of other institutions which I have declined; and I may say that the particular business to which he referred only forms a very small part of the work which I discharge in the course of the year. As to his suggestion that I have too many engagements to do my work properly, I may point out that only recently I was asked to be in my own country what corresponds in this country to the Chairmanship of the County Council. Everybody knew how much I was occupied, but notwithstanding that this position was offered to me, and I accepted it. There must be some reason for this—I do not wish to say much on the point—but there must be some reason why I should be invited to occupy the position which I have the honour to fill to-day. Mr. Humphreys, I think, suggested that some alteration should be made in the constitution of the Company. If Mr. Humphreys will submit any scheme which he thinks is likely to be adopted by his brother shareholders, we should be very glad to consider it. He also suggested that our stock might be bought, but we have no power to do so; nor could we do anything with respect to a dividend on the Deferred stock until the Preferred stockholders have had their dividend in full. There is one remark I see I have omitted to make with respect to Mr. Leon's complaint. I do not remember whether he referred to it, but I wish to point out to him that our Companies were the only ones which carried the traffic during part of the day on which the great storm occurred in America. Mr. Wood wished for further information with respect to the lawsuit. If you will let me, I will read the last part of the report which has been drawn up with respect to that suit, as it will put him in possession of all the information which can be afforded him.

A SHAREHOLDER: Could you say what is the amount involved?

The CHAIRMAN: Oh, it is a very considerable sum. I may repeat that in July, 1889, this Company lodged its appeal to the Council of State, and that on March 28, 1890, the French Company's defence was entered; and now I may read this extract from the report which I have just referred to: "Since then we have several times communicated with Paris, but have been unable to ascertain when the appeal can be heard. It appears that the Council of State, besides the ordinary legal business, has to decide contested elections and questions arising with certain public bodies. When the papers are completed they have to be submitted for examination to the advocates of both sides, and also to the Minister within whose department the matter lies. This stage was reached long ago. Next, the papers have to be sent back to the Council of State, and put into the hands of the Master of Requests, who sends to the contentious section of the Council a report, which is examined and discussed in secret. We understand the office of the Master of Requests is overwhelmed with business, and that each case has to come in turn. When the Master's report is completed it goes with the papers into the hands of the Commissary of the Government, who, after examination and approval, has the case entered on the roll. We have reason to suppose that the case will be soon put on the roll, but it is impossible to say more." I think, gentlemen, I have now replied to all the questions which were addressed to the Chairman, and I will therefore put the resolution which I have read to you, and which was seconded by Sir James Anderson. He then submitted the resolution in the usual way, and declared it carried unanimously.

Sir JAMES ANDERSON said that he had the next resolution to propose, but before doing so he desired to make one remark respecting the observations of Mr. Jackson and of his friend Mr. Leon. Those gentlemen had referred to "new blood" coming on to the Board. If, however, the shareholders would look around them they would see how many new faces there were, and how many of the old hands had dropped off. Nearly all the original Directors had passed away, and there were now on the Board four Directors who were not there a year ago—certainly not eighteen months ago. He, therefore, thought that there was "new blood" enough on the Board, unless they wanted the Directors to pass away a little faster. He then proposed the re-election of the Marquis of Tweeddale. After all that had been said about his lordship having so much to do, he could only tell the shareholders this, that there was no part of the whole business, from first to last, that did not enter into their Chairman's notice and that he did not have time to consider.

Mr. WILLIAM S. CUNARD briefly expressed his pleasure at seconding the resolution, which was carried unanimously.

The CHAIRMAN: I beg to return you my warm thanks for the confidence you have shown in re-electing me, and I hope I may be able to justify what you have done to-day. Continuing, he proposed the re-election as a Director of Mr. Cyrus W. Field, who, he said, had been connected with submarine telegraphy in the most honourable manner ever since it had existed.

Mr. CHARLES BURT, in seconding the resolution, observed that though they did not see Mr. Field much in this country, he was looking after their interests on the other side, and it was useful to have a man who would discharge this duty in New York.

The CHAIRMAN put the resolusion, and it was carried unanimously.

On the motion of Mr. JACKSON, seconded by Mr. HUMPHREYS, Mr. Joshua Dean and Mr. John Gane, F.C.A., were severally re-elected auditors of the Company.

The CHAIRMAN having intimated that this concluded the business,

Mr. JACKSON said he wished it to be clearly understood that he had the greatest respect for their noble Chairman, but had advocated what he thought was a business principle in the City of London. He had much pleasure in proposing a cordial vote of thanks to his lordship and his colleagues.

Mr. LEON, in seconding the motion, said that he would like to add a word more arising from what the Chairman had said, that their Company was now going to open offices at Bradford and Dundee. What he wished to say was, why were they not in advance of the Commercial Company? Why did not they open offices before the Commercial Company did, instead of "hanging on to their tails," and so carry on an active competition with such an important rival.

The motion was carried unanimously.

The CHAIRMAN having briefly replied, the proceedings terminated.

## City and South London Railway Company.

An extraordinary general meeting of the shareholders of this Company was held on Tuesday at the offices, 46, King William-street, E.C., to consider a Bill proposed to be introduced into Parliament to empower the Company to make an underground railway from the City to Islington. Mr. C. G. Mott presided.

The SECRETARY (Mr. H. H. M. Smith) having read the notice calling the meeting,

The SOLICITOR of the Company (Mr. Robert Fowler) briefly explained the main clauses of the Bill.

Digitized by Google

The CHAIRMAN: As regards the meeting to-day, it is simply called to consider the question whether we should or should not proceed with the Bill which has been introduced provisionally into the House of Parliament for the construction of an extension of this line from King William-street up to the Angel at Islington. It is not and has never been the desire of the Directors of this Company to proceed at all hastily with anything in connection with this line. We have been from time to time, during the years in which we have been constructing our line asked to go for various extensions, but except the small one at the Clapham end for which we obtained powers last year we have declined all such proposals up to the present time. Our desire was rather to consolidate this railway satisfactorily before we proceeded to extend it in any shape or form. That has been the view which the Directors took all along. We took it last year, and declined this very line that was proposed to us. The result was that we were threatened with another Bill which was proposed by the Central London, by which they were to occupy the ground which would have prevented this railway from being extended in the City of London. We must look to the fact that some of the best traffic for a railway such as this must ultimately come from the busy portions of the City. It did not appear to us a desirable thing that our road should be permanently blocked so that we could never go in for that traffic at any time, whatever might happen. On that account we thought it desirable and wise in your interests that this Session notice should be given for such a Bill as this, to allow us the right to go into the City at any time it would be desirable to go there. This line is one which I think can be carried out at comparatively small expense, and will go through one of the busiest parts that we could well have in the City. It is going straight up by the Bank, Moorgate-street, and the City-road. I think that the line in itself is a good one, and one that, so far as we can judge, will pay quite as well, perhaps better, than our existing line. The traffic is very large there, and the line would be a good one in itself. I would rather that the matter had been postponed, but it did not appear to us that it was safe in your interests that a postponement should take place, but we considered that we should occupy the ground at present and obtain the Act. As to the exact time of carrying it out, and as to the mode of doing it, that is, whether it is to be part of the capital of this line, or consist of a separate capital; these are matters which, if the Bill were obtained, the shareholders will have to decide for themselves at a later date. That is not the question before us at the present moment. We are here to decide whether it is desirable to go on with the Bill or not. That is really the position in which we stand. We should have postponed any further action in the matter if we could have done so safely, but we still think that it is most desirable in your interests that this Bill should, if possible, be obtained, and that it will be a very good line. The great object of a line of that kind I may tell you is this. As you know every morning and evening there is a very large rush of traffic, such as the line could take into and from the City, but during the middle of the day the trains are not by any means full. That is the experience of all the Metropolitan railways, and the great object of every one of these railways, in order to make good a dividend, is as far as possible to fill up the mid-day trains. The effect of another line such as this will be that we shall largely improve the mid-day traffic on the existing lines, and our existing line itself would improve the mid-day traffic on such a line as this. Therefore we should have a chance of a very much better dividend, I think, on our existing line if such a project were carried out. Whether we incorporate it as part of our own system, or make it an independent concern with a separate capital, is a matter which we can decide afterwards if we obtain powers. Upon all these grounds the Board are disposed to recommend you to go on with this Bill. The immediate effect of our proceeding has been that we have prevented the Central London from occupying the ground and blocking us out as they proposed to do last year. They have altered their Bill for the present, but if we leave the ground unoccupied it will be open for anyone to take possession of it. As regards our own railway, we have been only six weeks at work up to the present moment, and in a new line, and especially a new line such as this, there are a great many difficulties to contend with in working it, and giving a service which, as you know, is practically unexampled in the history of railways in this country. A rapid service such as we have started which we hope to still further develop, has never been attempted by any railway as a complete railway. There are small portions of the Metropolitan and District Railways where there is a train service similar to that which we now run, but no complete railway has run at the rate or the number of trains which this railway is doing. I think we have reason to be extremely satisfied with the whole of the working of this line as an electrical line. You have seen, no doubt, many paragraphs in the newspapers complaining of breakdowns on this line. We are, unfortunately, very much before the public at the present moment, and notice is taken of every little thing done on this line in a way that is never done in the case of other railways. We have run up to the present time about 11,000 trains over the line. The failures of our engines, which have been the chief cause of the delays out of those 11,000 trains, numbered only eighteen. I do not think you will say that that is a great figure, seeing that the number of trains run on our line is very large, and that it is quite impossible that so many should be run without some accident occasionally. That during the first six weeks of the existence of this new line there should have been only 18 failures is a fact creditable to the electrical system. Of course we are doing our best now to prevent, and, if possible, to get rid altogether of any ground for complaint, but whether we shall be able to do so or not with human inventions seems hardly likely to be the case; but we will do our best, so that the public will feel that they have little or no inconvenience from any accident. But, of course, we cannot do everything in six weeks. The result of those paragraphs in the newspapers is that many people who would naturally have travelled with us supposed that the line was stopped, and the traffic for the time being has been damaged; but I feel satisfied that we shall very soon be steadily improving the traffic on the line, and that you will in the end have a satisfactory result from it. The expenses of working it, so far as electricity is concerned, has turned out as far as we can see at the present moment satisfactorily. They are quite equal to what we anticipated from an economical point of view, and, on the whole, the prospects of the line are by no means gloomy. I do not know that I can say any more to you on the subject than that. You know what our object has been in introducing the Bill. If you think, on the whole, that it is desirable that we should run the risk of not proceeding with it we are quite in your hands with regard to the matter; but I think you would be wiser to let the Bill go on, and let us obtain powers, and deal with the undertaking afterwards in the way that we think most judicious. He concluded by moving a resolution approving of the Bill in question.

Mr. HUBBARD seconded the motion.

A SHAREHOLDER suggested that if the Bill were passed by Parliament it might be expedient not to proceed with the construction of the line until the Company had had more experience of its present line.

The CHAIRMAN pointed out that five years is the usual period given for the construction of a line, and if they desired not to go on with it the custom was to go to Parliament for an Abandonment Bill. If they desired to go on with it they could do so at any time within that period.

Mr. BROAD objected to any portion of the funds of the Company being devoted to that purpose.

The CHAIRMAN: We do not in the slightest degree want to proceed with the Bill if the shareholders do not like it. We have rather reluctantly ourselves gone into it as a protection to the shareholders. I have told you the circumstances, and if the shareholders think it is better to run the risk of withdrawing the Bill—for a very considerable risk is run in withdrawing it—it is for them to say so. We have done the best we


# PATENT

# SILICIUM BRONZE AND SILICIUM COPPER WIRE.

## The best for overhead Telephone and Telegraph Lines,

AND ALL ELECTRICAL PURPOSES.

Hard Drawn High Conductivity Copper Wire.

ROLLED AND DRAWN PHOSPHOR BRONZE.

PHOSPHOR BRONZE BEARINGS, BUSHES, AND OTHER PARTS OF ELECTRICAL MACHINERY

*SOLE PROPRIETORS of the British, Indian and Colonial Patents,*

## THE PHOSPHOR BRONZE COMPANY (Limited),

*87, Sumner Street, Southwark, London, S.E.*

WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

could in giving you an opportunity to discuss this question, and it is for you to decide. If you think it is better to withdraw it, we shall acquiesce.

A SHAREHOLDER asked who would have to pay for the Bill.

The CHAIRMAN replied that the shareholders of the existing line would if they were prepared to go on with it. The Bill was not likely to be seriously opposed or very expensive, probably £1,500.

Mr. H. BISHOP thought it would be much better to stick to the line they commenced with until it was proved and tested in every way. If other people took up the matter the shareholders in this Company could take shares in the other Company that might be formed. He did not think they should spend money on what was not contemplated in the first instance.

Mr. COURT said that he had not seen the plans of the proposed undertaking until that moment, and one would naturally like to have an opportunity of considering them before giving one's decision. Many of the shareholders were in the same position, knowing little or nothing of the proposal, and he thought that in the interests of all concerned it would be better to adjourn the meeting until such time as they thoroughly understood it. His own feeling was that if one or two small objections could be got rid of the scheme might be an advantage to the Company. But it was better to carefully discuss it.

The CHAIRMAN: You can adjourn until the 24th, the date of the general meeting.

Mr. W. A. SMITH asked what the amount of the capital was.

The CHAIRMAN replied that the amount of capital was apparently larger than what the present line cost. The present line cost £600,000, whereas it was proposed to raise £660,000 for the new one. In going through the City they must be aware that it might be necessary to pay a large sum for a particular site for a station. But the arrangements they made were such that they should practically get the money back, or get very good interest for it, which was the same thing, but they were obliged to have in their Bill powers for raising sufficient capital to cover the temporary costs they might incur. Otherwise the cost of the line would not be heavy, but very reasonable. There were very good reasons why the Bill had been drafted in its present form. He would, of course, like to go into them, but if the Bill was to be proceeded with, it would be desirable not to discuss those reasons publicly. But the Bill had been exceedingly well considered, and he would be glad to explain privately anything they might desire to know.

Mr. COURT formally moved that the meeting should be adjourned till the 24th inst., immediately after the conclusion of the business of the half-yearly meeting.

Mr. W. A. SMITH seconded the amendment, which

The CHAIRMAN put to the meeting and declared carried.

A SHAREHOLDER asked how many passengers had been carried by the existing line?

The CHAIRMAN: Up to the present moment we have carried somewhere about a million passengers.

Mr. COURT said he was very much pleased with the rapidity with which passengers were taken from one end of the line to the other.

The CHAIRMAN said that they must have patience with a new thing that had never been tried in the history of the world before. They had a great deal of anxiety in connection with it, and the staff were employed night and day. They had gradually to feel their way. All their difficulties and delays were capable of being remedied, and were being remedied, but they could not do everything in six weeks. They would be perfectly satisfied by-and-by. They were doing their very best, and no stone was being left unturned to make the undertaking a success.

Mr. W. A. SMITH proposed a vote of thanks to the Chairman, which brought the proceedings to a close.

## The Cuba Submarine Telegraph Company (Limited).

The following is the report of the Directors of the above Company for the half-year ending December 31, 1890, to be presented at the thirty-ninth ordinary general meeting of shareholders to be held at the office of the Company on the 11th inst. at 12 o clock:—

From the balance-sheet and accounts it will be seen that the gross receipts (including the balance brought from last account) amount to £21,325. 19s. 0d., and the gross expenditure (including the half of the annual payment on account of the 1881 cable) to £6,759. 11s. 3d., leaving a sum of £14,566. 7s. 9d. to the credit of revenue account. Of this the sum of £4,450. 13s. 10d. has been added to the reserve fund, which now stands at £79,000. The dividend on the Preference shares will absorb £3,000, and leave £7,115. 13s. 11d., out of which the Directors recommend the payment of a dividend on the ordinary shares at the rate of 8 per cent. per annum, free of income-tax, the balance, £715. 13s. 11d., being carried forward to the current half-year's account.

The new cable between Batabano and Cienfuegos, referred to in paragraph six of the last report, was completely laid on 19th instant, but will not be taken over from the contractors until it has undergone the tests required by the contract. The instalments already paid have been deducted from the reserve fund, which will also be charged with the balance of the contract price. The Cienfuegos-Santiago 1881 cable broke down on August 21st last, and the 1875 one, between the same points, became interrupted on 13th instant. The latter is now being repaired by the Company's engineer, the vessel which laid the new Batabano cable having been hired for the purpose, and the restoration of communication is daily expected. When this is accomplished the vessel will proceed to repair the 1881 cable, the cost of which has to be borne by Messrs. Hooper, the contractors.

A special meeting has been convened to remedy a defect in the Articles of Association which is deemed to be necessary in the interests of the shareholders.

With regard to the suit against the Spanish Government, the necessary forms for bringing the case under the consideration of the Contencioso Court are not yet complete, but it is expected that within a short time the case will be ready for hearing.

The usual comparative statement of traffic accompanies the Directors' report.

## CITY NOTES, &c.

**BRAZILIAN SUBMARINE TELEGRAPH COMPANY.**—The receipts of this Company for the week ended January 30th amounted to £6,215.

**CITY AND SOUTH LONDON RAILWAY COMPANY.**—The receipts of this Company for the week ended January 31st amounted to £704.

**DIRECT SPANISH TELEGRAPH COMPANY.**—The traffic receipts of this Company for the month of January were £2,147, against £2,415 last year.

**EASTERN TELEGRAPH COMPANY (LIMITED).**—The traffic receipts for the month of January, 1891, amounted to £60,005, and to £59,478 in the corresponding period of 1890.

**EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY.**—The traffic receipts of this Company for the month of January, 1891, amounted to £46,575, and to £40,610 in the corresponding period of 1890. Increase £5,965.

**NEW COMPANIES REGISTERED IN JANUARY.**—Amongst the new companies registered at Somerset House during the month of January were the following:—

| | |
|---|---|
| Leeds Copper Company (Limited), £1 shares | £450,000 |
| North-Eastern Telephone Company (Limited), £1 shares | 4,600 |
| Shropshire Electric Light and Power Company (Limited), £10 shares | 25,000 |

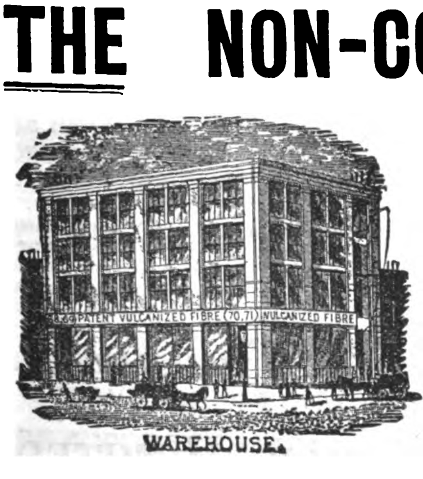
**VENEZUELA TELEPHONE AND ELECTRICAL APPLIANCES COMPANY.**—The coupons on the debentures of this Company, now due, are payable on presentation at the Consolidated Bank (Limited), 52, Threadneedle-street.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY.**—The traffic receipts of this Company for the week ending January 30, 1891, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £4,996.

**WEST INDIA AND PANAMA TELEGRAPH COMPANY.**—The traffic receipts for the half-month ended Jan. 31st were £3,801, as compared with £3,556 for the corresponding period of 1890. The October receipts, estimated at £5,797, realized £5,847.

**WOODHOUSE AND RAWSON UNITED.**—The Directors of this Company have declared an interim dividend at the rate of 15 per cent. on the ordinary shares and 8 per cent. on the Preference shares, in respect of the profits to December 30th last.


# THE NON-CONDUCTOR OF ELECTRICITY.



WAREHOUSE.

**VULCANISED FIBRE,**
PATENTED.

This new material is supplied in two qualities, Flexible and Hard.

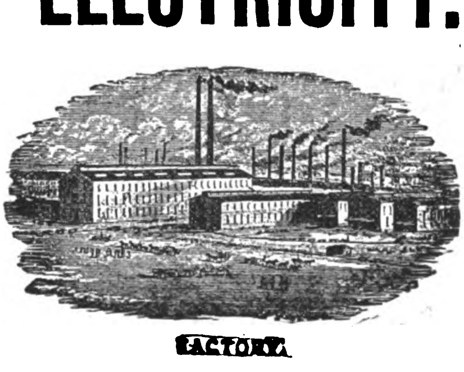
The FLEXIBLE is a substitute for Leather, Rubber, Gutta Percha, &c., and is extensively used by Brass Founders, Axle Makers, Hydraulic, Sanitary, and other Engineers, Pump Makers, Carriage Builders, &c.

It makes the best Hot and Cold Water Packings, and for Axle Washers of all kinds it is unequalled.

The HARD is a substitute for Metals, Hard Wood, Ivory, Vulcanite, Ebonite, &c., and is a good Insulator.

Sold in sheets, 5ft. 6in. by 3ft. 6in., varying in thickness from 1-50in. to 1in.

FLEXIBLE, 2/- per lb.; HARD, 2/3 per lb.


FACTORY.

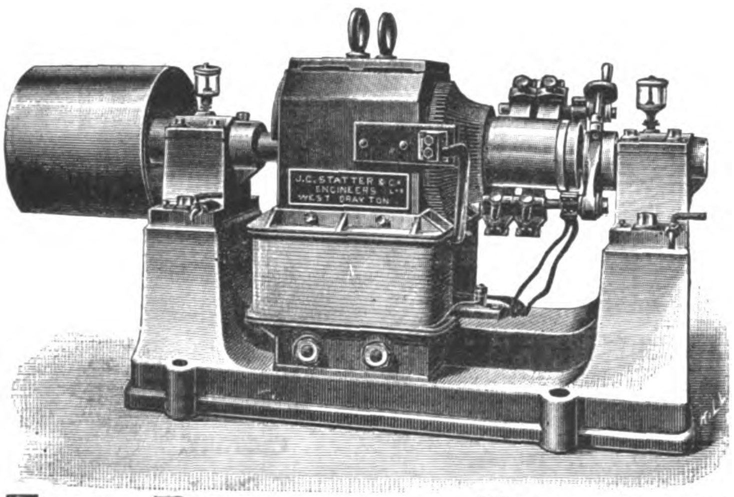
**MOSSES & MITCHELL, 70, Chiswell-st., London, E.C.**


Digitized by Google

# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name. | Previous Week's Price, Jan. 28. | | Price Wednesday, Feb. 4. | | Rate per Cent. Yielded. £ s. d. | Dividend Due. | Business Done During Week Ending Jan. 28. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **TELEGRAPHS.** | | | | | | | | |
| £1,381,380 | Stock | 15/0 | Anglo-American | 48 | 49 | 48½ | 49½ | 5 16 2 | Jan., Apr., July, Oct. | 49½ | 48½ |
| £2,809,310 | Stock | 30/0 | Do. Preferred | 85 | 86 | 85½ | 86½ | 6 12 11 | ,, ,, | 86¾ | 85¼ |
| £2,809,310 | Stock | .. | Do. Deferred | 12¼ | 12¾ | 12½ | 13 | .. | ,, ,, | 12 13/16 | 11¾ |
| £250,000 | 100 | 4% | African Direct, Telegraph 4% Debentures | 98 | 101 | 99 | 102 | 3 18 5 | January and July .. | .. | .. |
| 130,000 | £10 | 3/0 | Brazilian Submarine | 11½ | 12 | 11¾ | 12¼ | 6 2 5 | Mar., June, Oct., Dec. | 11⅞ | 11¾ |
| £84,500 | £100 | 5% | Do. 5 per Cent. Bonds ...xd | 102 | 105 | 100 | 103 | 4 17 1 | January and July .. | .. | .. |
| £75,000 | £100 | 5% | Do. 5 per Cent. Bonds (2nd Series, 1906) | 102 | 106 | 103 | 107 | 4 13 6 | June and December | .. | .. |
| $7,216,000 | $100 | 7% | Commercial Cable Capital Stock | 104 | 105 | 104 | 106 | 6 12 1 | April and October .. | 104½ | .. |
| 16,000 | 10 | 8/0 | Cuba Submarine | 11 | 12 | 11 | 12 | 7 1 8 | February and August | 11¼ | 11½ |
| 6,000 | 10 | 10% | Do. Preference 10% | 16½ | 17½ | 16½ | 17½ | 5 14 3 | ,, ,, | .. | .. |
| 12,931 | 5 | 2/4¾ | Direct Spanish (£4 paid) | 3½ | 4 | 3¾ | 4 | 6 0 0 | April and October.. | 3¾ | .. |
| 6,000 | 5 | 10% | Do. Preference 10% | 9 | 10 | 9 | 10 | 5 0 0 | ,, ,, | 9 11/16 | 9½ |
| 60,710 | 20 | 3/6 | Direct United States | 10⅛ | 10⅝ | 10½ | 10⅝ | 6 15 0 | Jan., Apr., July, Oct. | 10 7/16 | 10½ |
| 400,000 | 10 | 2/6 | Eastern | 14 | 14¼ | 14⅛ | 14⅜ | 4 10 5 | ,, ,, | 14⅜ | 14⅛ |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference | 14¾ | 15¼ | 15 | 15½ | 3 17 5 | ,, ,, | 15 3/16 | 15 |
| £1,200,000 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock | 105 | 108 | 105 | 108 | 3 13 9 | May and November | 108 | 107 |
| £200,000 | 100 | 5% | Do. 5 per Cent Debentures, 1899 ...xd | 108 | 111 | 106 | 109 | 4 11 9 | February & August | 108¾ | 106½ |
| 250,000 | 10 | 2/6 | Eastern Extension | 14⅜ | 14⅝ | 14½ | 15 | 4 13 4 | Jan., Apr., July, Oct. | 14 13/16 | 14⅝ |
| £320,000 | 100 | 6% | Do. 6 per Cent. Debentures, 1891 ...xd | 101 | 103 | .. | | .. | February & August | .. | .. |
| .. | £100 | .. | Do. 4 per Cent. Debentures Stock | 103 | 105 | 103 | 105 | 3 16 2 | .. | .. | .. |
| £91,800 | 100 | 5% | Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900 | 102 | 105 | 102 | 105 | 4 15 3 | January and July .. | 103 | .. |
| £145,300 | 100 | 5% | Eastern & S. African 5 per Cent. Mor. Deb., 1900.. | 102 | 105 | 102 | 105 | 4 15 3 | ,, ,, | .. | .. |
| 180,227 | 10 | 1/9 | Globe Telegraph and Trust ...xd | 8⅞ | 9⅜ | 9 | 9¼ | 5 5 6 | Jan., Apr., July, Oct. | 9 3/16 | 8⅞ |
| 180,042 | 10 | 6% | Do. 6 per Cent. Preference ...xd | 14⅞ | 15¼ | 14⅞ | 15⅛ | 3 19 4 | ,, ,, | 15⅛ | 14⅞ |
| 150,000 | 10 | 5/0 | Great Northern | 16¾ | 17¼ | 16½ | 17 | 4 8 3 | Jan., April, and July | 16 13/16 | 16½ |
| £230,000 | 100 | 5% | Do. 5 per Cent. Debentures, 1883 | 105 | 108 | 105 | 108 | 4 12 7 | March & September | .. | .. |
| 17,000 | 25 | 12/6 | Indo-European | 35 | 37 | 35 | 37 | 6 15 2 | May and November | .. | .. |
| 38,348 | 10 | 4/0 | London Platino-Brazilian | 6 | 7 | 6 | 7 | 5 14 4 | ,, ,, | .. | .. |
| £100,000 | 100 | 6% | Do. 6 per Cent. Debentures | 107 | 110 | 107 | 110 | 5 9 1 | March & September | .. | .. |
| 9,000 | 8 | 4/0 | Reuter's | 8½ | 9 | 8½ | 9 | 5 11 1 | April and October.. | .. | .. |
| 3,381 | £100 Cert. | 6% | Submarine Cables Trust 6% | 112 | 115 | 112 | 115 | 5 4 4 | ,, ,, | .. | .. |
| 15,609 | 10 | 4/0 | West African Telegraph | 8 | 9 | 8 | 9 | 5 11 1 | January and July .. | 8¾ | .. |
| £290,900 | 100 | 5% | Do. 5 per Cent. Debentures | 98 | 101 | 98 | 101 | 4 19 0 | March & September | 100½ | 100 |
| 30,000 | 10 | 3/0 | West Coast of America | 2 | 4 | 2 | 4 | .. | January and July .. | .. | .. |
| £150,000 | 100 | 8% | Do. Debentures 8% 1902 | 95 | 100 | 95 | 100 | .. | June and December | 98 | .. |
| 88,321 | 10 | .. | West India and Panama | 2⅝ | 2⅞ | 2¾ | 3 | .. | .. | 2 11/16 | .. |
| 34,563 | 10 | 6/0 | Do. 1st Preference 6% | 11¼ | 11¾ | 11¼ | 11¾ | 5 2 2 | May and November | 11⅝ | 11½ |
| 4,669 | 10 | £3 | Do. 6 p. c. 2nd Pref. | 11 | 12 | 11 | 12 | 5 0 0 | | .. | .. |
| 64,174 | 15 | 6/0 | Western and Brazilian | 11¼ | 11¾ | 11¾ | 12¼ | 4 18 0 | ,, ,, | 11⅝ | 11½ |
| 27,873 | 7½ | 6/0 | Do. 5 per Cent. Cumulative Preferred | 6½ | 7 | 6½ | 7 | .. | — | 7 | 6⅝ |
| 27,873 | 7½ | 4/6 | Do. 5 per Cent. Deferred | 4¾ | 5¼ | 5¼ | 5¾ | .. | .. | 5½ | 5⅛ |
| £200,000 | 100 | 6% | Do. 6 per Cent. Debs., Series "A" 1910 ..xd | 103 | 106 | 102 | 105 | 5 14 3 | February & August | .. | .. |
| £250,000 | 100 | 6% | Do. 6 per Cent. Mort. Debs., Series "B" 1910 | xd 103 | 106 | 102 | 105 | 5 14 3 | ,, ,, | 106 | 105¼ |
| $1,336,000 | $1,000 | 7% | Western Union 7 per Cent. 1st Mortgage | 120 | 125 | 120 | 125 | 5 12 0 | May and November | .. | .. |
| £175,100 | £100 | 6% | Do, 6 per Cent. Sterling Bonds | 99 | 103 | 99 | 103 | 5 16 0 | March & September | .. | .. |
| | | | **TELEPHONES.** | | | | | | | | |
| 224,850 | 14/0 | 0/4½ | Consolidated Telephone Const. & Maintenance. .. | 7/16 | ½ | 7/16 | 9/16 | .. | May and November | 9/16 | .. |
| 220,000 | £1 | 3% | Oriental (11s. paid) | ⅜ | ⅝ | ⅜ | ⅝ | 5 5 9 | Yearly | .. | .. |
| 438,984 | 5 | 2/6 | National | 4⅝ | 4⅞ | 4⅝ | 4⅞ | 5 12 10 | June and December | 4 11/16 | 4⅝ |
| 15,000 | 10 | 6/0 | Do. 6 per Cent. Cumulative 1st Pref. | 12½ | 13 | 12½ | 13 | 4 12 4 | ,, ,, | 12 13/16 | .. |
| 15,000 | 10 | 4/9⅗ | Do. 6 per Cent. Cumulative 2nd Pref. (£8 pd) | 10½ | 10¾ | 10 | 10½ | 4 12 1 | ,, ,, | .. | .. |
| 209,750 | 1 | ½% | South of England, Ordinary | ⅛ | ⅜ | ⅛ | ⅜ | .. | — | .. | .. |
| 20,000 | 5 | 2/1 | Do. 6 per Cent. Cumulative Pf. (£3 10s. pd) | 2¾ | 3¼ | 2¾ | 3¼ | 6 9 0 | .. | .. | .. |
| 58,000 | 5 | 1/0 | United River Plate | 3 | 4 | 3 | 4 | .. | January and July .. | 3 7/16 | .. |
| £146,128 | Stock | 5% | Do. 5 per Cent. Debenture Stock | 90 | 95 | 90 | 95 | 5 5 3 | .. | .. | .. |
| £3,200 | 100 | 7% | Do. 7 per Cent. Debentures | .. | | .. | | .. | — | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | | | |
| 200,000 | 5 | .. | London Electric Supply | 1½ | 1¾ | 1½ | 1¾ | .. | — | .. | .. |
| 43,900 | 10 | .. | Metropolitan Electric Supply (£8 paid) | 7½ | 8 | 7½ | 8 | .. | — | 7¾ | 7⅝ |
| 42,853 | 5 | .. | Westminster Electric Supply (£3 paid) | 3½ | 4 | 3½ | 4 | .. | — | .. | .. |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | | | |
| 63,416 | 3 | .. | Brush Electrical Engineering | 2¼ | 2½ | 2⅜ | 2⅝ | .. | .. | 2⅝ | 2¼ |
| 63,416 | 2 | 0/10 | Do. 6 per Cent. Preference | 1½ | 2 | 1½ | 2 | 6 0 0 | June and December | 1⅞ | 1¾ |
| 20,000 | 5 | 3/6 | Crompton and Co., 7 per Cent. Pref. Shares | 5 | 5½ | 5 | 5½ | 6 7 3 | January and July .. | .. | .. |
| 17,139 | 5 | .. | Edison and Swan United | .. | | .. | | .. | .. | .. | .. |
| 45,000 | 10 | 6% | Electric Construction | 6¾ | 7¼ | 6½ | 7 | 8 8 0 | .. | 7 | 6⅝ |
| 70,000 | 2 | 10/0 | Elmore's Patent Copper Depositing | 3¾ | 4¼ | 3¾ | 4¼ | .. | .. | 4¼ | 3⅞ |
| 20,000 | 5 | .. | Fowler-Waring Cables (£4 paid) | 2½ | 3½ | 2½ | 3½ | .. | .. | 3 1/16 | .. |
| 41,600 | 10 | 10/0 | India Rubber, Gutta Percha & Telegraph Works... | 18½ | 19½ | 18½ | 19½ | 5 2 7 | February & August | 19¼ | 19 |
| £200,000 | 100 | 4½% | Do. 4½ per Cent. Debentures, 1896 | 103 | 105 | 103 | 105 | 4 5 9 | March & September | .. | .. |
| 11,334 | £10 | 6/4 | International Okonite Limited Ordinary | 9¼ | 9¾ | 9¼ | 9¾ | 10 4 7 | .. | .. | .. |
| 11,334 | £10 | 5/0 | Do. Preference | 9¼ | 9¾ | 9¼ | 9¾ | 8 4 1 | .. | .. | .. |
| 78,949 | 5 | 4/10⅘ | Swan United (£3. 10s. paid) | 4½ | 5 | 4½ | 5 | 6 19 10 | May and November | 4⅞ | 4 13/16 |
| 37,350 | 12 | 12/0 | Telegraph Construction and Maintenance | 44 | 46 | 46 | 48 | 5 0 0 | March and July | 47½ | .. |
| £150,000 | 100 | 5% | Do. 5 per Cent. Bonds, red. 1894 | 101 | 103 | 102 | 105 | 4 15 3 | January and July . | .. | .. |
| | | | **RAILWAYS.** | | | | | | | | |
| 50,000 | £10 | .. | City and South London Railway | 7 | 8 | 7 | 8 | .. | .. | 6¾ | .. |


IMPROVEMENTS IN DYNAMOS.




STATTER-BRUNTON

DYNAMO.

**The latest design in the market, made with all the advantages of the latest scientific knowledge and the highest mechanical skill.**

The woodcut represents our B TYPE DYNAMO. A most efficient machine, working noiselessly, and without sparking or overheating; is highly finished and well proportioned. The output is so rated in our Catalogue that the machines may be worked very much in excess of their stated full output for short periods.

STOCK SIZES UP TO 77 KILOWATTS.

MACHINES BUILT TO 500 KILOWATTS.

THE ELECTRICAL ENGINEERING CORPORATION, LIMITED,
(STATTER'S) (UNITED.)

68, Victoria Street, London, S.W. WORKS:—ALLIANCE ENGINEERING WORKS, WEST DRAYTON, NEAR LONDON.


Digitized by Google

# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 665.—Vol. XXVI. FRIDAY, FEBRUARY 13, 1891. Price Fourpence.


## NOTES.

The proceedings of the Electrical Standards Committee appointed to advise the Board of Trade, have been kept profoundly secret, but the public are now permitted to have a glimpse at some of the work in hand by the publication of the draft resolutions, which will be found in another column. These resolutions will be submitted to the Committee next Friday, and the fact of their being published may be taken as a sure indication that the members of the Committee are unanimous, except, perhaps, as to the exact value of a Clark cell in volts. The resolutions contain several concessions and compromises which, if they fail to please everybody, must be acknowledged to represent a praiseworthy attempt to execute this difficult task. That the C.G.S. system should be adopted for determining the dimensions was to be expected, and it will be hailed by many persons as a step towards the general use of the metric system. The grounds for such a hope are, however, slender in the present case; for, with the exception of Mr. Sprague's carefully worked out scheme of chemics and equivolts, which referred to grains and feet though not independent of the received units, no one has attempted to construct a system of electrical measurements with the British standards of length and mass.

The adoption of a "mercury ohm" is a concession to our Continental friends, who would never recognise any other mode of definition. But the construction of a material standard of solid metal is a compromise on which the committee is to be congratulated, as practical engineers will have nothing to do with columns of mercury. The seventh resolution seems to have been suggested by the Standards Department of the Board of Trade, for it resembles the provisions made for the replacing of the standard yard should it again be destroyed. It was proposed that it should be replaced by reference to pendulum experiments, but whether from any want of confidence in the state of knowledge, or on account of some departmental principle, it was enacted, as in the present resolution, that copies should be constructed, and that they, rather than fresh absolute determinations, should be used if occasion should arise. In the case of the ohm, however, periodic comparisons must be made, as changes certainly do occur, and as these changes did not appear, at the last British Association meeting, to be thoroughly understood, there is room for argument that the standard, if destroyed, should be redetermined.

If the "mercury ohm" be a mark of respect to the Continent, the "silver ampere" is a tribute to Cambridge, and "the instrument constructed on the principle of a balance" is a compliment to Glasgow; while the C.G.S. system and science generally are thrown to the winds in the final recommendation, eminently practical and thoroughly reliable though it be, of offering the Clark cell as a standard of electrical pressure.

The more we examine the prospectus of "The City of London Electric Lighting (Pioneer) Company (Limited)," the more difficult do we find it to discover its *raison d'être*. The Brush Company and the Laing, Wharton, and Down Company has each an excellent business of its own, and such an undertaking as the lighting of the City might well be transferred to a company formed specially for that purpose. They have made contracts with the Commissioners which "require that the works. . . . shall be commenced by February 19 and February 28, 1891, respectively. It is to comply with this requirement that this Pioneer Company has been formed, the short time at disposal being insufficient to enable the arrangements for the formation of the larger company to be completed." The Royal Assent was given to the Provisional Orders in August for two-thirds of the work, and it has taken more than seven months to make this preliminary step. The contracting companies are debarred from subletting their concessions to any existing metropolitan supply companies; but this pioneer Company, formed under the auspices of the Electric and General Investment Company, which itself is formed to supply ready money to contractors "for the purpose of facilitating the promotion and development of undertakings for electric lighting," &c., is, after all, only formed "with the intention of forming a larger company" which is ultimately to do the work. Neither the pioneer company nor its prospective offspring has any *locus standi*, and are not recognised by any of the several authorities concerned. The Board is eminently fitted for some of the objects of the concern, but pioneering the supply of electricity for public and private purposes is not one of them. Among this multitude of companies there is more scope for the art of the promoter than for the talents of the engineer.

The most ardent advocates of the electro-magnetic theory will be willing to admit that it is not an easy one to trace out correctly in its different aspects; and the discussion on this subject which is at present being carried on in our correspondence columns will serve a useful purpose if it removes some of the vagueness attaching to ordinary notions about the theory,

Digitized by Google

or if it crystallises into more definite form the objections of its opponents. Mr. Sprague calls out for proofs of the existence and properties of the ether, but he makes demands upon Maxwell's theory for many more hypotheses with regard to the medium than are really needed. Careful reading of the different letters which have been written will show that much of the present controversy arises simply from a different use of terms, and it is thus fortunate that Prof. Thompson, in this week's letter, renders the real point at issue clear by distinctly stating his views in tabular form.

Mr. Sprague's contention that we know nothing about the ether will not be seriously objected to, since he admits the power of the ether to transmit light across space by undulatory motion. Maxwell made no hypothesis as to the nature of the ether, and, although many theories have been put forward, Sir William Thomson, to whom the ablest of these are due, confessed, in his Presidential Address in 1889, that after over forty years' consideration of the subject he still must reserve *for a future paper* any explanation of the nature of the etherial mechanism. The experiments of Hertz have not solved the mystery of the ether, but they have shown that electric and magnetic actions take time to travel from the origin of the disturbance. As Mr. Sprague states, undulatory disturbances must produce undulatory actions at a distance, but it does not follow that they will be perfectly "in step" unless the disturbances travel with an infinite velocity. If the velocity is finite, the more distant effects will lag behind the nearer ones, and by considering this lag it has been shown that electric actions are propagated with the speed of light. The medium which transmits such effects must have exactly the same properties as that which transmits light, and, without further assumption, may be regarded as the same.

Mr. Sprague takes uncertain ground when he boldly champions the notion that electric energy is conveyed longitudinally in the direction of the current instead of transversely. It would be impossible experimentally to prove either theory, because the movements of energy cannot at present be traced; but a careful comparison of the two shows that, whereas the latter theory has a scientific basis, the former has nothing but long custom to recommend it. One was arrived at by mathematical reasoning, while the other is a mere arbitrary hypothesis. What kind of proof can Mr. Sprague give of the longitudinal theory which he upholds?

A novel distinction between paramagnetic and diamagnetic bodies has been pointed out by M. P. Joubin in the current number of the *Comptes Rendus*. For those metals which obey Dulong and Petit's law of atomic heat, it is possible to calculate quantities which are proportional to the number of molecules contained in a unit volume, and hence the average distance of the molecules from each other can be compared. When these distances are examined in connection with the corresponding values for the specific resistance, it is found that the metals arrange themselves into two groups, those in one class being paramagnetic, while the remainder are diamagnetic. The two curves which represent the results graphically are found to be such that the number of molecules per unit volume is proportional to the sixth root of the specific resistance for magnetic bodies, and inversely proportional to that quantity for diamagnetic ones. A comparison of the thermo-electric powers of the metals, with the corresponding molecular numbers, yields a similar result, the metals dividing into exactly the same groups, although the shape of the curves is somewhat different, and it is significant that a comparison of the magnetic coefficients, as far as our present knowledge of these quantities renders it possible, leads to the same grouping. While it would no doubt be rash to enter too fully into Prof. Crookes' ideas about the genesis of the elements, it will be admitted that investigations of this nature are not only serviceable in connecting a number of isolated phenomena, but also tend to show the direct dependence of the physical properties of metals on their molecular structure in general, and in particular on the average distance of their molecules from each other.

Our New York correspondent calls attention this week to a result, not altogether satisfactory, which has followed from the extension of electric traction in Boston. While the extreme outlying suburbs of that city have greatly benefited by the increased rapid transit facilities afforded by the electric car, the more central districts are being deserted. Much the same phenomenon, due to much the same cause, has been long taking place in London. The suburban lines are constantly pushing further and further out into the country, with the result that the metropolis grows by accretion rather than by intussuception, to use biological expressions. It will be interesting to see whether the Bostonian property holders will adopt a more effective policy than that of opposition to electric traction, and take the heroic course followed in many instances in London of rebuilding the districts to suit the exigencies of the new situation.

**The "Sirene."**—The construction of a new electrical submarine torpedo boat, the "Sirène," is being actively pushed forward at Toulon.

**A Long Run.**—During the December fogs one of the dynamos of the House-to-House Station is stated to have run uninterruptedly for nearly four weeks (665¾ hours).

**New Peru and Chili Cables.**—The "Silvertown" has been reported from Arica, all well. She completed the cables between Chorillos—Yquique—Valparaiso on February 2nd.

**Berlin Electric Lighting Statistics.**—According to the *Zeitschrift für Elektrotechnik* the present number of 8 candle-power glow lamps installed in Berlin is 100,000, and that of arc lights 3,000.

**Portsmouth.**—The Electric Lighting Committee have decided to recommend the Town Council to take the management of the electric lighting into its own hands instead of leasing the powers obtained to a private company. The low tension system is recommended.

**A Helmholtz Medal.**—An International Committee has been formed to collect the sum necessary for a marble bust to Prof. Helmholtz, and for a Helmholtz medal, to be bestowed on the most eminent German and foreign physicists, in memory of the Professor's seventieth birthday, on August 31st.

**Chelmsford.**—The irregular working of the electric light has led to a complaint being made to Messrs. Crompton by the Town Council, and the sub-committee has been instructed to

Digitized by Google

endeavour to ascertain from Messrs. Crompton the advisability of lighting the town by incandescent lamps of equal power to, and in lieu of, the present arc lamps.

**Aberdeen.**—A sub-committee of the Corporation Gas Committee has instructed the Gas Manager to report on the cost of laying down electric lighting plant within the area sanctioned by the Provisional Order obtained last year, and also to procure from three of the best electrical engineers in London estimates of the cost at which they would be willing to supply the light.

**"Electric Light Installations and the Management of Accumulators."**—It has been pointed out to us, in connection with our review of this work, which appeared on page 426 of our last issue, that the chemical symbols expressing the reaction that takes place in an accumulator during charging, referred to by our reviewers, were not cast in the form of an equation, and that the context shows that they were merely intended to explain in a briefer way than words could do the author's idea of what goes on.

**The Registration of Trade Marks in Japan.**—The British and Foreign Patents and Trade Marks Society have called the attention of the Foreign Office to the fact that the excellent regulations in force in Japan since July 1, 1889, cannot be made use of by British subjects for the protection of their interests. In reply the Foreign Office state that the hardship involved by this law will not be lost sight of in future negotiations for treaty revision.

**A "Lost Child" Telephone Service.**—In Indianapolis as soon as a child is lost the information is telephoned to the central station. When a lost child is found this also is telephoned. The finding is then telephoned to the number that reported the losing. In some cases the child has been restored in twenty minutes after the loss was reported. The service costs the telephone company comparatively nothing, and no charge for finding lost children is made to parents or friends. This service has made many friends for the telephone company.

**Electric Traction in Boston.**—The West End Street Railway Company have awarded the contract for the large generators for the new power house to the Thomson-Houston Electric Company. The order at present is for 17 of these generators, but 34 will be required in all. Each generator is to be capable of giving out 360,000 watts, at a maximum pressure of 600 volts, that is to say, the total available E.H.P. will amount to over 8,000. The generators will be of the multipolar type, with Gramme armatures, compound-wound, and about 31 tons in weight.

**Personal.**—Mr. R. T. Glazebrook, of Trinity College, has been appointed assistant-director of the Cavendish Laboratory.——Prof. J. A. Ewing, Professor of Mechanism at Cambridge, has been made Master of Arts, *honoris causâ*.——Mr. H. E. Hunt has been appointed managing electrical engineer to the Taunton Electric Light Company from February 1st, in the place of Mr. O. V. Thomas. Mr. Hunt was formerly in the employ of the Taunton Company for a period of three years, and left about twelve months since to fill an important position at the Bath Electric Light Works.

**A Novel Use for the Electric Heater.**—The Burton electric heater has recently been put to a novel use in the Government bureau of printing and engraving in Washington, D.C. The plates from which bank notes are printed have first to be warmed, when the ink is rubbed into the cuts after the manner of printing visiting cards. The ink is then cleaned off the face of the plate while hot and the impression taken. Hitherto gas stoves have been used for the purpose of warming these plates, but objections to these are many and obvious, and electric heaters have been fitted instead.

**The High-pressure Transmission of Power Experiments at the Oerlikon Works.**—The experiments with high-pressure currents, referred to on page 386 of our issue of January 30, consisted in the transformation of a 100 volt current by means of the Oerlikon Company's "oil transformer" to a pressure of 33,000 volts. The current at the latter pressure traversed a conductor 7km. in length, and was then converted back to 100 volts, and used to run glow lamps. The result is stated to be that the practicability of transmitting power from Lauffen to the Frankfort Exhibition has been demonstrated.

**Vulcanite.**—The mean of twelve determinations of the coefficient of linear expansion of vulcanite, by Mr. A. M. Mayer—*American Journal of Science*—obtained by means of a specially devised piece of apparatus, gave the value 0·0000636, between the temperature at which the experiments were made, viz., 0deg. and 18deg. C. The cubical expansion of the substance is closely represented by the formula $v_t = v_0 + 0{\cdot}000182\,t + 0{\cdot}00000025t^2$. The specific heat equals 0·33125. The angle of maximum polarisation of a polished surface of vulcanite was found to be 57° 29′. Hence the index of refraction equals 1·568.

**Newcastle.**—At a recent meeting the Town Council considered the application of the Newcastle and District Electric Lighting Company for a Provisional Order. It was ultimately resolved to give consent to the application upon the lines recommended by the Town Improvement Committee, which are that the Corporation should have the option of purchase at the end of 31 years, that the maximum rate of dividend should be 8 per cent., cumulative, and all profits above such dividend should be equally divided between the consumers and the shareholders. These terms have been agreed to by the Company.

**The Measurement of Large Currents.**—For the accurate measurement of large currents, such as are obtained from accumulators (a point on which technical literature does not afford much information), F. Himstedt makes use of a tangent galvanometer, with two consecutive copper rings, each 1cm. broad and ·4cm thick, of radii 23·276 and 27·422 cm. respectively. These rings are connected in opposition, so that the needle is acted upon by a differential couple. The advantages of this method are that the measuring apparatus is inserted in the actual circuit, that only a single observation is required, and that no resistance measurements are necessary.

**Bath.**—At a recent meeting of the Surveying Committee, a deputation appeared before the Committee on behalf of the residents in the middle of Gay-street, asking that some improved mode of distributing the electric light at present given should be adopted. Under the present state of things their doorways were in complete darkness. Mr. Sturges said this matter had been under the consideration of the Lighting Committee, but until the report of Prof. Forbes had been received upon the installation they had not thought it well to make any alterations. They would, however, deal with the matter as early as they possibly could.

**The Patent Office.**—Mr. Leng asked the Chancellor of the Exchequer on Monday evening whether he would consider the propriety of applying the surplus of £93,534, received by the Patent Office in excess of its expenditure, to a large reduction of the present heavy renewal fees. In reply, the Chancellor of the Exchequer stated that there was much to be said in favour of the present scale; it operated in the later years to cause useless and unsuccessful patents to fall out. Some people believed that this was an advantage, and not a disadvantage, to British trade. Sanction had been given to a large expenditure for building a new Patent Office, and providing additional facilities to the public.

**The South Kensington Subway Bill.**—On the motion for the second reading of the South Kensington and Paddington Subway Bill in the House of Commons yesterday Mr. Baumann protested against the conduct of the promoters of the Bill, who, he said, would not adjourn the second reading in order to give him an opportunity of ascertaining the feelings of the 60 metropolitan members on the subject. The beauty of Kensington Gardens was imperilled because a tunnel was to be made under, and a station erected in the middle of the gardens, simply to put money in the tills at the Albert Hall. Obviously, this was a question which should not be settled in haste. Mr. Whitmore supported the second reading, and remarked that in no way would the gardens be interfered with. Mr. Courtney thought it right to say that the promoters had done nothing unusual. The second reading was then agreed to.

Digitized by Google

**The Science Collections at South Kensington.** — In the House of Commons on Friday last Sir H. Roscoe asked the First Commissioner of Works what steps had been taken to carry out the undertaking given by him on April 1, 1890, with regard to the housing of the science collections at South Kensington. Mr. Plunket stated in reply that it had been decided to proceed at once with the completion of the buildings on the east side of the Exhibition-road. These would ultimately be devoted wholly to art collections, although for some years it was probable that some portions of them might be temporarily available for science collections. He was now in communication with the Science and Art Department as to the best means of providing for scientific requirements, and he hoped soon to submit a proposal to the Treasury. The buildings on the east side of Exhibition-road would cost some £300,000 or £400,000.

**City and South London Railway.**—Last week a stoppage occurred on the City and South London Railway which, says the *Engineer*, was the cause of considerable annoyance as it was at a rather busy part of the day. Those connected with the line had, however, the most cause for feeling the annoyance, the cause of the stoppage being of such a very simple and easily remediable kind. There is a lock-nut on the armature spindle of the motors, between the armature and the brass bearing at one end. This nut, like a good many other lock-nuts, unlocked itself, and turned back until it touched the brass bearing. When this occurred the direction of rotation of the armature spindle soon caused the nut to lock hard against the brass, and ultimately to fix the spindle absolutely. The cause was not ascertained until the engine had been hauled away, with the drivers fixed, by another engine. It might have been put right in five minutes, if the real cause had been guessed, but it was too simple a cause to be guessed very readily. It was simply a bit of electro mechanics without the least bit of mystery.

**The Electrical Bills of the Session.**—On Saturday the report of the Board of Trade upon the railway, canal, tramway, gas, electric lighting, and water Bills of the Session 1890-91 was issued. It shows that the total number of Bills relating to such undertakings deposited during the Session number 148, against 173 in the Session of 1890; the total amount of money proposed to be raised is £58,132,590, against £40,106,611, an increase of £18,025,979. Thirteen Bills relate to tramways, and propose the construction of 24 miles of tramway, and the raising sums of money amounting in the aggregate to £500,000. As compared with 1890, the number of Bills shows a decrease of six, and the capital proposed a decrease of £153,250. Of the 38 gas, electric lighting, and water Bills one only relates to gas and electric lighting. The number of applications made to the Board of Trade for Provisional Orders relating to tramways and the supply of gas and water and electric lighting amounts to 91. Of the 14 relating to gas and water, the proposed capital is £259,250, of the seven tramways £120,632, and of the 70 electric lighting orders £2,125,000.

**The Curtis Conduit System.**—The growing dislike in the States to the overhead system of traction, and the continued opposition of the telephone companies to earth returns, have resulted in the bringing out of numerous complete metallic circuit conduit systems, the majority of which have so far been remarkable neither for novelty nor practicality. One of the latest systems is that due to a Mr. H. N. Curtis, of New York. The conduit in this case is built up of sheet iron. The slots are closed by iron angle bars, upon which are fastened rubber strips, which almost entirely cover the top of the metal bar, leaving a small portion only uncovered for the purpose of making metallic contact with the trolley wheel, and which effectually seal the conduit, and prevent the entrance of water and dirt. These bars are made in lengths of three or four feet, and joined together flexibly so that they form a continuous length which can be depressed. As the car travels along, the trolley wheels depress the bars and bring them in contact with the conductors in the slot; as soon as the pressure of the trolley wheel is removed, the flexible contact strip returns to its normal position by the pressure of springs. A rotary brush attached to the car in advance of the trolley wheel clears the contact strip of all foreign material.

**The Henry Electric Motor Truck.**—The *Electrical World*, in a recent issue, describes a new style of motor and tram-car truck designed by Mr. J. C. Henry. In this motor and truck all spring supports are avoided. Only one motor is employed, and only one pair of wheels is driven by the gearing, the other being operated by a connecting rod. The motor, which has a Gramme ring armature, is rigidly fastened to the steel frame that connects the axles, its ends having bearings on 3in. steel axes, parallel with the axles of the wheels. The gearing consists in the well-known epicyclic arrangement, capable of running freely when the epicyclic pinion is free to move, and exerting its full power when the pinion is held fast as it can be by the clutch lever. The armature therefore can run all the time, or be allowed to give its full speed before any of the load is thrown on; as soon as the clutch is tightened the clutch can take hold and utilise its momentum in starting the car, thereby avoiding a sudden rush of current. The epicyclic gear is enclosed in a dust-tight case and runs in oil, so that the noise is diminished. The armature is only geared down once, the reduction being seven to one. A slight modification will allow the armature to be connected directly with the internal gear after the car is under way, thus allowing very high speeds. The motor, which is of 30 horse-power weighs a little over one ton.

**Elihu Thomson Lightning Arrester.**—Where a number of breaks are made in a circuit or a number of discharge spaces have to be successively traversed by a discharge, the total distance represented by the sum of the breaks, can be made much greater than the striking distance of the discharge between two plates where a single break only exists. Advantage has been taken of this by Prof. Elihu Thomson in the construction of a lightning arrester. This device consists of a pile of circular metallic plates separated by insulating washers, each washer projecting a little beyond the metallic plates. Each metallic disc is provided with a narrow projecting strip which carries a discharge terminal, such as a ball, which lies within a small distance of the succeeding ball of the series. At one end of the series is a connection to the line, and at the other a connection to the earth. The effect of arranging the plates in this way is to give each one a certain static capacity and permit the discharge points to be adjusted at any desired distance apart by simply swinging the plates around circularly so as to arrange the discharging points in a spiral fashion around the column of plates. The sum total of the spaces that must be jumped by the discharge is largely in excess of the striking distance of an ordinary lightning arrester, or several times the largest possible space which could be used with safety to protect a dynamo against injury from discharges.

**Obituary.**—The death of Mr. Robert Forester Mushet, the well-known metallurgist, took place on the 3rd inst. Mr. Mushet devoted the greater part of his life to the improvement of the manufacture of crucible steel at his small experimental works at Coleford, in the Forest of Dean. Among the many notable developments originated there was the production of specially hard steel by the addition of tungsten and other metallic elements to the iron in the crucible, which resulted in the production of the well-known "special tool steel," which has proved of immense value in the engineer's workshop. These results, were, however, overshadowed by his application of spiegeleisen to the Bessemer process. It is sad to think, says the *Engineer*, that the discoverer lost the fruits of his labour through the trustees of his patent omitting to pay the fees due in the third year. The value of the discovery was, however, fittingly acknowledged by the award of the Bessemer Gold Medal of the Iron and Steel Institute in 1876, and in a more substantial manner by Sir Henry Bessemer.——We regret to announce the death at Madrid, on the 2nd instant, of Senor Angel Mansi, who was until recently Director-General of the Spanish Posts and Telegraphs, and represented Spain as Chief Delegate at the Paris Telegraph Conference, where his amiable and courteous manner was much appreciated by all the Delegates.

**International Niagara Commission.**—The Cataract Construction Company, having invited various firms to send in projects for the utilisation of about 125,000 horse-power at Niagara, and its distribution, partly to an industrial district in the neighbourhood of the Falls, and partly to the town

Digitized by Google

of Buffalo, appointed an International Commission to adjudicate on the plans sent in. This Commission consisted of Sir William Thomson, F.R.S., President; Dr. Coleman Sellers, Prof. E. Mascart, and Colonel Th. Turrettini. After a careful examination of a large number of projects sent in, in accordance with the letter of invitation of the Cataract Company, the Commission have awarded the following prizes:— Projects combining the Development of Power and its Distribution: 1st prize not awarded; 2nd prize, MM. Faesch and Piccard (Geneva) and MM. Cuenod, Sautter and Co. (Geneva); 3rd prizes (four), M. A. Hillairet and M. Bouvier (Paris), M. Victor Popp and Prof. Riedler (Berlin), Prof. L. Vigreux and M. L. Levy, the Pelton Water Wheel Company, San Francisco, California, and Norwalk Iron Works Company, S. Norwalk, Connecticut. Projects for the Hydraulic Development of the Power: 1st prize, MM. Escher Wyss and Co. (Zurich); 2nd prizes (two), Ganz and Co. (Budapest), Prof. A. Lupton (Leeds) and Mr. J. Sturgeon. Projects for the Distribution of the Power: No prize awarded.

**The Use of Electric Motors in War Ships.**—Although England may claim to rank foremost in the application of the electric light to her war-ships, and the fittings for firing guns by electricity have been in use for many years, it would appear, says the *United Service Gazette*, that we are, for the present at any rate, rather behind some foreign Powers in the utilisation of the electric current as a motive power. Whilst our prominent naval architects have been thinking about it the French Admiralty have, in one of their new ironclads, abandoned hydraulic power in favour of electricity for moving the turrets, working the guns and ammunition hoists. The same idea has been approved by the Chilian Government, and applied to three of their large war-ships. The Americans are also using electric motors in some of their new ships for training the guns; and it may be interesting to note here that the "Baltimore" is probably the first war-vessel in which a telephone service has been established so as to enable the commander to communicate from the conning tower with the various parts of the ship. A still wider field of action is open to the use of electrical energy in substitution for the large number of auxiliary engines, both steam and hydraulic, now existing on board a large man-of-war. They are to be found scattered all over the ship, involving a labyrinth of steam, exhaust, circulating, and drain pipes, complex in arrangement, and requiring constant care and attention to keep in order. Joints and valves leak, steam condenses, and water freezes, as in the "Camperdown" lately, totally disabling some part of the mechanism. Repairs with only the ship's resources are difficult. The complicated system of steam circulation would also be extremely dangerous to the crew when the vessel was in action. It has been truly said that "almost fabulous expense is one of the characteristics of modern warfare." But we do not think, if the experiment were tried of extending the electric plant now fitted to our men-of-war by substituting electric motors for the present hydraulic and steam auxiliary engines, that there would be any grounds to find fault either with their safety, utility, or economy.

**Ferranti Alternators.**—The following list of some of the supply stations equipped with Ferranti plant may be of interest. Deptford Station: the capacity of the plant now erected at Deptford is 90,000 lamps, and this capacity is being increased by the building of two 200,000 light machines. Rochester: small station capacity of 3,000 lamps. Glasgow: two alternators, capacity of 6,000 lamps. La Plata: three alternators, capacity of 9,000 lamps. Rosario: two alternators, capacity of 6,000 lamps. Barcelona: two alternators, capacity of 6,000 lamps. Municipal Station, Paris: three alternators, capacity of 9,000 lamps. Plaza de Toros, Paris: one alternator, capacity of 3,000 lamps. Nancy: three alternators, capacity of 9,000 lamps. Havre: two alternators, capacity of 12,000 lamps. Melun: two alternators, capacity of 6,000 lamps. Troyes: two alternators, capacity of 6,000 lamps. Nimes: two alternators, capacity of 6,000 lamps. Dijon: one alternator, capacity of 3,000 lamps. Sens: one alternator, capacity of 3,000 lamps. St. Ceré: one alternator, capacity of 600 lamps.

**Dublin.**—Our Dublin correspondent informs us that the Corporation have accepted the tenders of the Electrical Engineering Company of Ireland and of the Irish House-to-House Electricity Company. The facts of the case are, we believe, somewhat as follows:—The Irish House-to-House Electricity Company tendered upon the specification published by the Dublin Corporation and submitted their own plans, which have not been altered in one single detail. The Electric Lighting Committee of the Corporation, however, reported to that body that on the whole they considered the contract should be given to the Electrical Engineering Company of Ireland, but there was a strong minority in favour of the contract being given to the Irish House-to-House Company, in order to secure a station upon the lines of that at West Brompton. With a view of meeting both parties in the Corporation, the two companies, viz., the Electrical Engineering Company of Ireland, and the Irish House-to-House Company, settled terms of amalgamation, and the Committee of the whole house of the Dublin Corporation on Wednesday afternoon decided to give the contract to the Electrical Engineering Company of Ireland on the assurance that they would have the assistance of the Irish House-to-House Company in carrying the contract out. This resolution was confirmed by the whole of the Council at a subsequent sitting on Wednesday evening. The resolution was to the effect that the Committee were empowered to close the contract with the Electrical Engineering Company of Ireland, with such modifications as they might deem fit, and it appears probable that the incandescent lighting portion of the contract will be carried out in accordance with the plans submitted by the Irish House-to-House Company, and the arc lighting plant in accordance with the plans submitted by the Electrical Engineering Company of Ireland.

**The Action of the Silent Discharge on Chlorine.**—Arguing from the fact that oxygen gas, when subjected to the silent discharge, partially undergoes condensation into ozone, it seemed possible, says Mr. H. M. Vernon, in the *Chemical News*, that other elementary gases, as chlorine and bromine vapour, might undergo an analogous change when subjected to the same treatment. A glass tube, with a U-shaped index of fine-bore glass tubing, was filled with purified and dried chlorine. After passing a current of the gas through the tube for some time, the end was sealed in the blowpipe flame. The tube was then warmed slightly, and a few bubbles of gas thus driven out. The end of the index tube dipped under strong sulphuric acid saturated with chlorine gas, so that, on cooling, a short column of the acid was drawn up. This served as an index for any changes of volume which might take place in the chlorine in the tube. A silent discharge of electricity was then passed. The volume of the gas was observed to increase slightly, but afterwards it remained quite constant even after the discharge had been passed for several hours. We may therefore conclude that no allotropic change takes place when chlorine gas is subjected to the silent discharge of electricity, the initial increase of volume being merely due to the heating effect the discharge has upon the gas. Into another similar tube, filled with chlorine, was introduced a small quantity of liquid bromine. The tube thus contained chlorine saturated with bromine vapour. The silent discharge on being passed through this tube did not produce any different effect than for chlorine alone, so we may conclude that bromine vapour also does not undergo any allotropic condensation when subjected to the influence of a silent discharge of electricity. The fact that oxygen gas is capable of undergoing condensation while chlorine and bromine are not is easily explained. The oxygen atom, being divalent, is capable of uniting itself to two other atoms of oxygen or other elements, and thus with oxygen forming ozone. The atoms of chlorine and bromine, however, being only mono valent, have all their affinity satisfied when they are united to a single other atom of chlorine and bromine. It is not possible, therefore, that condensation can take place if the atoms remain monovalent. Hydrogen gas and iodine vapour are in a similar manner debarred from undergoing condensation. Mr. Vernon, therefore, comes to the conclusion that it is most improbable that any other element but oxygen will be found capable of undergoing molecular condensation when in the gaseous state and subjected to the silent discharge.

Digitized by Google

## ELECTROMAGNETIC THEORY.—IV.

BY OLIVER HEAVISIDE.

*(Continued from page 389.)*

§ 20. Our primary knowledge of electricity, in its quantitative aspect, is founded upon the observation of the mechanical forces experienced by an electrically charged body, by a magnetised body, and by a body supporting electric current. In the study of these mechanical forces we are led to the more abstract ideas of electric force and magnetic force, apart from electrification, or magnetisation, or electric current, to work upon and produce visible effects. The conception of fields of force naturally follows, with the mapping out of space by means of lines or tubes of force definitely distributed. A further and very important step is the recognition that the two vectors, electric force and magnetic force, represent, or are capable of measuring, the actual physical state of the medium concerned, from the electromagnetic point of view, when taken in conjunction with other quantities experimentally recognisable as properties of matter, showing that different substances are affected to different extents by the same intensity of electric or magnetic force. Electric force is then to be conceived as producing or being invariably associated with a flux, the electric displacement; and similarly magnetic force as producing a second flux, the magnetic induction.

If **E** be the electric force at any point and **D** the displacement, we have

$$\mathbf{D}=c\mathbf{E} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

and similarly, if **H** be the magnetic force and **B** the induction, then

$$\mathbf{B}=\mu\mathbf{H} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Here the ratios $c$ and $\mu$ represent physical properties of the medium. The one ($\mu$), which indicates capacity for supporting magnetic induction, is its inductivity; whilst the other, indicating the capacity for permitting electric displacement, is its permittivity (or permittancy). Otherwise, we may write

$$\mathbf{E}=c^{-1}\mathbf{D} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

$$\mathbf{H}=\mu^{-1}\mathbf{B} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

and now the ratio $c^{-1}$ is the elastivity and $\mu^{-1}$ the reluctivity (or reluctancy). Sometimes one way is preferable, sometimes the other.

§ 21. Al space must be conceived to be filled with a medium which can support displacement and induction. In the former aspect only it is a dielectric It is, however, equally necessary to consider the magnetic side of the matter, and we may, without coining a new word, generally understand by a dielectric a medium which supports both the fluxes mentioned.

Away from matter (in the ordinary sense) the medium concerned is the ether, and $\mu$ and $c$ are absolute constants. The presence of matter, to a first approximation, merely alters the value of these constants. The permittivity is always increased, so far as is known. On the other hand, the inductivity may be either increased or reduced, there being a very small increase or decrease in most substances, but a very large increase in a few, the so-called magnetic metals. The range within which the proportionality of flux to force obtains is then a limited one, which, however, contains some important practical applications.

When the fluxes vary, their rates of increase $\dot{\mathbf{B}}$ and $\dot{\mathbf{D}}$ are the velocities corresponding to the forces **E** and **H**, provided no other effects are produced. The activity of **E** is $\mathbf{E}\dot{\mathbf{D}}$, and that of **H** is $\mathbf{H}\dot{\mathbf{B}}$. The work spent in producing the fluxes (not counting what may be done simultaneously in other ways) is, therefore—

$$\mathrm{U} = \int_0^{\mathrm{D}} \mathbf{E}\, d\mathrm{D}, \qquad \mathrm{T} = \int_0^{\mathrm{B}} \mathrm{H}\, d\mathrm{B}, \quad . \quad . \quad . \quad (5)$$

where U is the electric and T the magnetic energy per unit volume.

When $\mu$ and $c$ are constants, these give

$$\mathrm{U} = \tfrac{1}{2}\mathrm{ED} = \tfrac{1}{2}c\mathrm{E}^2 \quad . \quad . \quad . \quad . \quad . \quad (6)$$

$$\mathrm{T} = \tfrac{1}{2}\mathrm{HB} = \tfrac{1}{2}\mu\mathrm{H}^2 \quad . \quad . \quad . \quad . \quad . \quad (7)$$

to express the energy stored in the medium, electric and magnetic respectively.

When $\mu$ and $c$ are not constants, the previous expressions (5) will give definite values to the energy provided there be a definite relation between a force and a flux. If, however, there be no definite relation (which means that other circumstances than the value of the force control the value of the flux), the energy stored will not be strictly expressible in terms simply of the force and the flux, and there will be usually a waste of energy in a cyclical process, as in the case of iron, so closely studied by Ewing. This does not come within the scope of a precise mathematical theory, which must of necessity be a sort of skeleton framework, with which complex details have to be separately adjusted in the most feasible manner that presents itself.

§ 22. But a precise theory nevertheless admits of considerable extension from the above with $\mu$ and $c$ regarded as scalar constants. All bodies are strained more or less, and are thereby usually made eolotropic, even if they be not naturally eolotropic. The force and the flux are not then usually concurrent, or identical in direction. But at any point in an eolotropic substance there are always (if force and flux be proportional) three mutually perpendicular axes of concurrence—the principal axes—when we have (referring to displacement)

$$\mathrm{D}_1=c_1\mathrm{E}_1, \qquad \mathrm{D}_2=c_2\mathrm{E}_2, \qquad \mathrm{D}_3=c_3\mathrm{E}_3,$$

if the $c$'s are the principal permittivities, the E's the corresponding effective components of the electric force, and the D's those of the displacement. If **E** be parallel to a principal axis, so is **D**. In general, by compounding the force components, we obtain **E** the actual force, and by compounding the flux components obtain **D** the displacement to correspond, which can only concur with **E** in the above-mentioned special cases if the principal permittivities be all different. But should a pair be equal, then **E** and **D** concur in the plane containing the equal permittivities, for the permittivity is the same for any axis in this plane.

The energy stored is still half the scalar product of the force and the flux, or $\tfrac{1}{2}\mathrm{ED}$, understanding that the scalar product of two vectors, which is the product of their tensors (or magnitudes) when they concur, is the same multiplied by the cosine of their included angle in the general case.

Vector analysis is, I think, most profitably studied in the concrete application to physical questions, for which, indeed, it is specially adapted. Nevertheless, it will be convenient, a little later, to give a short account of the very elements of the subject, in order not to have to too frequently interrupt our electromagnetic arguments by mathematical explanations. In the meantime, consider the dielectric medium further.

§ 23. The two quantities $c$ and $\mu$ are to be regarded as known data, given over all space, usually absolute constants; but when the simpler properties of the ether are complicated by the presence of matter, then varying in value from place to place in isotropic but heterogenous substances; or, in case of eolotropy, the three principal values must be given, as well as the direction of their axes, for every point considered. Keeping to the case of isotropy, the *ratios* $c/c_0$ and $\mu/\mu_0$ of the permittivity and inductivity of a body to that of the standard ether are the specific inductive capacities, electric and magnetic respectively: and are mere numerics, of course. They do not express physical properties themselves except in the limited sense of telling us how many times as great something is in one case than in another. This is an important point. It is like the difference between density and specific gravity. It is possible to so choose the electric and magnetic units that $\mu=1$, $c=1$ in ether: then $\mu$ and $c$ in all bodies are mere numerics. But although this system (used by Hertz) has some evident recommendations, I do not think its adoption is desirable, at least at present. I do not see how it is possible for any medium to have less than two physical properties effective in the propagation of waves. If this be admitted, I think it may also be admitted to be desirable to explicitly admit their existence and symbolise them (not as mere numerics, but as physical magnitudes in a wider sense), although their precise interpretation may long remain unknown.

Digitized by Google

If, for example, **H** be imagined to be the velocity of a substance, then $\frac{1}{2}\mu H^2$ is its kinetic energy, and $\mu$ its density. And if **E** be a torque, then $c^{-1}$ (the elastivity) is the corresponding coefficient of elasticity, the rigidity, or *quasi*-rigidity, as the case may be; whilst $c$ is the coefficient of compliance, or the compliancy; and $\frac{1}{2}cE^2$ is the stored energy of the strain.

§ 24. Besides influencing the values of the ether constants as above described, we have also to admit that in certain kinds of matter, when under the influence of electric force, energy is dissipated *continuously*, besides being stored. These are called electrical conductors. When the conduction is of the simplest (metallic) type, the waste of energy takes place at a rate proportional to the square of the electric force. Thus, if $Q_1$ be the Joulean waste,

$$Q_1 = k\mathbf{E}^2 = \mathbf{EC}, \qquad (8)$$

if

$$\mathbf{C} = k\mathbf{E} \qquad (9)$$

This new flux **C** is the conduction current, and $k$ is the conductivity (electric). Its reciprocal is the resistivity.

The termination-ivity is used in connection with specific properties. It does not always sound well at first, but that wears off. Sometimes the termination ancy does as well.

The conductivity $k$ is constant (at one temperature), or is a linear operator, as in the previous cases with respect to $\mu$ and $c$. The dissipation of energy does not imply its destruction, but simply its rejection or waste, so far as the special electromagnetic affairs we are concerned with. The conductor is heated, and the heat is radiated or conducted away. This is also (most probably) an electromagnetic process, but of a different order. Only in so far as the effect of the heat alters the conductivity, &c., or, by differences of temperature, causes thermo-electric force, are we concerned with energy wasted according to Joule's law.

The activity of the electric force, when there is waste, as well as storage, is

$$\mathbf{E}(\mathbf{C} + \dot{\mathbf{D}}) = Q_1 + \dot{U} \quad . \quad . \quad . \quad . \quad . \qquad (10)$$

The sum $\mathbf{C} + \dot{\mathbf{D}}$ is the electric current, when the medium is at rest. When it is in motion, a further term has sometimes to be added, viz., the convection current.

§ 25. If a substance were found which could not support magnetic force without a continuous dissipation of energy, such a substance would (by analogy) be a magnetic conductor. Let, for instance,

$$\mathbf{K} = g\mathbf{H} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (11)$$

then **K** is the density of the magnetic conduction current, and the rate of waste of energy is

$$Q_2 = \mathbf{HK} = g\mathbf{H}^2 \quad . \quad . \quad . \quad . \quad . \qquad (12)$$

The activity of the magnetic force is now

$$\mathbf{H}(\mathbf{K} + \dot{\mathbf{B}}) = Q_2 + \dot{T} \quad . \quad . \quad . \quad . \quad . \qquad (13)$$

Compare this equation with (10). The magnetic current is $\mathbf{K} + \dot{\mathbf{B}}$.

As there is (I believe) no evidence that the property symbolised by $g$ has any existence, it is needless to invent a special name for it or its reciprocal, but to simply call $g$ the magnetic conductivity. The idea of a magnetic current is a very useful one, nevertheless. The magnetic current $\dot{\mathbf{B}}$ is of course real; it is the part **K** that is speculative. It plays an important part in the theory of the transmission of waves in conductors.

(*To be continued.*)

**Terrestrial Magnetism.**—M. Moureaux, of the Parc St. Maur Observatory, states that at 4 a.m., on January 15th, a violent shock of earthquake occurred on the coast of Algeria, and that at 4:15 a.m. on that day the magnetographic curve at the observatory was much disturbed. The amplitude of the oscillation did not exceed 1′·5. The bifilar and the balance instruments do not appear to have been affected like the declination needle.

## A NEW PRINCIPLE IN ELECTRO-METALLURGY.

No physical principle is new; all are co-existent with the matter and force of whose inter-relations they are the expression, but it is a defensible convention to use the term "new" when one of those relations is consciously recognised as distinct and coherent. As often happens, this particular principle with which we are concerned has been long in practice before its separate existence was suspected, but signs are not wanting that it will shortly receive—nay, is actually now receiving—the earnest study that will lead to speedy and wide application. Stated in the baldest form, it consists in the unique capability of electricity of furnishing a highly localised source of energy. Every arc lamp in existence is an instance of this capability; every eudiometer fitted with a pair of fused-in platinum wires used by the chemist in ordinary gas analysis is a practical application of the same fact. It may claim rank only second to the most striking of all the properties of electricity—that power of passing from the condition of low-pressure energy to high-pressure energy, which is precisely equivalent to the transformation of low-temperature heat to high-temperature heat, were that practicable, as at present it is not. Of utility almost equal to the *transformability* of electrical energy we may reckon its *compactness*.

An illustration of an extremely simple adaptation of the means thus provided to an industrial end is afforded by a recent German patent for a process and apparatus for superheating metals already fused. A glance at the accompanying figure (Fig. 1), which represents a longitudinal section of

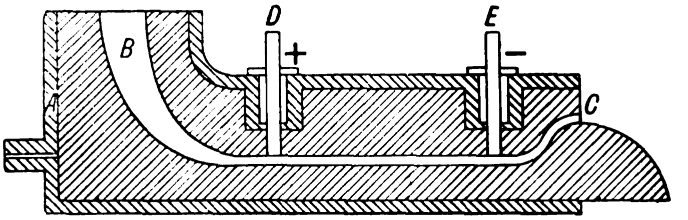



Fig. 1.—Apparatus for Superheating Molten Metal.

the apparatus, will show the plan adopted. A cast-iron box A, capable of being divided into two parts, is packed full of any suitable refractory material, such as sand, fireclay, or magnesia, and a channel B formed therein, funnel-shaped at the top, becoming parallel-sided when it has reached a horizontal position and taking an upward curve at C before the end of the box is reached. Two electrodes D and E pass through stuffing boxes packed with asbestos or some similar material at once capable of withstanding heat and of acting as an insulator. The metal to be superheated flows in at B, passes along the horizontal channel, serves as a conductor between D and E, and has its temperature raised thereby, and escapes at C. Consider the simplicity of such a method compared with any more usual mode of heating. With a common furnace fuel would have to be burnt in a refractory chamber surrounding the vessel containing the liquid to be superheated. If a continuous flow were required this vessel would take the form of a tube, through whose walls every unit of heat imparted to the liquid would have to be transmitted, while the surface from which radiation could take place would not be that of the tube itself but of the necessarily larger chamber surrounding it.

It is thus self-evident that where heat has to be applied to the interior of a vessel it is vastly more economical of energy to introduce it in the form of an electric current, convertible into heat on the spot where the heating is to be done, than to produce heat on the exterior of the vessel and transmit it through its walls. Whether it is more economical commercially is another matter. As long as the energy furnished by an electric current has to be derived from the combustion of fuel through the intermediaries—a boiler, engine, and dynamo—it must needs compete at a great disadvantage with the energy resulting from the direct combustion of the same fuel. But another factor here steps in which may turn the scale. Few materials can withstand the transmission of large quantities of heat at a high temperature, and the most refractory fireclay

soon fails when thus employed, the expense of renewal being considerable, and, in fact, the cause of failure of many important industrial enterprises. Nevertheless, it is not to be supposed that it would necessarily be commercially profitable to distil coal in a gas retort which was heated internally by the passage of a current instead of being fired externally in the usual way, though cheaper methods of producing electricity may yet make it so. Strange if the profitable manufacture of gas should come to depend on the aid of its hated rival!

But when we turn to the production of more costly commodities the case is altogether different. For the reduction of aluminium from its oxide it was tolerably certain that an extremely high temperature was necessary to give even a chance of success. When the Cowles' process was devised it first became practicable to attain such a temperature. By the happy device of conveying the energy to the centre of the charge before it became actual heat the problem was solved. The arrangement necessary for this was of the simplest description; as shown in Fig. 2, it simply consisted of two carbon electrodes A A′ passing through boxes B B′ filled with copper shot, and serving to maintain a sliding contact with them, into a rectangular box C, of firebrick, lined with refractory material (limed charcoal) so as to form a central cavity D for the charge. By this device loss by radiation is reduced to a minimum, the arc forming in the very heart of the charge, which can be surrounded by non-conducting material to any desired extent. The high price of aluminium alloys—for the Cowles' process is better adapted for their production than that of the pure metal—made it only of secondary importance that a costly transformation of heat into electricity had first to be performed; the advantage of being able to produce an enormously high temperature at the very spot where it was wanted outweighed all other considerations.

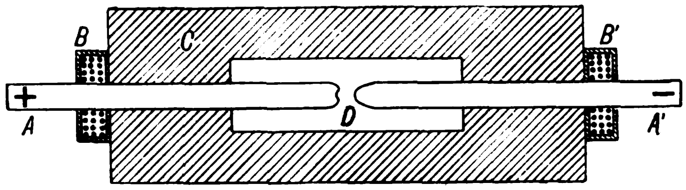



FIG. 2.—Arrangement of Electric Furnace in Cowles' Process.

It is most instructive to observe in how many different and independent minds the central idea of which we are endeavouring to give an exposition is working, or has worked, with fruitful issue. Appreciation of its value is not confined to the technologist. It has been applied to purely scientific purposes. Hempel, in a recent number of the *Berichte* of the German Chemical Society, has made use of it in the following way:—Being confronted with the fact that iron begins to soften at a dull red heat, thereby preventing its use for vessels for heating under pressure if the heat be applied to the exterior of the vessel, he succeeds in utilising that material for such purposes by conveying a current of electricity to the interior of the experimental vessel, and there converting it into sensible heat. A convenient arrangement of the kind is shown in section in the accompanying figure (Fig. 3).

A steel vessel A bored from the solid is fitted with a cover B screwing closely into it. A screw-down valve C provides means of communication with the interior. In the cavity of the vessel thus made is a porcelain tube D containing the substance whose behaviour under the combined influences of heat and pressure is to be studied. It rests on a cylinder of carbon E, which makes a sliding fit with the steel vessel in which it is. The upper end of the porcelain tube is closed by a slightly-coned plug F, also of carbon, and through this passes a carbon rod G, about $\frac{1}{8}$in. in diameter, reaching to the lower plug E, and connected above with a conductor H, also slightly coned, and kept from contact with the conical hole in the cover through which it passes by the ebonite bush K. The steel vessel itself serves as one electrode, being joined to the conductor L by the band M. The charge having been placed in the porcelain tube, the vessel closed, and any suitable gas pumped in till the desired pressure has been reached, the valve is shut and a current passed through the slender carbon rod G, thus heating it and the charge. The entire apparatus can be immersed in water if thought necessary, and the temperature approximately controlled by varying the current.

This apparatus, though primarily one suited for the needs of research, becomes indirectly of great technological importance. By its means the best conditions for the execution of technical processes may be worked out. In one special instance something in this direction has already been done. It is well known that a recently introduced and promising method of gold extraction depends on the solvent powers of alkaline cyanides upon gold. Cyanide of potassium, which is most generally used, is a somewhat costly substance, and a cheaper method of manufacture than that at present in use would greatly develop not

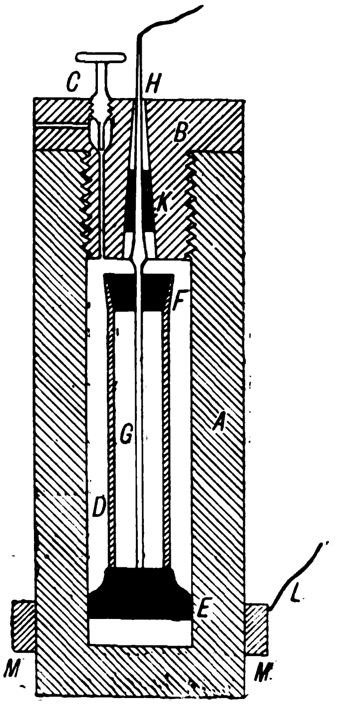



FIG. 3.—Apparatus for Applying Heat Gases.

only this particular process but many other industries. In the records of the attempts of previous experimenters to make cyanides cheaply, one is struck by the persistency with which failures are ascribed to the difficulty of obtaining sufficiently refractory material for the vessels in which to carry on the chemical reactions necessary. The most refractory fireclay soon became destroyed and its renewal was a serious expense. This was, of course, with externally fired retorts. The production of cyanides being, therefore, peculiarly a subject with which the apparatus described above is fitted to deal, experiments have been made on the direct synthesis of cyanogen from carbon and nitrogen under the influence of basic materials such as baryta and potassium carbonate, with the result that it was found that the latter was the better and, further that an increase of pressure greatly favoured the formation of cyanides. Here, then, is a direct instance of the application of the power of producing a temperature at once high and strictly local, which is so useful a property of a current of electricity, to a purpose of great industrial importance. Not only may the best conditions for large scale processes be thus ascertained, but such processes may themselves be executed by similar means.

Of the truth of the last statement there is ample evidence. A glance through the list of recent patents will show that inventors are already at work in this direction. Messrs. T. Parker and A. E. Robinson, of the Electrical Construction Corporation, have taken out a patent, No. 11,099 of 1889, for the production of carbon disulphide, which distinctly embodies this principle. The formation of carbon disulphide can only be effected by the aid of heat, the reaction

$$C + S_2 = CS_2$$

being endothermic, the quantity of heat absorbed being 19,610 thermal units. In consequence of this, the retorts in which the

Digitized by Google

reaction takes place have to be heated from without, with all the resulting disadvantages that have already been detailed. In the ordinary process an iron or fireclay retort filled with charcoal or coke is heated to redness, and sulphur dropped in through a tube from time to time. Combination takes place with absorption of heat, and the product passes away to a worm and is there condensed. In the new process, as described in the patent, wood charcoal is heated between carbon electrodes connected with a dynamo, and sulphur vapour passed through the heated mass. Thus the walls of the vessel in which the operation is conducted will be the coolest instead of the hottest part, and the loss of heat by radiation will be reduced to a minimum. Added to this is the important advantage that the vessel can be massively constructed, as no heat has to be transmitted through its walls, and will not need renewal as do the present retorts. In this case, the product the formation of which is desired is a highly volatile substance, and distils from the spot at which it has been brought into existence without extraneous aid. But by somewhat increasing the current used, or by diminishing the size of the vessel in which the reaction takes place, so that no part of it may be remote from the source of heat, substances of considerably less volatility may be similarly prepared and distilled. Such substances are the metals sodium, potassium and magnesium, for which a large and increasing demand exists. The same ingenious inventors have secured a patent, No. 11,707, of 1889, for preparing these metals by heating their oxides, hydrates and carbonates mixed with carbon by means of an electric current. The electrodes used are of iron, but the idea underlying the process is the same as that in the former patent. The chief expense encountered in the manufacture of sodium, until the Castner process came into use, was that caused by the destruction of the wrought-iron retorts necessary to withstand even fairly the high temperature required to reduce sodium carbonate by means of carbon. In the improvement just described no such expense exists. The process is precisely analogous with the Cowles' for the reduction of aluminium, with this important difference: aluminium being non-volatile, even at extremely high temperatures, remains in the focus of the operation of reduction, and there combines with the numerous impurities, all similarly reduced to their elementary state, and forms alloys with such bodies as iron and silicon, all far less valuable than the pure metal. In consequence, as has been already pointed out, aluminium itself cannot be economically produced in the Cowles' furnace, although its copper alloys are readily made. But sodium, potassium and magnesium are, when compared with aluminium, readily volatile, and they are therefore removed from the sphere of action as fast as they are formed. On *prima facie* grounds, therefore, there is reason to expect this novel process to prove a success.

Thinking upon the lines that we have endeavoured to indicate many other applications of this luminous principle suggest themselves. Messrs. Parker and Robinson have already in hand a large installation, the output of the dynamo being about, it is said, 700 electrical horse-power, at Wednesfield for the purpose of manufacturing phosphorus. Although details are not yet to hand, there is little doubt that the rationale of the process is the same as those already quoted. Phosphoric acid, or a phosphate mixed with charcoal, or other form of carbon, and heated by a current passed between carbon electrodes, would be decomposed, evolving vapours of phosphorus which could be led away and condensed in the ordinary manner. On the precise method and plant employed the smoothness and economy of working would of course largely depend, and of these we shall doubtless hear in due time, when it will be our duty to communicate them to our readers.

All these applications are practicable to-day with electricity at current prices, but a large reduction in its cost such as would result from any workable process for producing it directly by the oxidation of coal would open the door to still wider developments. No matter how low the price of the material manufactured, every process in which external heating is at present performed by the direct consumption of fuel would then be carried out by internal heating effected by the passage of an electric current though a medium of high resistance.

## ELECTRICAL STANDARDS COMMITTEE OF THE BOARD OF TRADE.

The following draft resolutions, with others, dealing with the practical measurement of power, whether developed by unvarying or alternating currents, will be submitted to the Electrical Standards Committee for discussion at their next meeting, which will take place on Friday, the 20th inst.

Board of Trade, February 10th, 1891.

1. That it is desirable that new denominations of standards for the measurement of electricity should be made and approved by Her Majesty in Council as Board of Trade Standards.

2. That the magnitudes of these standards should be determined with reference to the centimetre as unit of length, the gramme as unit of mass, and the second as unit of time, and that by the terms centimetre and gramme are meant the standards of those denominations deposited with the Board of Trade.

3. That the standard of electrical resistance should be denominated the ohm, and should have the value 1,000,000,000 in terms of the centimetre and second.

4. That the resistance offered to an unvarying electric current by a column of mercury of a constant cross sectional area of one square millimetre, and of a length of 106·3 centimetres at the temperature of melting ice, may be adopted as one ohm.

5. That the value of the standard of resistance constructed by a Committee of the British Association for the Advancement of Science in the years 1863 and 1864, and known as the British Association unit, may be taken as ·9866 of the ohm.

6. That a material standard constructed in solid metal, and verified by comparison with the British Association unit, should be adopted as the Board of Trade Standard ohm.

7. That for the purpose of replacing the standard, if lost, destroyed or damaged, and for ordinary use, one or more copies should be constructed, which should be periodically compared with the standard ohm, and with the British Association unit.

8. That the standard of electrical current should be denominated the ampere, and should have the value one-tenth (0·1) in terms of the centimetre, gramme, and second.

9. That an unvarying current which, when passed through a solution of nitrate of silver and water containing from 15 to 20 parts by weight of nitrate of silver in 100 parts of water, deposits silver at the rate of 0·001118 of a gramme per second, may be taken as a current of one ampere.

10. An alternating current of one ampere shall mean a current such that the square root of the time average of the square of its strength at each instant, in amperes, is unity.

11. That an instrument constructed on the principle of the balance, in which by the proper disposition of the conductors forces of attraction and repulsion are produced which depend upon the amount of current passing, and are balanced by a known weight, should be adopted as the Board of Trade standard for the measurement of one ampere, whether the current be unvarying or alternating.

12. That the standard of electrical pressure should be denominated the volt, being the pressure which, if steadily applied to a conductor whose resistance is one ohm, will produce a current of one ampere.

13. That the electrical pressure at a temperature of 62° F. between the poles or electrodes of the voltaic cell, known as Clark's cell, constructed and used in accordance with the specification attached to these proceedings, may be taken as not differing by more than——— parts in one thousand from a pressure of ——— volts.

Digitized by Google

## THE PELTON WATER-WHEEL.

It is as impossible to select any one kind of turbine as the "best-all-round" as to point to any one battery as being superior to all others. The volume and head of the water-supply not only vary as widely in different instances as do the volts and amperes of different dynamos taken at random, but Nature, who shows what she can do in forming blades of grass and grains of sand to uniform patterns, does not, unfortunately for the turbine maker, construct waterfalls to standard sizes. The design of turbines for low pressure is undoubtedly more difficult, by reason of the attention which must be paid to reduce skin friction, shocks caused by improper curvature of the blades, and eddies which may dissipate energy in the tail. High-pressure motors on a large scale are little known in this country, where mill streams are common and mountain torrents are rare. The pressure of the hydraulic service in London is too high for the direct driving of turbines, but for limited powers the Thirlmere water motor is well known, and consists of a set of buckets on the periphery of a wheel, the water impinging on them tangentially from a single jet. A similar wheel is coming into extensive use in America, and is specially adapted for the heads of from 100 to 1,000 or even 1,500 feet which are to be found in Canada. The design of the buckets, though more simple than that of a central-flow or inward-flow turbine, admits of definite mathematical treatment. The Pelton wheels (Fig. 1) employ round jets which strike the bucket fairly in the plane of rotation, and by means of a wedge-shaped division (Figs. 2 & 3) prevent the accumulation of idle water at the bottom of the pocket (Fig. 4), and discharge the water at a low velocity. The absence of joints and casing, of skin friction, and other matters which affect the useful results of low-pressure turbines, cannot be claimed as an advantage, because they need not exist with a motor intended for a considerable head. For electrical purposes a wheel which naturally runs on a horizontal shaft is preferable to one in which the water has to be brought round a bend in order to avoid a vertical shaft on which no dynamo maker would care to couple his armature. The Pelton Water Wheel Company have forwarded to the Niagara Falls Commission an estimate for wheels to develop 20,000 horse-power, of which four wheels to give 8,000 horse-power are for driving dynamos, and, as recorded in another column, have been awarded a fourth-class prize for their plans, no first prize being awarded. These wheels present an advantage in this case, since they would have to be placed in excavations in the solid rock, and would, probably, take less room than Girard turbines; and although the fall would not be sufficient to bring out their best qualities, they would certainly be much less

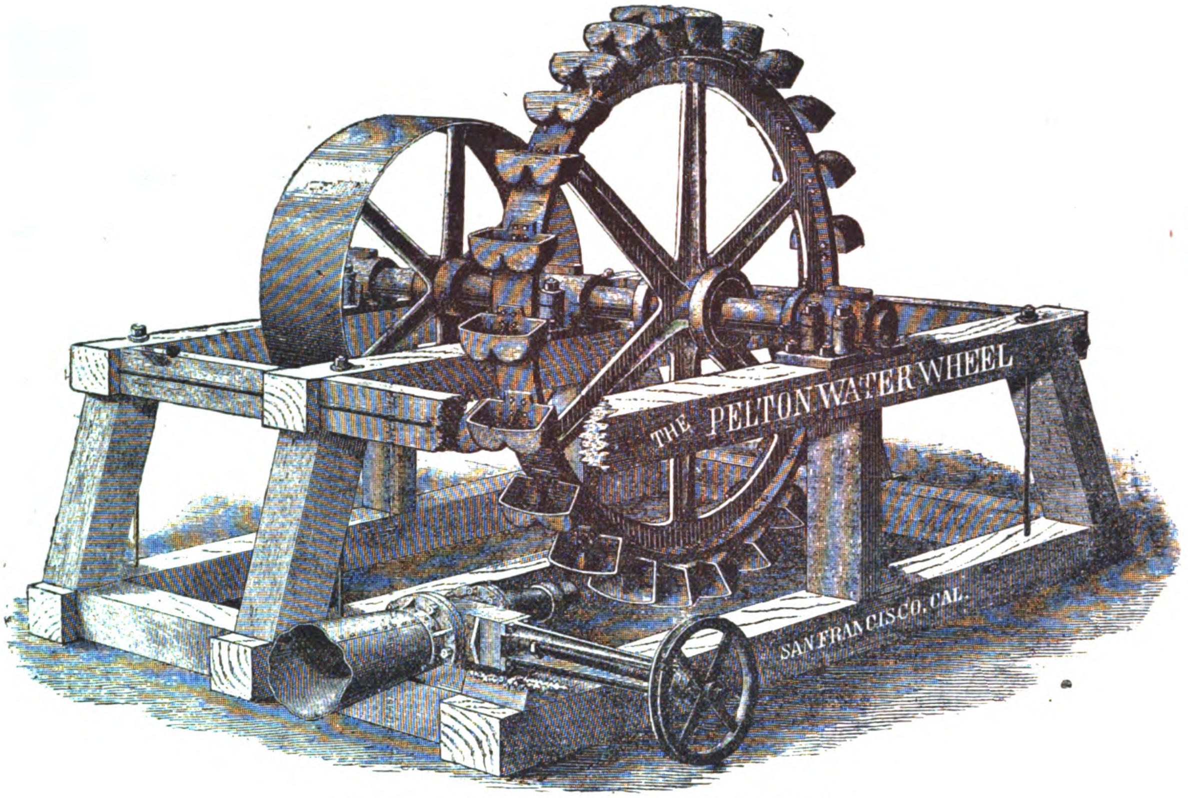



FIG. 1.—The Pelton Water Wheel. Cover removed.

FIG. 2.—Bucket used on the Pelton Wheel.

FIG. 3.—Section of Pelton Bucket showing the Deflection of the Water.

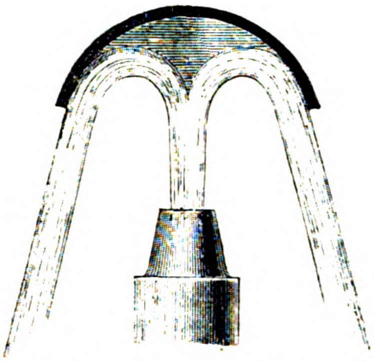


FIG. 4.—Section of an Ordinary Bucket showing Accumulation of Idle Water.

Digitized by Google

troublesome to maintain under a head of 140ft. than most other kinds of turbines. The mining plant at Rock Creek, El Dorado County, California, is worked at a distance of two miles by a 100 horse-power Brush dynamo driven by an 8ft. Pelton wheel. The head is 110ft., the wheel runs at 100 revolutions per minute, the water flowing through a 5½in. nozzle, and it can deliver 130 horse-power. In another case, four Pelton wheels were used to drive Brush dynamos, using water which had already been used by other turbines in the immediate neighbourhood.

## TIGHT BELTS.*

BY ROBERT GRIMSHAW.

This is not to be an article advocating tight belts; rather one upon the tightness of belts, and complaining that belts are more often too tight for their good and for that of the shafts which they connect than too loose.

It is usually set down in text books, and in ninety-nine cases in a hundred in the "experience boxes" of men who call themselves practical, that the tighter a belt is (other things being equal) the more it will drive. I had the honour of being the first, so far as I know, to point out that this was true only to a certain extent; that there was a limit, with each kind of belt and each set of conditions, beyond which further tightening not only gave no further increase of driving, but actually lessened the capacity of the belt—to say nothing of the injurious effect upon belt, fastenings, and shaft bearings. What is that "slipping point," beyond which no further tightening will give more driving power? And why does it exist?

We had better answer the second question first. We know that the tendency of the pull on a belt is to bed it down to the face of the pulley, thus bringing more and more of the surface in contact with the pulley face, according as the tension is made greater and greater. A belt that is soft and flexible will, of course, bed down better than one which is not smooth and flat. The effect of bedding a soft surface down to the pulley face is to change its character. A surface which is comparatively porous, or rough, becomes smooth by the pressure, and with some kinds of belts takes on a sort of a glaze—only temporary in some cases, permanent in others. A glazed surface will not drive so well as one which is unglazed; and more harm may be done by glazing the surface, either temporarily or permanently, than can be balanced by the advantage of having the belt touch the pulley all over its surface. In other words, if, before excessive tension was resorted to, the belt touched the pulley with three-fourths of its surface, and if, after excessive tension was put on, it touched over the whole surface, we would expect one-third increase in the driving-power, as a maximum. But if the character of the three-fourths which touched the pulley before straining is so changed that each square inch of it is only as good as one-half square inch was before, we have the value of the three-fourths lessened to three-eighths, and this plus the new one-fourth, which we will assume is as good as any equal portion of the three-fourths, makes only five-eighths, which is not as much as three-fourths.

This is the theory of the thing, and it is simply borne out by tests made in a belt-testing machine and by experience with belts running in saw-mills, electric light plants and other establishments. It is more so with leather belts than with raw hide; more so with leather and raw hide than with cotton, and more so with cotton than with rubber. At least, this is the general run of things.

The moral of all this is to run your belts loosely; then you will be sure that you are not hurting them, while at the same time lessening their driving power. So long as a belt will start its driven pulley suddenly, it is tight enough for the work. It may be tight enough to run the job right along and yet not be able to start a machine from a state of absolute rest; particularly if there be heavy rotating parts which absorb power during quiet running, to give it out when needed to overcome a sudden excess of load. Of course, I do not mean that a belt should be run so loose that it would flap and weave; but so long as it runs quietly, and without slinging from side to side, it should be allowed to be as loose as it can be slacked up to, and yet drive the load. And if there be a flapping fold running from the driving to the driven side, it is much better to take it up by an idler pulley near the smaller of the two pulleys connected by the belt, than to take up the slack at the fastening.

Idler pulleys are great things if people will only distinguish between them and tighteners. An idler should in no way increase the strain at the fastenings; should in no way increase the pull on the bearings; that is the test. The minute that it does this it is not an idler, but a worker, and a mischievous worker. The proper way to apply an idler is so that it will increase the wrap on the pulley on which the belt drives the most poorly. (This is not necessarily the smaller of the two pulleys, for sometimes a small wood pulley will have more grip upon a belt than a large one of iron; sometimes a small iron pulley may be lagged with leather or paper so as to drive better than the larger one over which the belt runs.)

Of all the ways by which a belt may be made to drive more, giving it greater tension may be regarded as the poorest all around. Give it more arc of contact; give it better pulley surface, run it faster—do almost anything except increase its tension. Of course, increase of width or of thickness gives increase of driving power under similar circumstances, but that means another belt, and should not be resorted to so long as the simple means of giving more arc of contact, better surface to grip on, and greater speed, remain untried.

* From the *Electrical Engineer* of New York.

## MEETINGS OF SCIENTIFIC SOCIETIES, &c.

**FRIDAY, February 13th.**

PHYSICAL SOCIETY.

*5 p.m.* Annual General Meeting, after which the following Papers will be read or discussed: 1. "Photo-Electricity," by Prof. MINCHIN. 2. "The Change in the Absorption Spectrum of Cobalt Glass produced by Heat," by Sir JOHN CONROY. Bart.

INSTITUTION OF CIVIL ENGINEERS.

*7.30 p.m.* Students' Meeting. Paper to be read: "The Cleaning and Deepening of Rivers and Canals by means of the Transporting-power of Water," by W. HERBERT WHEELER, S.I.C.E.

ROYAL INSTITUTION.

*9 p.m.* Evening Discourse: "Some Results of Recent Eclipse Expeditions," by Prof. A. SCHUSTER, F.R.S.

**SATURDAY, February 14th.**

ROYAL INSTITUTION.

*3 p.m.* Afternoon Lecture: "The Forces of Cohesion," by LORD RAYLEIGH, F.R.S.

**MONDAY, February 16th.**

SOCIETY OF ARTS.

*8 p.m.* Cantor Lecture III. 1. "The Electric Transmission of Power." by GISBERT KAPP.

**TUESDAY, February 17th.**

INSTITUTION OF CIVIL ENGINEERS.

*8 p.m.* Ordinary Meeting. Paper to be further discussed: "Electric Mining-Machinery," by LLEWELYN B., and CLAUDE W. ATKINSON, A.MM.I.C.E.

**WEDNESDAY, February 18th.**

ROYAL METEOROLOGICAL SOCIETY.

*7 p.m.* Ordinary Meeting. Papers to be read: "The Great Frost of 1890-1891," by CHARLES HARDING, F.R.M.S; "On the variations of the Rainfall at Cherrapoonjee in the Khasi Hills, Assam," by H. F. BLANFORD, F.R.S.; "The problem of Probable Error as applied to Meteorology," by T. W. BACKHOUSE.

SOCIETY OF ARTS.

*8 p.m.* Ordinary Meeting. Paper to be read: "Methods and Processes of the Ordnance Survey," by Colonel Sir CHARLES WILSON, K.C.B., F.R.S.

ROYAL MICROSCOPICAL SOCIETY.

*8 p.m.* Ordinary Meeting. Papers to be read by Dr. W. B. BENHAM and T. B, ROSSETER.

OLD STUDENTS ASSOCIATION.

*8. p.m.* Ordinary General Meeting at Finsbury Technical College. Paper to be read: "From College to Factory," by DUNCAN PEARCE.

**THURSDAY, February 19th.**

CHEMICAL SOCIETY.

*8 p.m.* Ballot for the Election of Fellows.

**FRIDAY, February 20th.**

INSTITUTION OF CIVIL ENGINEERS.

*2 p.m.* Students' Visit to the Tower Bridge Works.

SOCIETY OF ARTS.

*4.30 p.m.* Popular Afternoon Lecture: "The Science of Colour," by Capt. ABNEY, F.R.S.

ROYAL INSTITUTION.

*9 p.m.* Evening Discourse: "Infectious Diseases, their Nature, Cause and Mode of Spread," by Dr. ED. E. KLEIN, F.R.S.

**SATURDAY, February, 21st.**

ROYAL INSTITUTION.

*3 p.m.* Afternoon Lecture: "The Forces of Cohesion," by Lord RAYLEIGH, F.R.S.

*** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

Digitized by Google

# The Electrician.

**Published every Friday, Price Fourpence; Post Free, Fourpence Halfpenny**
**Editorial, Publishing, and Printing Offices:**
**SALISBURY COURT, FLEET ST., LONDON, E.C.**
*Telephone No. 2714. Telegrams:* "ELECTRICIAN NEWSPAPER, LONDON."

*All Letters relating to Subscriptions, Advertisements and other business matters should be addressed to the Publisher, "THE ELECTRICIAN," Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to "THE ELECTRICIAN" Printing and Publishing Company, Limited, and be crossed "Coutts and Co." All other letters to be addressed to the Editor.*

*All letters intended for insertion in "THE ELECTRICIAN," or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

"THE ELECTRICIAN" *is published every Friday morning, in time for the morning mails. Subscribers should receive their copies by the first post on Friday morning.*

"THE ELECTRICIAN" *is on sale at the railway bookstalls throughout the Kingdom on Friday morning, and can be obtained of all Booksellers and Newsvendors; or direct from the Publishing Offices as above.*

*New Volumes of* "THE ELECTRICIAN" *commence in May and November.*

## SUBSCRIPTION RATES

The rates for Subscriptions to "THE ELECTRICIAN" are as follows:—

| | 3 months. s. d. | 6 months. s. d. | 12 months. s. d. |
|---|---|---|---|
| For the United Kingdom | 5 0 | 10 0 | 19 6 |
| For Foreign Parts and Colonies:— | | | |
| Within Postal Union | 6 6 | 12 6 | 24 0 |
| Aden Borneo, Ceylon, China, India, Japan, Java, Labuan, Mozambique, New Caledonia, Persia, Philippine Islands, Siam, Transvaal, and Zanzibar | 7 6 | 14 6 | 28 0 |

## TO ADVERTISERS.

"THE ELECTRICIAN" *offers exceptional advantages to Advertisers.*
**It has by far the largest circulation of any English Electrical paper, and circulates all over the World.**

*Particulars relating to Advertisements will be promptly forwarded on application to the Offices as above.*

TRADE ADVERTISEMENTS *intended for the current issue must reach the Offices not later than First Post on Thursday morning. Renewals of expiring advertisement orders and alterations to standing advertisements should be in the Publisher's hands by Wednesday at latest. No alteration can be made in Wrapper advertisements after Wednesday evening.*

SMALL PREPAID ADVERTISEMENTS *(for Rates see page xvii.) are accepted up to 4 p.m. on Thursday.*

## TECHNICAL PRINTING.

"THE ELECTRICIAN" PRINTING AND PUBLISHING COMPANY (LIMITED) *inform Electricians, Electric Light Engineers, &c., that they make a speciality of Technical Printing, and have a large Staff thoroughly acquainted with Electro-Technology. They can, therefore, promise Accuracy and Despatch in the Printing of Electro-Technical Literature, &c.*

## "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. (Royal 8vo.)

*Early in each year is issued* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. *The* DIRECTORY *was established in 1883, and the 1890 Edition consisted of about 850 pages of printed matter. The names and addresses of all persons engaged in the Electrical Industries at home and abroad may be relied upon as accurate. Useful Tables and Electrical Formulæ, and information specially compiled for this work are given, together with popularly-written Biographical Notices of the leading Electricians, Electrical Engineers, &c., accompanied in many cases by Portraits.*

*The 1891 Edition is now actively preparing, and Subscription and Advertisement Orders, New Names, Corrections, &c., can be received.*

## ELECTRICAL BOOKS AND PUBLICATIONS.

***All Books, Newspapers, and other publications, dealing with Electrical and kindred subjects, can be ordered direct of "THE ELECTRICIAN" Printing and Publishing Company, who are proprietors of the well-known "ELECTRICIAN" Series of Standard Electrical Works, and are agents for all the leading publishing houses at home and abroad.***

## CONTENTS OF THE CURRENT NUMBER.

NOTES ... 443
Electromagnetic Theory.—IV. By Oliver Heaviside. Continued ... 448
A New Principle in Electro-Metallurgy. Illustrated ... 449
Electrical Standards Committee of the Board of Trade ... 451
The Pelton Water Wheel. Illustrated ... 452
Tight Belts. By Robert Grimshaw ... 453
Meetings of Scientific Societies. 453
ELECTRIC LIGHTING IN THE CITY OF LONDON ... 454
Notes on the Electric Railway: Historical, Statistical and Technical. By Franklin Leonard Pope ... 455
Electricity in the French Navy. By M. Foris. Illustrated ... 458
An Electric Wave Measurer. By C. Grawinkel and K. Strecker. Illustrated ... 459
Havoc among the Poles and the Wires. Illustrated ... 461
The London County Council and Technical Education... 462
American Notes ... 463
Paris Notes ... 462
CORRESPONDENCE—
Electric & Magnetic Theories —John T. Sprague, Silvanus P. Thompson and Gavin J. Burns, B.Sc. ... 463
The Induction Coil and Dr. Callan of Maynooth College — Gerald Molloy ... 464
Resistance Coils—Edward W. Adamson ... 464
"More Board of Trade Rules" —"In Statu Pupillari" ... 465
Legal Intelligence ... 465
Trade Notes and Notices ... 466
PATENT RECORD ... 466
COMPANIES' MEETINGS, &c.—
The City and South London Railway Company (Ltd.)... 467
Cuba Submarine Telegraph Company (Limited) ... 467
Hastings and St. Leonards-on-Sea Electric Light Company (Limited) ... 468
The India-Rubber, Gutta-Percha and Telegraph Works Company (Limited) 469
Liverpool Overhead Railway Company (Limited) ... 469
New Companies Registered ... 469
City Notes, &c. ... 469

## STEEL-PLATE PORTRAITS

*Of W. H. Preece, F.R.S.; Michael Faraday; Sir John Pender, K.C.M.G.; Sir William Thomson, F.R.S. (Past-President of the Institution of Electrical Engineers); C. H. B. Patey, C.B. (Late Secretary of Telegraphs, G.P.O.); Dr. John Hopkinson, F.R.S. (Past-President of the Institution of Electrical Engineers); Dr. Oliver J. Lodge, F.R.S., and Prof. William Crookes, F.R.S. (President of the Institution of Electrical Engineers), have been issued as Supplements to* "THE ELECTRICIAN." *A few Copies of these admirably-executed Steel Engravings can be supplied, price 1s. each, post free on roller, 1s. 2d. Or framed in neat Black Pillar or Brown Ornamental Frames, price, post free, 4s. 6d.*

## ELECTRIC LIGHTING IN THE CITY OF LONDON.

WHEN it is remembered that the "City" was the scene of the first experiment in electric lighting on a considerable scale, some ten years ago, last week's ceremony in connection with its establishment on a permanent footing may well give rise to some curious reflections. All London can call to mind the spectacle they were invited to witness in the spring of 1881, when, at a given signal, the ill-lighted and generally deserted thoroughfares extending south and west of the Royal Exchange, along King William-street and over the Bridge, up Cheapside and down Ludgate-hill—to say nothing of the Thames Embankment—were suddenly bathed in a flood of light the like of which no man had seen before, and, as the event proved, no man wished to see again. From one point of view the problem of street lighting seemed to be solved; electricity, which had annihilated time and space, was now to obliterate the distinction between day and night. But from a more prosaic and practical point of view the exhibition was overdone and proved nothing, except, perhaps, that the new illuminant was apparently fickle, and certainly uncanny. Then when the price had to be named, and the aims of the experimenters more closely inquired into, there came the inevitable rebound; and although for some considerable time in portions of the principal streets electric standards continued to compete with the lowly gas-lamp, they never extinguished it, and finally left it for many years in undisputed possession.

Digitized by Google

Ever since the period to which we are alluding the City authorities have been, so to speak, pregnant with the electric light, and are only just now being safely delivered. Somebody who has been so unkind as to count up the Commissioners' Reports on the subject of electric lighting to the Corporation authorities finds that the number corresponds to the Church's Articles. Thirty-nine abortive attempts were at all events evidence of perseverance, and the Corporation seems to have finally accepted them also as proof of sound orthodoxy; for at length the necessary tenders were issued, contracts accepted, and the work is now begun. What has been the motive or the cause of this prolonged gestation we need not too closely inquire into. Some people allege that the oft-recurring Reports of the Commissioners served the same purpose as eggs at an election. Certain it is that they—the Reports—were always the occasion of a good deal of undignified and sometimes inodorous squabbling; but whatever may have been the real grounds of hesitation, certainly they were not those implicitly assigned by the LORD MAYOR at last week's municipal function. The City of London, though reputed slow in its general movements, has never been backward in spending money, and the fanciful picture of the civic authorities cautiously watching and profiting by the experience of similar undertakings elsewhere is one which only reminds us of those other long-drawn and highly-coloured artistic productions familiarly associated with his lordship's progression.

Turning, however, to the practical features of the scheme now auspiciously inaugurated, it may be freely admitted that in some important particulars the City is exceptional, and calls for special treatment. In the first place, early closing prevails generally for business of all kinds; offices are deserted soon after six o'clock, and the shops quickly follow their example. If we except those of the public-houses and tobacconists, hardly a window is to be seen shedding light on the pavement after half-past seven. On this account alone the contrast between the heart of London and the main arteries leading from it in every direction, where much business of a light-giving kind is still carried on to a late hour, is very marked. Add to this the fact that the foot traffic in the City after eight o'clock is very small, we have a comparatively deserted and peculiarly dark neighbourhood, comprising within its limits probably more wealth and treasure than are to be found in a similar area anywhere else in the world. Here distinctly is a call for better illumination. But it is chiefly, if not wholly, from the streets that this call is heard. Few, if any, of the shops require any sort of light except to show both burglars and police where the safes are kept. As for dwelling-houses, there are none. Thus it is that we find the Provisional Orders now obtained by the City of London relate chiefly to the lighting of the thoroughfares; and on this account, no doubt, it is that the conditions upon which they are granted differ in many respects from those imposed where the contractors may reasonably form high expectations of the profits to be derived from private customers. Then, again, having to rely upon the street lighting almost exclusively—at all events, for some time to come—the contracting engineers will have to hold themselves in readiness to meet the not infrequent, and some times quite unexpected, fogs which envelop the City in darkness, even at mid-day, and which will tax the resources of the supply stations to their utmost.

These circumstances, peculiar to the undertakings, are evidently taken into account by the framers of the Orders, which, in several material points, are more favourable both to the Local Authorities and to the undertakers than is usually the case. As regards the former, this is especially noticeable, and shows how powerful the City is to fight its own battles even against all the armoury of the Board of Trade. In some respects, indeed, the undertakers themselves have suffered for the same reason. Twenty-four years is laid down as the absolute term of the undertakings, after which period the local authorities reserve the right, upon due notice, to purchase on the terms specified in the Electric Lighting Act of 1888; this at all events in respect to public lighting. Private lighting is treated separately, and is to be acquired, if demanded, on such terms as the parties may agree upon, or be determined by arbitration. As the scheme covers the whole of the City from Aldgate to Temple Bar the private business will in time not be inconsiderable. Any place of business, we notice, situated within 25 yards from a distributing main may require the undertakers to supply light, and on terms which we consider rather favourable to the customer. The two companies, however, who have accepted all this responsibility are fully equal to it; or perhaps we should say fully able to attract enough capital to work the project satisfactorily. So far as we can judge of the terms of their contract there would seem to be a good margin of profit on the side of the contractors. If, as appears to be foreshadowed in the wording of the Provisional Orders, the two undertakings become merged into one, its chances of prosperity would be still more favourable. On one point at least we gladly agree with the LORD MAYOR, that although its delay has been great, the task, when accomplished, will be far better done than if it had been seriously attempted eight or ten years ago.

## NOTES ON THE ELECTRIC RAILWAY: HISTORICAL, STATISTICAL AND TECHNICAL.*

BY FRANKLIN LEONARD POPE.

It is only six years ago that an electric street railway was put in actual commercial service in the United States for the first time. This was in the city of Cleveland, O. Less than four months ago the American Street Railway Association held its annual meeting at Buffalo, and in his opening address the president made the following significant remark :—"I am so thoroughly convinced that electricity is the coming power for street railways (except on very heavy grades, where the cable is best suited), and that it will prove so effective as a means of rapid transit for cities, that I believe that this is the last convention that will ever seriously consider horses for the operation of street railways."

Few people have any conception of the enormous extent of city and suburban traffic in the cities of the United States. Statistics indicate that the street railways of the United States carry something like twice as many passengers as all the steam roads, and, moreover, it has also been found that the number of passengers increases from year to year in a much greater ratio than the population, which means, not only that more people ride, but that the same people ride more frequently each succeeding year. The transportation of this enormous number of passengers, probably not less than four or five billions, taking the whole country together, with safety, comfort, speed and economy, must be recognised as an undertaking of the most gigantic description. It is well worth our efforts to carefully consider the best means by which it can be accomplished.

The discovery that it is possible to produce continuous mechanical motion by the agency of the electric current is due to Michael Faraday. In 1831 Joseph Henry, then Professor of Natural Philosophy in the Academy at Albany, N.Y., and afterwards the distinguished secretary of the Smithsonian Institution at Washington, in a letter to Prof. Silliman, of New Haven, said: "I have lately succeeded in producing motion by a little machine which I believe has never before been applied in mechanics, by magnetic attraction and repulsion." Time has shown that Henry's moderate conception of the legitimate field of the electric motor was prophetically accurate, but his views failed to impress themselves upon the minds of his contemporaries. In the expectation that electricity would soon be the universal motive power, the problem of its utilisation was, during the next 10 years, attacked with great zeal by a considerable number of inventors. The earliest as well as the most meritorious of these was a Green Mountain village blacksmith by the name of Thomas Davenport. Some time since, while preparing a lecture to be

* Abstract of a Paper read before the New York Electric Club.

Digitized by Google

delivered before the Board of Trade, in Springfield, Mass., I accidentally learned that this inventor had constructed a model of an electric railway in Springfield more than 50 years ago, undoubtedly the very first appearance of the electric railway in the history of the world. The record of his career shows that Thomas Davenport was a man of no ordinary merit. Pursuing the occupation of a village blacksmith in Brandon, Vt., at that time an obscure country town, far removed from all main lines of travel and transportation, he had no sooner been shown as a curiosity the effect of Professor Henry's electro-magnet in lifting a blacksmith's anvil by the magnetic power generated by three small battery cells then he was seized with the idea that electro-magnetism might be applied to the propulsion of all kinds of machinery, and, in fact, might be made a universal motive power. From that moment his whole life was devoted solely to the realisation of this conception. We must remember that at that time the steam engine was a comparatively uneconomical, inefficient, and dangerous apparatus, and was regarded at best but as a necessary evil; a thing to be tolerated and endured in the absence of available water power, but best dispensed with altogether wherever possible. At that date and for years afterwards the annual catalogue of disasters by fire and explosion due to the use of steam was a lengthy and horrifying one. With such facts as these in mind it is easy to understand why the possibility of a new motor, compact, noiseless, manageable, free from all danger of fire and explosion, should be hailed with enthusiasm as a priceless boon to the industrial community. We must remember, too, that there existed at that time no data from which could be foreseen or determined, even with remote approximation, the relative economy of steam and galvanic power. It was not until 10 years later that the great law of the conservation of energy and the correlation of the physical forces—now familiar to every schoolboy—was first formulated by Grove and Mayer and Joule; a law now so interwoven with our scientific conceptions that it is hardly possible for us to imagine that it could ever have been unknown. At a much later date than that of which I am now speaking, men whose names will be recognised as the foremost scientists of the time, such men as Lardner, Jacobi, and Joule, did not hesitate to put upon record the belief that within a few years the power of steam would be wholly superseded by that of electro-magnetism, and the *Scientific American* was publishing illustrated description of perpetual motion machines.

From the moment in which he first witnessed the experiment of lifting an anvil by Henry's electro-magnet to the very last hour of his life, Davenport never once wavered in his belief that steam was ultimately destined to be supplanted by electro-magnetism. Within six months from that time, with the assistance of another mechanic of the same town, he succeeded in constructing a machine by which he obtained continuous rotation by electro-magnetic power. During the six years between 1835 and 1841 he built more than 100 operative electric motors, scarcely any two of which were of the same design, and which varied in size from a small model up to an engine capable of driving a rotary printing press for 12 hours in succession. In December, 1835, he exhibited in Boston the model of an electric locomotive and circular railway which he had built in Springfield, and a similar though more finely finished model, which was built by him the following year, is still in existence in a good state of preservation. He published in 1840, now more than 50 years ago, in the city of New York, a weekly journal called the *Electro-magnet and Mechanics' Intelligencer*, which was printed upon a press driven by an electro-magnetic engine. Some of his motors, constructed as early as 1837 and 1838, were admirably designed, and in essentials, even to the shunt-winding, differed but little from some of the most advanced and successful types in use at the present day. Less than a year before his death, upon reading a newspaper account of the trial of the large engine built at Washington by Prof. Page under an appropriation from Congress, Davenport wrote a long and interesting letter to a local newspaper, congratulating Prof. Page upon his success, giving a concise but full account of his own work, and predicting with an earnestness born of entire conviction the ultimate triumph of electro-magnetism over steam.

It has been the fashion to smile at such men as Davenport as enthusiasts. Yet if Davenport was an enthusiast, so are we all enthusiasts as respects our anticipations of the realisation of the result which he predicted and for which he wrought unceasingly. Steam is nothing more than a convenient agency for the *transmission* of power, which derives its energy from heat and imparts it to mechanism. So soon as the great riddle of the day has been read—the production of electricity, as steam is produced, directly from heat—then, indeed, will the predicted triumph of electro-magnetism over steam become an accomplished fact. Forty years have passed away since all that was mortal of Thomas Davenport was laid to rest beneath the Brandon elms, yet I think there are not many present in this audience to-night who do not cherish the expectation, if not the conviction, that before the half-century has been completed the great problem will have been solved, and the era of a new industrial revolution will have dawned upon the world.

The electric locomotive constructed by Prof. George G. Page, which was tried by him on the Baltimore and Ohio Railroad, in 1851, deserves a passing notice here. It was a noteworthy achievement, but developed no new principle, nor did it contribute anything to the ultimate solution of the problem of the electric railway. Many other promising experiments were made, but all resulted in failure, until the very name of electro-magnetic motor became almost a synonym for "humbug." The electric motor, therefore, remained, for something like 40 years after its invention, an interesting but practically useless philosophical toy. It was like half of a pair of scissors—of no earthly use without the other half. The other thing that was needed was an organised machine which could convert large quantities of mechanical power into electricity. The discovery that it was possible to effect this conversion was also due to Faraday. With his usual sagacity he had suspected that it might be done, and undertook a series of experiments for the express purpose of finding out. On the second day he wrote to a friend: "I think I have got hold of a good thing, but cannot say; it may be a weed instead of a fish, which, after all my labour, I may pull up." On the tenth day he pulled it up, and it was a *fish*; it was not a small fish either. This was the beginning of the development of the magneto-electric generator. The next step is due to the genius of another American scientist and inventor, one whose name will occupy a far more prominent position in the annals of American science a century hence than it does to-day, Moses G. Farmer. He it was who, in 1867, in a letter to Henry Wilde, of Manchester, first described the principle of the modern dynamo-electric machine. Almost at the same time similar machines were independently invented by Wheatstone and Varley in England, and by Dr. Siemens in Berlin.

The earliest field of usefulness of the dynamo machine was found in arc lighting. One of the most effective of the early machines was designed by Gramme, of Paris, in 1872, and a number of them were shown by him at an industrial exhibition at Vienna in the following year. Here occurred one of those extraordinarily fortunate incidents which again and again have played such a prominent part in the history of industrial progress. In making the electrical connections to one of these machines not yet belted to the engine shaft, a workman attached to it by mistake a pair of wires which were already connected with another dynamo machine which was in rapid motion. The second machine instantly commenced to revolve. When the attention of Gramme was called to this phenomenon, he saw at once that the second dynamo was performing the function of a motor, and that what was taking place was the actual transference of mechanical power through a small wire by the means of electricity. This singularly opportune occurrence being commented upon in the scientific journals led to the almost instant recognition of the true place of the electric motor in the domain of mechanics.

The principle of converting mechanical energy into electricity and reconverting this by a reversed dynamo into mechanical power naturally suggested the practicability of transmitting power through electric wires to any required distance. One of the earliest results of this conception was the revival of the electrically operated railway, the commercial development of which had necessarily remained in abeyance until machinery was available for furnishing large quantities of electricity at a moderate cost.

The credit of priority in the invention of the electric railway in its modern form, that is to say, the moving electromotor on the car connected by electric conductors with a stationary dynamo, I believe to be justly due to Stephen D. Field, now of Stockbridge, Mass., who was living in San Francisco in 1877. This was about the time of the introduction of the cable system of street railways into San Francisco. Observing the operation of the cable road, it at once occurred to Field that electric power might be applied to the same purpose with as great or even greater advantage. At that time no dynamo-electric machines suitable for this purpose were to be had in the United States, and he accordingly ordered one from Europe for experimental purposes. It took a long time to make it, but at last it was completed and shipped to San Francisco by a sailing vessel. The vessel was wrecked on the voyage, and the machine went to the bottom of the sea. Not yet discouraged, he ordered another one, which eventually reached him in good order, and enabled him to commence his long-delayed experiments. He tried first an electric elevator, in which he was successful. In 1879, having exhausted his resources, he came to New York, bringing with him his plans, with which he hoped to enlist capital to continue his work. He laid these plans before me, and, being impressed with the entire practicability of his scheme, I gave him every encouragement in my power. The plan which he had devised contemplated the enclosing of the conducting wire in a conduit beneath the street. He was not successful in obtaining sufficient means to properly develop his invention; he became involved in tedious, harassing, and expensive litigation with wealthy Corporations, and his health failed him at a critical time, so that for years he was incapacitated from active work, but the single railway which is in operation in this country to-

Digitized by Google

day, and embodies his matured conceptions, is regarded by competent judges as in many respects superior to any yet brought before the public. Field's electric locomotive was first exhibited at the exhibition of railway appliances in Chicago in 1883, during the continuance of which 27,000 passengers were transported by it. In the summer of 1882, Dr. Joseph R. Finney exhibited in Allegheny, Pa., an electric street-car, for which the current was supplied by a copper wire, about the thickness of a lead pencil, 15 or 20ft. above the street. A small trolley fitted with grooved wheels, running on this wire as on a track, and connected with the car by a flexible conducting cord, served to convey the electric current from the suspended conductor to the motor. Some of the earliest of the successful lines in this country were arranged upon this plan.

The problem of the underground conduit does not at first sight appear to be a very difficult one, but without going into details it is sufficient to say that the conduit system has been tried on an extensive scale in Denver, Cleveland, and Boston, and to a lesser extent in several other places, but in every case the continual interference and interruptions consequent upon its use have exhausted the patience of the travelling public and compelled its abandonment. I do not wish for one moment to convey the impression that the problem is an insoluble one. My attitude is rather that which was taken by Prof. Tyndall some 10 years ago upon the question of the practicability of domestic electric lighting by incandescence. He had no doubt that the problem would be solved, but it was a great satisfaction to him to know that it would have to be done by somebody other than himself.

The storage battery system, both from the standpoint of the public and the street-car manager, is an ideal solution of the problem of electrical transportation. It has many features which especially commend it for city work. Each car is an independent unit, and hence no accident can materially cripple a well-organised system. The idea of being able to store a large quantity of electricity in a box under the seats of a car, to carry it around, and to draw from it a large amount of power, as required, is a most attractive one. Storage battery cars can be introduced in the existing systems, one car at a time. In cases of emergency they can be run over almost any route where a horse car can be run, not being restricted to the route of an electric conductor, and under ordinary circumstances the car can be run just as rapidly and controlled just as effectively as it can be with the trolley system. All these advantages were recognised at an early day, and hardly had the storage battery been invented before it was applied to street-car propulsion. The first storage car was operated in Paris in 1882. The system was then put in practical service on one of the lines in Brussels, and continued for two years. It was also introduced in 1886 on the Madison-avenue line in New York, and has been in operation there ever since. The results of the ten cars now running on the Madison-avenue line appear to have demonstrated that the system may, with careful management, be made thoroughly reliable. Each car will carry a full load on a straight and level track 15 miles per hour, and will ascend grades not exceeding 5 per cent. and not more than 500 feet long at five miles per hour. A run of 40 miles can be made on a level track, which is considered a half-day's work, with one charge of battery. The time required to replace the exhausted batteries with fresh ones is not more than two minutes.

There are, however, two serious objections to this system which have thus far been sufficient to prevent its adoption in other than exceptional cases. One of these is the great weight of the batteries, and the other is the lack of reserve power in the emergencies which sometimes occur. In other words, two considerations enter into the question, one of economy and the other of efficiency. To take up the question of comparative efficiency first, a very little consideration of the matter will show that the progress of the art, so far as yet developed, practically limits the use of storage battery cars to lines having very light grades—not more than 5 per cent. at the outside. Very many of our eastern cities, for instance, Springfield, Providence, Worcester, Albany, Troy and many others which I might mention, have very severe grades, from 7 to 10 per cent., and some of them half a mile long. To start a heavily loaded car in bad weather on such a grade as this means an expenditure for a few seconds of from 50 to 80 horse-power. Experience has shown that this is far too heavy a tax upon the powers of a storage battery. Even on comparatively level lines, in our northern climates, the occurrence of a heavy storm of snow or sleet necessitates the expenditure of an abnormal amount of power, and it is on just such occasions as these when everybody wants to ride, so that the cars are loaded to their utmost capacity, and great dissatisfaction prevails if there is any delay or any lack of sufficient accommodation. It is at such times as this that the advantages of a distribution from a central station are most apparent. The whole number of cars, or extra ones if necessary, can be run, and any amount of power required to force them through obstructions and to keep them running on schedule time can be supplied from the power station. It is merely a question of burning more coal. Considering the economical aspect of the question, first, as to the original cost, it may be said roughly, the difference between the storage and overhead line system is not very great; but the best authorities seem to concur in the opinion that it requires, roughly speaking, nearly twice as much power per unit of useful work done, with the storage battery system, that it does with the direct distribution system. The dead weight of the battery is nearly equal to that of a paying load of 30 passengers, and this load must be transported whether there are any passengers or not. The increased weight adds to the cost of renewal and repairs, both of the track and of the cars. The cost of horse-power for drawing cars has been found by long experience to vary from 10 to 11 cents per car per mile. The cost of power for the 10 storage battery cars on the Madison-avenue line in New York is said to figure out 10·6 cents per car per mile, practically the same as horse-power. A careful computation of the average cost of power by the direct distribution system, on a considerable number of different lines in this country, shows that the cost for coal, attendance, real estate, oil and waste, repairs of machinery and line, foots up 5·09 cents per car per mile.

I once had occasion to study this whole question very minutely. In the fall of 1886, when the West End Street Railway Company, of Boston, was first organised, I was commissioned by President Whitney to make for him a careful investigation of the subject of electric propulsion, which he desired to apply to the entire street railway system of Boston. It was a gigantic proposition, for at that date there was hardly a dozen electric street-cars running in this country. I was told by him at the outset that I must confine my researches to conduit and storage systems; that anything in the shape of an overhead line was out of the question and would never be tolerated in Boston for a moment. I submitted my report to Mr. Whitney on April 30, 1887. At that time no experience had been gained which would enable me to compute accurately the cost of operation of the different systems, but the final result of my estimate then given to Mr. Whitney, of the cost of power per car per mile, was as follows:—

| | |
|---|---|
| Horse-power | 11·07 cents. |
| Electric storage system | 7·34 „ |
| Electric underground distribution | 6·02 „ |
| Electric overhead distribution | 3·28 „ |

It will be seen that these figures estimated the cost of the storage system as a little over twice that of the overhead system. Experience has confirmed the substantial accuracy of my original estimate in respect to relative cost. The absolute cost for all electric systems is considerably greater than was anticipated. This is partly due to the item of repairs for the electric motor and gearing, which are found to be subject to much greater wear and tear than experience had given reason to anticipate, and partly to the great increase in the number of passengers per car mile, caused by the popularity of the electric cars, which adds greatly to the loads carried. Mr. Whitney then authorised me to construct an electric car operated by storage batteries, and to give the practicability of the scheme a thorough test. This pioneer car, the very first electric car of the West End Company, was put in service in the early part of October, 1887, and was run for some time between Cambridge and Boston. A careful series of tests and measurements showed the cost of operation to be about the same as that of a horse car of equal capacity. The West End Company continued to experiment, putting down the next year an expensive conduit line on Boylston-street, in Boston, and an overhead line on the extension of Beacon-street in Brookline. The comparative results of the practical trial of the three systems was so favourable to the overhead line that the objections of the citizens of Boston were gradually overcome, and at length overhead wires were permitted to be placed in the streets of the city proper.

Are electric railways dangerous? With a view of getting at the actual facts in the case, the *Boston Advertiser*, a few months ago, sent out a circular letter asking information from every city in which electric railways are in actual operation, from Portland, Me., to Galveston, Tex. Replies were published from 64 cities and towns. All but four of them were favourable. Not one solitary instance of accident or serious injury from electric currents was reported.

The average speed of the horse car is about six miles per hour. The question is sometimes asked, How fast may electric cars be safely run in a city street? At first the cable cars were run at the rate of seven miles per hour; afterward the speed was increased to 9½ miles per hour. The records show that there are not so many accidents under the present arrangement as there were before. The schedule rate of the electric cars in Cleveland is nine miles per hour, and in some parts of Boston as high as 12.

Limitation of time does not permit me to mention more at length the work of other American inventors, to whom the development of the electric railway is largely indebted. Among them are Charles J. Van Depoele, of Chicago, now with the Thomson-Houston Company at Lynn, who exhibited a car in operation in

Digitized by Google

Chicago in 1883; Leo Daft, whose motor drew a full-sized passenger car over the Mt. MacGregor Railway at Saratoga in 1883; and especially Lieut. Frank J. Sprague, who designed, carried out, and completed the first installation of electric railroading on a large scale in the world, in Richmond, Va., in 1888. This was a road 12 miles in length, with a great number of curves, a bad track, numerous grades of 10 per cent. and over, and an equipment of 40 motor cars. Labouring under enormous difficulties and drawbacks, Lieut. Sprague succeeded, by the completion and operation of this plant, in establishing beyond peradventure the future supremacy of the electric street railway, and many of the characteristic features at that time designed and introduced by him have practically become standards in the modern system, and are found in nearly every one of the thousands of cars now in service. The limits of time also compel me to content myself with the briefest possible reference to the most important development of electrical transportation which has yet come before the public: the electric underground railway. This undertaking having been placed in the hands of electrical engineers whose competency cannot be questioned, and backed by ample capital, has proved in London a phenomenal success. We are now assured that a syndicate of the most prominent capitalists of New York have undertaken to establish a system of transportation upon the same plan, consisting of a network of tunnels at a depth of 100 feet beneath the surface, and connecting all important points not only in the city itself, but in the adjacent sections of Long Island and New Jersey. Such a system would admit of the running of solid trains at very short intervals through the city, to and from all points in the suburbs, in every direction, and I venture here and now to predict that within the next 20 years, if not the next 10 years, electrical underground transportation will be brought to such a state of perfection that a passenger entering one of the central stations of New York may be deposited at his home station at any point within a radius of 10 miles in 15 minutes' time and at a fare of five cents. And this magnificent result is to be the contribution of the electrical engineer to the convenience and the prosperity of the public.

## ELECTRICITY IN THE FRENCH NAVY.*

BY M. FORIS.

At the present time, when electricity is about to extend the sphere of its operations on board ship by working most of the delicate and complex machinery now to be found there, it may be of interest to sum up in a few words the results which have been achieved during the first period of its utilisation on modern men-of-war, a period which was inaugurated some fifteen years ago by the introduction of the electric light.

The first lenticular projector was placed on board the Emperor Napoleon's yacht, the "Reine Hortense," in the year 1867. Soon afterwards a similar light was installed on the armoured frigate "L'Heroïne," and in 1870 the cruisers "Forbin" and "Destrées" were also fitted with electric light projectors. The generator was the Alliance magneto machine. In 1873 and 1874 the Russian naval authorities, who had closely followed the progress of the new illuminant, had projectors and Gramme dynamos fitted on board the ironclad "Peter the Great" and the Imperial yacht "Livadia." These machines were the first electric lighting Gramme dynamos ever built. In 1877 the French naval authorities again took up the question, and experimented on board the ironclads "Richelieu" and "Suffren," with lenticular projectors and gramme dynamos driven by Brotherhood engines. The improvements now brought about in the construction of dynamos and projectors resulted in electric search-lights becoming part of the regular equipment of our own and of foreign men-of-war. External electric lighting, rendered an absolute necessity owing to the rise of torpedo warfare, thus preceded interior electric lighting by several years. In 1881 the incandescent lamp was first revealed to the public at large by the Paris Exhibition of that year. In 1883, two years later, the French naval authorities were the first to make use of the incandescent light on board the "Redoutable," at Toulon, where 200 eight candle-power Swan lamps were arranged, three in series, and run off Gramme machines, driven by Brotherhood engines. The light was sufficiently successful to cause the authorities to decide to fit 300 lights on the ironclad "Richelieu," the dynamos being driven by high-speed Mégy engines. These early installations, very considerable for that time, were carried out by MM. Sautter-Lemonnier.

The advantages which the electric light possesses over oil and candle lighting for man-of-war work are as follows:—(*a*) Diminution of the staff required to look after the lighting of the ship; (*b*) greater security against fire; (*c*) the many dark and badly-ventilated corners of a modern battleship may be thoroughly illuminated without fear of the atmosphere being rendered unbearable; (*d*) suitability to night signalling.

On a man-of-war, as elsewhere, an electric light installation consists essentially of generators of electricity, mains and lamps, but the conditions imposed are very different from those generally met with on land. The first necessity to be complied with on board a modern man-of-war, namely the compactness required by the very small space available, rendered belting, driving, and slow-speed engines out of the question. The result of this was the creation of a special type of engine, such as the Brotherhood or Mégy, driving the dynamos direct, and running at 1,000 to 1,500 revolutions a minute. In the early days, when a few projectors, each run off a separate dynamo, were all the electric lighting there was, such apparatus sufficed. But as time went on the projectors increased in number, and incandescent lighting was introduced. Larger dynamos had to be built, until at the present day the lighting of a large ironclad requires the expenditure of at least 100 horse-power. For the early plant we have now substituted slow-speed compound-wound dynamos running at about 350 revolutions and driven direct by vertical engines, which are more powerful and more economical, using only from 28 to 33 pounds of steam per E.H.P. hour for an initial pressure of 70lb. to the square inch. The dynamo adopted most widely in the French Navy is the Gramme multipolar machine, though at the present moment we are returning to the two-pole type, as being equally efficient, stronger, and less liable to get out of order.

Within the last few years the Desroziers dynamo (see *The Electrician*, Vol. XXI., p. 762) constructed by the firm of Bréguet has also come into use. In this singular machine the Gramme ring is replaced by a flat disc, upon which the coils are wound, rotating between field magnets whose polar extensions are parallel to its axis. This ingenious dynamo works satisfactorily. Two ships, the "Formidable" and the "Forbin," have had two years' experience of the Desroziers dynamo, and it may be safely said that it has all the good points of other types at present in use in the French Navy, and is moreover lighter, better ventilated, and efficient. The Desroziers machine possesses the extremely valuable feature of retaining a high efficiency on a light load. On board ship a 150 or 200 ampere machine has a normal load of 80 to 90 amperes, so that this property of the Desroziers dynamo is of genuine importance, and it may be said that, other things being equal, this machine is the most economical of any in use on the ships of the French Navy.

The methods employed by the two leading firms to connect the dynamo and the engine merit special attention. MM. Sautter-Lemonnier couple the armature spindle to the engine by the intermediary of springs. The coupling is rigid and little liable to give way, but it is difficult to get at. The firm of Bréguet employ M. Raffard's ingenious coupling. This device consists essentially of two discs, one keyed to the engine shaft, and the other to the dynamo shaft. Upon these two discs are fixed an equal number of studs, arranged in two circles of unequal diameters, each pair of opposite studs being connected together by india-rubber bands. This elastic coupling in addition to its security and convenience has the advantage of insulating the dynamo from the engine.

Whatever else they may do, the engines employed on board ship in connection with the electric lighting must possess the following points: (*a*) Lightness and compactness; (*b*) parts easily accessible; (*c*) economy in steam consumption; (*d*) regularity of running; (*e*) ability to stand damp and heat without injury; (*f*) little attention required when running.

These diverse requirements are by no means easy to combine in a single engine, but French constructors have achieved success. It may be remarked that the difficulties of construction are greatly augmented by the necessity of adapting these plants to the ever-varying conditions brought about by the progress of artillery and metallurgy.

The latest style of engine brought out by MM. Sautter-Lemonnier is of the horizontal tandem type, only 3·6ft. high, and installed on board the cruiser "Davout." On the cruisers of the "Troude" class the combination shown in the accompanying illustration is used. This combination is 4·6ft. high, and is placed between decks below the water-line. For torpedo boats of the "Agile" class, the firm of Bréguet employ a single-cylinder vertical engine, driving a Desroziers dynamo mounted on the same bed-plate. This combination weighs 1,540lb., and has an electrical output of 3,500 watts (70 volts × 50 amperes), the space occupied being 3·8 × 4 × 2·4ft.

Whatever the class of vessel, electrical distribution is carried out at the standard pressure of 70 volts. This particular voltage has been fixed upon as the most suitable for circuits on which there are both arcs and incandescents. Experience has shown that the switching in and out of the projectors does not materially affect the internal lighting. The combination of the two kinds of lighting is only of recent origin; but its importance is very great when we

* From *Le Génie Civil.*

Digitized by Google

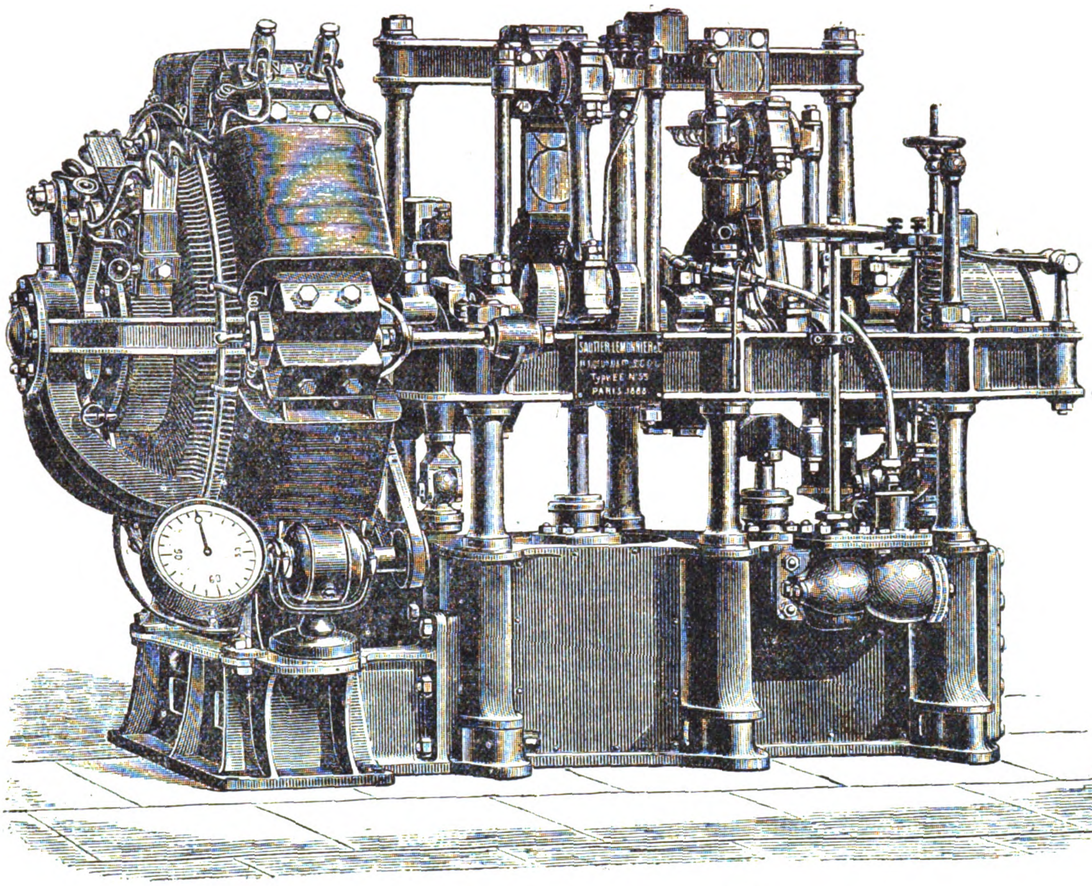
consider that on men-of-war the projectors absorb almost as much power as the incandescents.

The electric lighting system of a modern man-of-war is divided into two main divisions, viz., the internal lighting and the external lighting. The internal installation comprises (*a*) the all-day circuits, namely, those lighting the coal bunkers, passages, men's quarters, &c., in short all those portions of the ship into which daylight never penetrates ; (*b*) the night circuits, which include all parts where daylight penetrates ; (*c*) the sea-circuits, engine room, &c. ; (*d*) the fighting circuits, turrets, shot hoists, powder magazine, &c. The external installation comprises (*a*) the projector circuits, (*b*) the signal circuits, (*c*) the side-light and head-light circuits, (*d*) the miscellaneous circuits. The internal system is moreover divided into starboard and port circuits. The generating plant is usually divided into two groups, arranged under the protective deck, one forward and the other aft. Each group is joined up to special distributing boards which are in turn joined to each other. Hence it is possible to run the forward machines and manipulate the circuits from the other board and *vice versâ*, and matters are so arranged that any dynamo can be connected to any circuit.

One attempt was sufficient to cause the French naval authorities to renounce the employment of the shell of the ship as a return. Of course, the one great aim on board a man-of-war is to arrange matters so as to prevent anything like a complete breakdown of the light during an action. To attain this supreme object the port and starboard circuits are all joined across at intervals by connecting cables, so that when any portion of a circuit is damaged the lights are still supplied with current.

Great improvements have of recent years been effected in the construction of projectors ; they have become more powerful and more manageable, and the old hand-regulated apparatus has given place to one which can be worked automatically if required ; a great advantage when we consider that as many as half a dozen of these lamps are frequently simultaneously in use. The very latest improvement has been to enable the search-lights to be manœuvred from a distance. In future all the ship's projectors will be handled by one man, the captain of the ship perhaps, from the bridge. The electric current thus controls the illumination necessary for defence as well as the offensive armament. For defensive illumination in the immediate neighbourhood of the vessel projectors placed near the water-line and operated from within are now used.

The use of electricity as a motive power has already obtained considerable vogue on board ships, where ventilating fans so driven and little electric drills are becoming common. On the "Formidable" the electric drill has proved of great value. Quite recently a French naval constructor has succeeded in devising a satisfactory method for operating naval gun-carriages by electric motors, and their adaptation to pumps, hoists, and winches is only a question of time. Little by little we shall see the complicated, inefficient, and cumbersome hydraulic and steam pipes disappear from our battleships. Electricity will become supreme, and dynamos of 200 or 300 horse-power will be employed to supply power to the innumerable machines to be found on board a modern man-of-war.



Sautter-Lemonnier Combined Engine and Dynamo for Naval Purposes.

## AN ELECTRIC WAVE MEASURER.*

BY C. GRAWINKEL AND K. STRECKER.

If from any cause the strength of a current in a circuit varies, he change always takes place more or less gradually, the current during the change taking all values intermediate between the original and final ones. This happens more or less rapidly, as may be determined by the self-induction and capacity of the circuit. If, for instance, in Fig. 1, A is the original, E the final value of the current, this change may take place in the time $t_1$ or $t_2$, and even in the same time $t_1$ the change may occur in various ways as shown by the curves in the figure. On telegraph lines such changes follow one another incessantly, and consequently a knowledge of their nature is of great value in this branch of electrical engineering. In many cases this knowledge can be arrived at mathematically, but even then a corroboration is necessary, and sometimes a correction of the calculation is found by experiment to be required. On the other hand, a calculation is often quite impracticable.

In general, one is concerned with the question of determining the current strength at any chosen moment, or the relation between current and time. If these values are plotted out as in Fig. 1, in a system of co-ordinates, wave-like curves are usually obtained. From this fact the apparatus described below has been termed an apparatus for measuring electric waves or, briefly, an electric wave measurer.

We have already several means of solving the question, such as for instance Messrs. Siemens and Halske's soot writer, and Frölich's method of setting out current curves ; but in these cases the current is always measured through its magnetic properties,

* From the *Elektrotechnische Zeitschrift.*

Digitized by Google

and it must be considered that a certain interval always elapses between the commencement of a current and the appearance of its electro-magnetic effects, particularly where the latter entail the movement of a body possessing any considerable amount of inertia. It is only when this interval happens to be so small as to be negligible that one has hitherto had a method free from the inertia of magnetism and mass.

Such a method is, however, easily found. If we insert in the circuit a resistance, having as far as possible neither self-induction nor capacity, and measure the potential difference at the ends of this resistance, the current strength is proportional to the difference of potential. The latter can be measured either by applying the two ends of the resistance to an electrometer, or by connecting them to the terminals of a condenser, which is afterwards discharged through a galvanometer. Care has only then to be taken that connection with the two ends of the resistance is made at the proper moment.

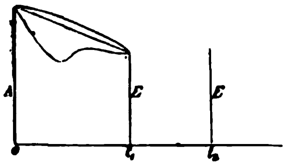



FIG. 1.—Time-current Curves.

This principle is not new, but has frequently been used for ends similar to that now in view, as, for instance, lately by Searing and Hoffmann in the determination of the form of the waves in an alternating current (*Journal* of the Franklin Institute, vol. 128, p. 93, and Fortschritte der Elektrotechnik, 1889, No. 2377).

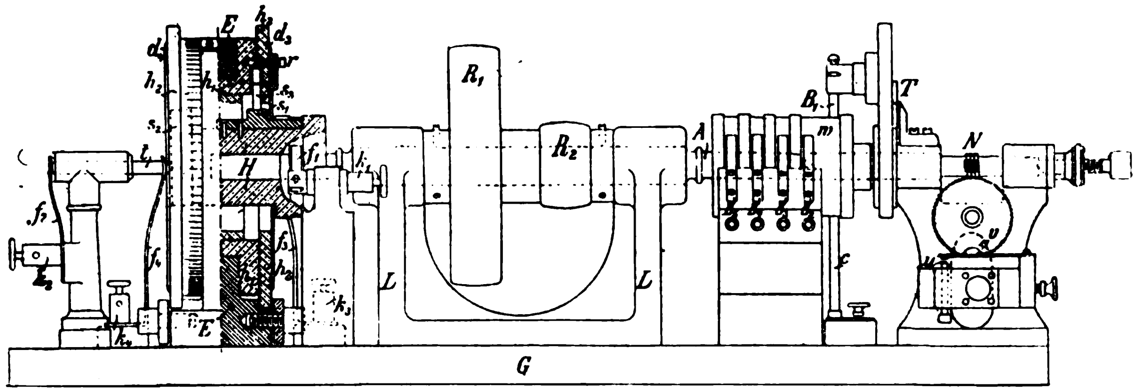



FIG. 2.—Apparatus for Reproducing and Measuring Time-current Curves.

The apparatus used in the telegraph office for the purpose above explained allows making and breaking of the circuit to be repeated at definite chosen intervals, so that a regular series of exactly equal current waves can be produced; the apparatus further renders it possible to connect either one or two points in the circuit at any desired interval in time from the instant of closing or interrupting the circuit to one or both terminals of a condenser,

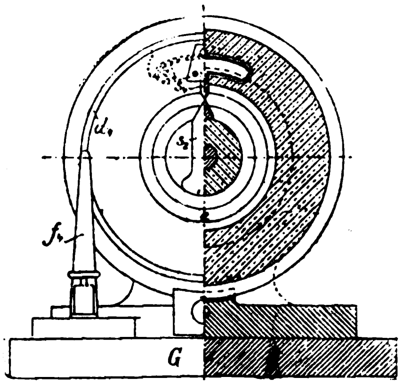



FIG. 3.

and thus to charge the latter with the potential of the one or the difference of potential between the two points. As connecting the condenser terminal to the chosen point of the circuit once only might not suffice to charge it, if the contact last only a few thousandths of a second, an arrangement is made so that the contact may be repeated in an exactly similar manner during several consecutive waves, so as to effect a complete charge of the condenser to the potential to be measured. For a condenser for this purpose an electrometer can be used and the deviation observed, or an ordinary condenser can be used, which, after being charged, can be discharged through a galvanometer.

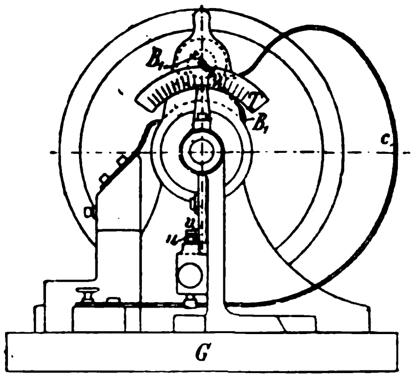



FIG. 4.

The apparatus may thus be used to form curves similar to those in Fig. 1, the ordinate (potential or potential difference) being found corresponding to any abscissa (time after closing circuit).

*Description of the Apparatus.*—In the middle of the bed-plate G (Figs. 2, 3, and 4) of planed iron is the pedestal L, which carries the steel shaft A. Between the two bearings are placed on the shaft two pulleys $R_1$ and $R_2$ of different diameters, one of which serves as a flywheel. The two ends of the shaft that project beyond the bearings are used for making the electrical connections. The left-hand end in Fig. 2 carries on a vulcanite cylinder H secured to the shaft two pointed contacts $s_1$ $s_2$. These, by means of the springs, $f_1$ and $f_2$ and the pin $t$, are connected to the binding screws $k_1$ and $k_2$. At each revolution of the shaft $s_1$ and $s_2$ make a single contact with the pointed contacts $s_3$ and $s_4$; the binding screws $k_1$ and $k_2$, as shown in diagram in Fig. 5, are connected with the two points in the circuit $p_1$ and $p_2$ between which the potential difference is to be measured. The points $s_3$ and $s_4$ are connected by means of the wires

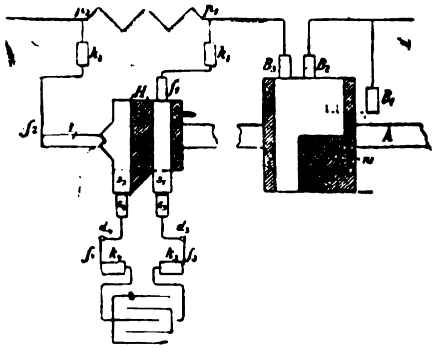



FIG. 5.—Contact Breakers

$d_3$ and $d_4$ laid in the vulcanite plate and the springs $f_3$ and $f_4$ bearing on them, with the binding screws $k_3$ and $k_4$, from which wires are carried to the terminals of the condenser or electrometer. Thus, at each revolution of the shaft, the point $p_1$ is brought into contact with one terminal and $p_2$ with the other terminal of the condenser.

Digitized by Google

The points $s_3$ and $s_4$ are attached to light springs in the vulcanite discs $h_1 h_1$ and $h_2 h_2$; the points can each turn independently on the iron ring E which carries them. The position of the points $s_3$ and $s_4$ can be read off (referred to a zero position which can be chosen) on two segments of circles, one only of which is visible in the figure. It is therefore possible by turning the vulcanite discs to set them so that the contacts between the points $s_1$ and $s_3$ and between $s_2$ and $s_4$ take place at any chosen moment, and to read off on the segments the position then occupied by the shaft. The two vulcanite discs can also be connected by a screw so that they both turn together. At $r$ are shown regulating devices by which the points $s_3$ and $s_4$ can be accurately set in position.

If the measurements are taken with the condenser and galvanometer it is sufficient to connect the point $p_2$ directly to the second terminal of the condenser.

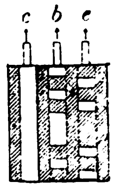



FIG. 6.—Contact Breakers to Imitate Morse Signals.
c Brush Connected with Conductor.
b " " " Battery.
e " " " Earth.

At the right-hand end of the shaft are several contact breakers. A vulcanite cylinder $w$ is placed on the shaft and furnished with several brass strips on its surface; on these slide brushes $B_1$ to $B_5$ in connection with binding screws. The first of the five brushes, which is connected to its binding screw by a long copper ribbon $c$, can be adjusted on the circumference of the vulcanite cylinder, its position being read off on the segment T. The surface of the vulcanite cylinder, with a brass strip of simple form, is shown developed in Fig. 5. A is the shaft of the apparatus; $B_1$ is the adjustable brush (shown at the side of the cylinder, its real position being indicated by the dotted lines.) $B_1$ and $B_2$ lie, during a revolution, sometimes on vulcanite, sometimes on brass. $B_3$ lies throughout on brass.

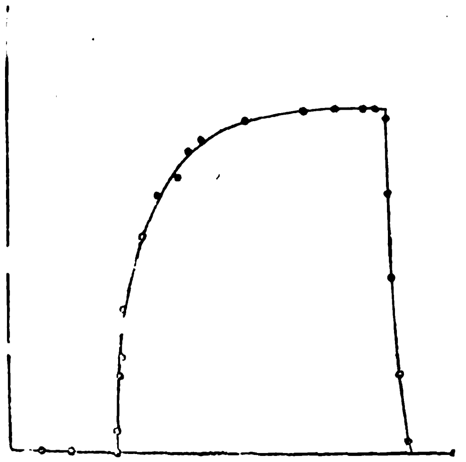


FIG. 7.—Curve Obtained from Readings given in Table.

The current will pass through the brushes $B_1$ and $B_2$ to $B_3$; so long as $B_1$ and $B_2$, or one of them, touch the brass the circuit is closed; whilst they touch ebonite it is broken. If $B_1$ and $B_2$ are placed close together, the circuit is closed through one-half and open through the other half of a turn. If $B_1$ and $B_2$ are exactly opposite the circuit is always closed, one or other of them being always on brass, so that the duration of the current can be regulated between a half and a whole revolution. If the current goes through $B_1$ and then through $B_2$ (in series) the circuit is closed so long as $B_1$ and $B_2$ are both on brass; if both brushes are together in each revolution, the circuit is closed during half of it, and if they are placed opposite the circuit is never closed, so that we can thus make the time during which the circuit is closed less than that of half a revolution.

For telegraphic researches it is useful to break the current so as to represent telegraphic signals. Fig. 6 shows the arrangement for the letter $f$ in the Morse alphabet (▬ ▬ ▬▬▬ ▬ ▬). The conductor is connected to the first brass strip, which is a complete ring, by means of a brush. The next ring shows alternately brass and ebonite; the brass portions which are in electrical conection with the brass ring form the dots and dash for an $f$. The third ring shows a form exactly the reverse of that of the second, its brass parts being also connected with the brass ring. The second ring is connected to the battery and the third to earth by their own brushes. If the second brush is on brass, the third is insulated and the current flows into the conductor; if the second brush is on ebonite, so that the battery is insulated, the third is on brass and the conductor is connected to earth. The cylinder shown therefore reproduces exactly the Morse character; the time can also be determined between the closing of the fixed contact and the opening of the working one. Similarly, cylinders can be arranged to give any other combination. As a rule, two or three only of the five brushes need be used.

At the right-hand end of the shaft is an arrangement for registering the revolutions. An endless screw, N, turns a wheel with 100 teeth. This carries a pin, $v$, which closes a contact, $u$, once during each revolution of the wheel. The number of contacts can easily be registered, or the time between two successive contacts can be taken. The speed is thus ascertained, and it can be seen whether it remains constant. To drive the apparatus one of Siemens and Halske's motors was used (K type ½ horse-power), with a cotton belt. It was found that the speeds, which ranged up to 30 or 40 revolutions per second, were quite constant.

*Results.*—After the condenser had been brought sufficiently often into contact with the points $p_1$ and $p_2$, it was cut out of circuit, and connected to the terminals of a sensitive galvanometer, and the deflection observed. This gave a value for the potential difference between $p_1$ and $p_2$, and the ordinate of the curve was determined; the abscissa is the time from the moment of contact of the brush B to that at which $p_1$ was connected to the condenser. This was read off in degrees and so obtained in fractions of the circumference.

The following is a series of readings, and Fig. 7 is the curve obtained therefrom. For plotting it, the values given in millimetres were taken for the ordinates. For the abscissæ 1mm. = ·0011 second; a complete revolution occupied ·15sec., the speed being, therefore, 400 turns per minute.

| Abscissæ. | | | Ordinates. | |
|---|---|---|---|---|
| Reading in degrees. | In fractions of circumference. | In m/m. circumference = 136mm. | Deflection of Galvanometer. | 1p = ·39mm. |
| 11 | 0·028 | 4·1 | 0p | 0· |
| 21 | 0·058 | 7·9 | 0 | 0· |
| 37 | 0·103 | 14·0 | 0 | 0· |
| 38 | 0·106 | 14·2 | 5 | 2·0 |
| 39 | 0·108 | 14·7 | 25 | 9·8 |
| 40 | 0·111 | 15·1 | 30 | 11·7 |
| 41 | 0·114 | 15·5 | 40 | 15·3 |
| 42 | 0·117 | 15·8 | 50 | 19·5 |
| 47 | 0·131 | 17·7 | 70 | 27·4 |
| 52 | 0·145 | 19·6 | 85 | 33·2 |
| 57 | 0·169 | 21·5 | 92 | 36·0 |
| 62 | 0·172 | 23·4 | 100 | 39·0 |
| 67 | 0·186 | 25·3 | 104 | 40·6 |
| 92 | 0·228 | 31·0 | 110 | 43·0 |
| 102 | 0·284 | 38·5 | 114 | 44·5 |
| 112 | 0·311 | 42·3 | 115 | 44·8 |
| 122 | 0·339 | 46·0 | 115 | 44·8 |
| 127 | 0·353 | 48·0 | 115 | 44·8 |
| 130 | 0·361 | 49·0 | 112 | 43·7 |
| 131 | 0·364 | 49·4 | 85 | 33·2 |
| 133 | 0·370 | 50·1 | 25 | 9·8 |
| 135 | 0·375 | 51·0 | 3 | 1·2 |
| 152 | 0·423 | 57·3 | 0 | ·0 |

The apparatus used was manufactured by Herr H. Heele, Berlin.

## HAVOC AMONG THE POLES AND WIRES.*

If the elements continue through the year to treat the telegraph and electric overhead lines as roughly as they have during the month of January in the year of grace 1891, the companies in this section of the country will find the balances on the wrong side of their ledgers. Every Sunday thus far since the beginning of the year has been stormy, with more or less damage to telegraph and electric conductors. Last Sunday, however, was the climax, for on that day the destruction of poles and wires in New York and the region round about was even greater than during the memorable blizzard of March, 1888.

The storm began on Saturday night with rain, followed by snow and wind, and apparently concentrated all its energies against the telegraphic system of the city. The result was the almost complete

* From the *Electrical World*, New York, Jan. 31, 1891.

Digitized by Google

demoralisation of the telegraph and telephonic service. Poles and wires went down in all parts of the city like so many toy telegraph lines, and as far as one could see along entire avenues were masses of broken and prostrate poles and hopelessly tangled wires. When the storm ceased and the sun came out the sight, even where the poles were not down, was both unique and impressive. Great white hawsers had taken the places on the poles where telegraph wires had been the night before. From pole to pole, swinging low down toward the earth, these hawsers hung as thick as a man's arm. The poles themselves had grown to an enormous size, and they, too, had changed from a rusty brown to the purest white. Their cross-arms, formerly small joists painted red, were now heavy pieces of timber and all white.

The telegraph and telephone companies were the greatest sufferers, and so complete was the work of destruction that New York's sole means of communication with the rest of the country for the twenty-four hours following three o'clock Sunday morning was over three Western Union Telegraph wires—one to Albany, one to Buffalo, and another to Chicago. But these surviving wires worked so poorly that only a very limited amount of business could be transmitted over them. Every message handed in at the telegraph offices

Scene in Thirty-Ninth Street, New York, after the snow-storm of Sunday, January 25th.

was received "subject" to indefinite delay. The officials were all of one opinion, that the storm had almost beyond doubt been the most disastrous for telegraph and telephone companies ever experienced. The few reports that are in show that the storm area was large.

The American Telegraph and Telephone Company, with its highly-perfected long-distance equipment, which has stood previous storms so admirably and which furnished the only communication with Boston for two days during the great blizzard, was badly worsted by this storm. All day Sunday and late into the night efforts were being made to break the blockade and provide a channel for business before the telegraph companies recovered.

All of the land wires out of the city belonging to the Commercial Cable Company were down, and they were handling no business. The Associated Press office in the Knox building was a great sufferer. Not much more than 1,000 words were received Sunday morning, afternoon, or evening, while it is a usual thing for 15,000 words to come in at that office every night. The Western Union was not able to handle more than 2,500 words of the matter the association offered. At the office of the United Press, in the Pulitzer building, it was stated that their business was at an absolute standstill, and they were unable to furnish the hundreds of newspapers depending on them a single line of news, domestic or foreign. The Metropolitan Telegraph and Telephone Company had a tale of direful disaster to tell. As far as they were able to ascertain the whole of their uptown service was crippled. The long-distance service shared in the disaster, and it is probable that the effects of the wreck will be felt for at least two months to come.

Nor were the electric light companies much better off. The direct damage done them was considerable, but far more serious was the tangle of fallen telephone and telegraph wires that crossed their lines in every direction and made it imperative to shut down for the protection of life and property. This precaution was ordered by the Board of Electrical Control, and all night the metropolis was in darkness. As it was, the live wires were unpleasantly frequent, but beyond shocking half-a-dozen pedestrians and killing a solitary street-car horse no serious results ensued. All the companies that operate overhead wires suffered, the Mount Morris Company most severely, perhaps. The Edison system, alone, which has all its wires under ground, escaped quite unscathed. Outside the city the case was just as bad.

The damage done in Brooklyn alone, on a conservative estimate, would amount to $100,000. And elsewhere it was the same story of disaster, Jersey City, Newark, Orange, Hoboken, all suffered alike. Telephone and telegraph poles fell by dozens, wires were hopelessly tangled and crossed with electric light wires, and the electric service all about New York was simply paralysed. Altogether, the storm was the most disastrous one for many years, and while an exact estimate of the damage done will not be possible for some days, it will probably rise in New York and vicinity to not less than a million of dollars. Our sketch gives but a feeble idea of the state of the wreck at one of the points. Scenes quite as bad were to be seen all over the upper part of New York City.

## THE LONDON COUNTY COUNCIL AND TECHNICAL EDUCATION.

At the meeting of the London County Council on Tuesday, the report of the Special Committee on Technical Education (see *The Electrician*, January 23rd, p. 376) came on for discussion.

Dr. Longstaff, the chairman of the Special Committee, said he was anxious to emphasise the fact that this was by no means a unanimous report. The fundamental question was whether there really existed a need for technical instruction. Was the end desired one which individuals could accomplish by themselves? If it was an end which the individual could accomplish, it was not desirable that the municipality should accomplish it. He thought, however, that it was absolutely hopeless to suppose that any technological instruction could be given to mechanics at such a cost that they could pay for it themselves. By no conceivable means could the artisan pay the sum the teachers and apparatus required. The next great thing they must prove was that technical education was so important that it was worth their while to do it in a combined or social fashion.

Mr. Benn moved: "That the sum to be received from the beer and spirit duties on account of the current financial year (over and above the £140,000 placed to the credit of the general county account) be carried to the credit of the general county account." The position of London in this matter was, he said, quite distinct from that of any other county council, because in no other district in the kingdom were educational funds held, as they were in the City, by a clique of men occupying only one-hundredth part of the whole area. He proceeded to give particulars of what the City companies had spent on technical education since 1878, and said that the entire sum did not amount to one year's income of the companies. The total amount now devoted by the companies to technical education out of their corporate funds was not more than £35,000 per year.

Mr. C. Harrison said London stood in an exceptional position. It had the City Guilds funds of £800,000 a year, and it had the Parochial City Charities Fund, recently placed under a scheme, and dealing with £100,000 a year. Up to the date of the Act of 1889 the City Guilds granted out of the Consolidated Fund to 878 institutions in the Metropolis £14,869, and beyond that nothing was done

Mr. Cohen thought that Mr. Harrison was hardly accurate, certainly not in stating to the Council that the income of the City companies was £800,000. The spendable income of those companies was £425,000 a year. How much of the sum within their control they did spend on technical education and other beneficent works could best be judged by a few figures, which he submitted to the Council. The companies had spent alone £350,000 on the varied work of the City and Guilds Institute since 1877.

Earl Compton opposed Mr. Benn's amendment, because he believed that it was to the interests of England that London, the chief centre of commercial activity in the world, should have a proper system of technical instruction and intermediate education. That was a prime necessity if they were to compete successfully

with the other nations of the world. He looked on this £23,000 as a stepping-stone to this object.

The CHAIRMAN (Sir John Lubbock) said the Council was asked whether it was desirable that they should undertake this immense addition to their present duties. In this case, however, it was not a question whether they should undertake a new duty, but whether they should shrink from an important duty entrusted to them. They had not to consider whether it was desirable to add another to the educational authorities already existing in London. That had been decided by Parliament. They were an educational body, and the only question was whether they would fulfil or neglect their duty in this respect. As far as technical education was concerned, they were the *only* London educational body. No other public body could apply any London funds to the purpose of technical education except themselves. If the technical institutions now being formed were to receive any aid from London in its corporate capacity it must be from the representative body of London. Mr. Benn blamed the City companies. He (Sir John Lubbock) could not pretend to give a complete account of what they had done for technical education. But to the City and Guilds of London Institute they had contributed £350,000. The Goldsmiths' Company had given also £135,000 to the New-cross Institution. The Carpenters' Company maintained the Technical Institute at Stratford. The Clothworkers had given £40,000 and £4,000 a year to the Yorkshire colleges. The Draper's Company had given £50,000 and £5,000 a year to the People's Palace. The vice-chairman asked them to wait until there was an entire reorganisation of the whole government of the metropolis. Others again, because the City companies had not, in their judgment, done enough, asked them to do nothing. The £23,000 under discussion was merely the first instalment. What they had really now to consider was the principle. Many other counties throughout England had devoted this money to technical education; some of their wisest and most advanced cities had gone even further, and rated themselves for the purpose. That they were not asked to do. He sincerely trusted that London would not remain behind other counties in this respect.

The Council divided, and there voted—

| | |
|---|---|
| For the amendment ... ... ... ... ... ... | 50 |
| Against ... ... ... ... ... ... ... ... ... | 45 |
| Majority for ... ... ... ... ... ... ... ... | —5 |

Mr. BECK then moved, and Mr. BERESFORD-HOPE seconded the following amendment:—"That if in any future year any portion of the money derived from the beer and spirit duties shall be handed over to the London County Council, the whole sum so received should be appropriated to the advancement of technical education." This was negatived, and the further consideration of the question was adjourned.

## AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *January* 30, 1891.

**Electric Traction in New York.**—Mayor Grant has apparently executed a change of front, the result of his trip to Boston to study the operation of the trolley system in that city. A franchise has been granted to one of the New York railway companies permitting it to string overhead wires on the upper part of Manhattan Island for the purpose of operating its cars. This step has aroused a storm of opposition, ostensibly coming from an outraged public, but probably emanating from a few newspaper offices, abetted by storage battery interests. Whatever the cause, the press has made a furious onslaught upon the permit just granted. Nevertheless, it is likely the road will be built, and the public will be only too glad to ride upon it after its completion. The electric roads at Boston have had a curious effect on property lying along their lines. The outlying districts have been greatly benefited in every way, and real estate has risen in value. In the central suburban district, however, the reverse has been the case, for the reason that the localities, which in the days of horse cars were at the extreme available limit for a residence district, now fall so far within it that the growth is largely outside of them. This, of course, is not pleasant to the property holders who are affected by this movement, and it is the protestations of this comparatively small part of the community that have been raised so loudly against the overhead system. They would be equally violent in denouncing any other form of rapid transit that enabled the less wealthy portion of the populace to build up new suburbs beyond the present ones.

**The Westinghouse Company.**—The Westinghouse Electric Company appears to be gradually emerging from the financial difficulties in which it has fallen, and there is every prospect of a speedy solution of all its difficulties. Mr. Westinghouse has been untiring in his efforts to sustain the Company through this critical period, and has met a remarkable degree of success in his work. The Stock of the Company has partially recovered from the extreme low water mark it reached a couple of weeks ago, and the outlook is decidedly brighter in every way.

**Edison Thomson-Houston Electric Traction Motors.**—The Edison Company is preparing to bring out some novelties in the way of street railway motors. One of these is a motor truck driven by two motors of comparatively low speed, each one wound for 250 volts and operated in series. Another is a device more especially the result of Mr. Edison's investigations, and contemplates the use of a single large four-pole motor, driving the car axle by means of a steel linked belt of peculiar construction. The Thomson-Houston Company is also making some modifications in its motor equipments, and experiments are being carried on by the closed conduit system patented recently by Mr. Vandepoele.

## PARIS NOTES.

(FROM OUR OWN CORRESPONDENT.)

PARIS, *February* 10, 1890.

A new form of single fluid battery was shown at the last meeting of the *Société Internationale des Electriciens* by M. de Meritens. The negative electrode is of zinc; the positive electrode is a carbon plate, covered on the surface opposite the zinc with a thin sheet of platinised lead, the carbon itself being pierced with numerous holes. The electrolyte is a 10 per cent. solution of sulphuric acid, and the working E.M.F. is ·8 volt. The chief point of interest in connection with this cell is the fact that when the circuit is closed a torrent of hydrogen bubbles rises up through the holes in the carbon, but there is absolutely no liberation of gas on the platinised lead itself. Polarisation effects are, therefore, reduced to a minimum. M. de Meritens also described to the meeting a scheme for electrolysing sulphate of zinc with iron electrodes and obtaining pure zinc and sulphate of iron. The zinc he proposes to employ in his primary battery, the sulphate of iron being an article of commerce. The combination of these two ideas have sufficed to cause the Parisian daily Press to announce the approaching substitution of de Meritens cells for dynamos in all the Paris central stations. Tests of this cell will shortly be carried out at the Ecole Municipale de Physique et de Chimie Industrielles, so that we may soon expect to ascertain the exact value of M. de Meritens much trumpeted invention.

Since the transfer of the telephones to the State there has been a remarkable extension of inter-urban telephony. The Paris-Nantes trunk wire, 225 miles long, is expected shortly to come into operation, the charge for a conversation of three minutes being 2fr., and a line connecting Paris and Bordeaux, a distance of 325 miles, will probably be finished by the end of the present year. The group of towns forming the centre of the southern wine district, Cette, Narbonne, Montpelier, and Nimes, will also be placed in telephonic communication with one another, although the local authorities are not showing themselves very eager to make the temporary advances in support of the scheme which Government regulations demand. Rouen, which forms the centre from which radiate trunk wires, to Havre, Dieppe, Elbœuf, and Louviers, is also to have a Paris wire, so that the capital will soon be able to speak with the first port of France, over 100 miles distant.

The electric meters sent into compete for the Municipal prize are now being tested by the committee of experts, and it is hoped that the award will soon be announced.

## CORRESPONDENCE.

### ELECTRIC AND MAGNETIC THEORIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I do not know whether it is my fault that Mr. R. S. Cole, p. 433, misses some of my points and gives me others I have not tried for. I endeavour to speak plainly. My "sweeping condemnation" is confined to one thing, viz., the making of assumptions without proof, and pretending that a hypothesis is an explanation; the instances may be manifold, that is a detail, it is still only one thing I condemn.

Digitized by Google

Mr. Cole gives a *resumé* of certain hypothetical growths: it is clear and interesting, but what I ask for is *proofs.* That facts are covered by a hypothesis amounts to nothing, because it is invented for the purpose; that it covers other then unknown facts, or even leads to their prediction, amounts to nothing. The later facts may be really consequences not of the hypothesis, but of the earlier facts; also, there is nothing to prevent several other explanations equally fitting the facts, so that this mere fitting of facts is no real evidence. Mr. Cole says this himself at the end of paragraph 2, but misses seeing that it justifies my objection to the etherial electric theories as being mere and needless hypotheses.

Paragraph 3 scarcely meets my point. My objection, which applies to all the etherial notions, is that we know absolutely nothing about the ether; therefore, no one is justified in applying to it the dynamical laws and the mathematical formulæ, which are wholly based on the properties of matter, while we are positively sure that it does not possess those properties. We have every reason to believe that if ether exists, it has its own specific properties and its own laws, as yet unsuspected; that if ever discovered these will need modes of analysis utterly different from those which apply to matter; and that till discovered the true philosophy is to say that the ether transmits light across space, but that we know absolutely nothing about the process, and that any pretended explanation is mere make-believe knowledge and "science falsely so called."

As to the existence of electric waves, and the consequences deduced from the experiments of Hertz, what I say is that they do not prove the existence of the ether, which Mr. Cole substantially agrees with. The fact is self evident that the impulses of electric induction, being periodic intentionally, and being of necessity of the nature of gradual increase and diminution, must be undulatory actions; and that Hertz's experiments are purely very interesting processes for examining the well-known effects of electric induction, first discovered by Faraday and Henry, well shown years ago by Willoughby Smith, and attributed to etheric force by Edison and Batchelor a little too soon, because before the phenomena of intermittent currents had drawn eager attention to the subject, and a certain school of philosophers had taken up the ether as a convenient explanation of anything they could not understand, and put into a formula.

As to the discussion itself, I propose, at the Editor's suggestion, to put my views into the form of some articles on the electric current and its laws.—Yours, &c.,

JOHN T. SPRAGUE.

---

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Pressure of engagements has delayed me in replying to Mr. Sprague's invigorating answer to my expostulations, and I shall be too late for this week's issue.

I am glad to see that on one matter the difference between us is resolving itself into one of mere interpretation of terms. I had asked Mr. Sprague whether he was prepared to maintain that Ohm's law, pure and simple, is applicable to alternating currents, and to currents in the variable period. He replies "Yes," and then proceeds to set up a nice distinction by saying that he separates the law itself from the formulæ by which it is expressed. And, if I rightly understand what follows in this transcendental distinction, he admits that the law has to be adapted to these cases by the introduction into the formula of "a variable function." By this term I think he must mean a factor, or coefficient, of which the value is not constant, but varies with the time. If so, I entirely agree with him, because such a factor is quite necessary in any formula that is to be true to the facts. For example, the facts about an alternating current are that the alternations of the current lag behind those of the electromotive force, and are diminished in amplitude (as compared with what they would be if they obeyed Ohm's law *pure* and *simple*), in a way that depends on the amount of lag. Of course it is possible, when the circumstances of the case are known, to frame the appropriate factors which take into account the time-lag and the diminution of amplitude depending on that lag. Having done this, we can insert them into Ohm's law, which is, therefore, no longer Ohm's law pure and simple. *Ohm's law pure and simple has no time-factors in it.* Whether we ought to call it Ohm's law when we have altered it by putting time-factors into it is the verbal question upon which Mr. Sprague and I differ.

Now I come to another matter, which is more serious, not being a question of terms but of facts. Mr. Sprague has set himself to champion, and that in the most solid and consistent way, the doctrine of the longitudinal transference of energy. All honour to him for this plainness of speech. Desiring to emulate him, and to be equally consistent in maintaining the doctrine of lateral transfer, I beg him kindly to help me to frame some definite statement of the point at issue. Let us first be quite sure that we understand each other's use of language. I will begin by asking him whether he assents to the following statements, and, if not, how he would propose to amend them:—

(1) When a lamp is being worked from a battery or a dynamo, the energy which is furnished by the chemical action in the battery, or by the mechanical action of the dynamo, is transferred, in some way or other, from the source to the place where the work is done at the lamp.

(2) The energy so received by the lamp is transformed, at least in part, into heat and light (which are themselves other forms of energy).

(3) When a conducting wire is heated by the passage of an electric current through it, the energy which it receives electrically, in some way or other, from the source is dissipated in the form of heat, which escapes by radiation, convection, or conduction.

(4) When an electric current is generated (or "induced") in a circuit separated by an insulating medium from a moving magnet, there is a transfer of energy, in some way or other, through the medium, from the magnet to the circuit.

(5) When an electric current is generated (or "induced") in a secondary circuit, separated by an insulating medium from a primary circuit in which a current is varying, there is a transfer of energy, in some way or other, through the medium, from the primary circuit to the secondary circuit.

I have tried to state these propositions in language that we can both adopt; but am quite open to suggestions as to phraseology from Mr. Sprague. In Nos. (1) (3) (4) and (5) I have purposely put in the words "in some way or other" to cover the question on which we differ. If we can agree to some statement that thus covers the matter at issue we shall be the better able to state clearly, fairly, and consistently our views, and argue them. Let us do so with the common hope that neither of us may gain any momentary advantage from any slip or indistinctness in the other's words; but that whichever view as to the transfer of energy is the true one, and better represents the facts than the other, that view may come out into clear relief as being the truer view.

Mr. Sprague says at the bottom of page 406:—"The point in debate is the longitudinal transfer of energy." I quite agree that that is the point. He is prepared to argue that the energy is transmitted longitudinally along the conductor "from the source to the work." I am prepared to argue that it is transmitted in another way, not longitudinally along the conductor. I think we understand that clearly. If we don't, then let us come to an understanding before another word is spoken. I do not like that Mr. Sprague should say (as he does on page 406) that I have shifted my ground. I am trying to make sure that we are on common ground from which neither of us can shift, and I do not admit having shifted one iota from the position which Mr. Sprague has assailed.

Since writing the preceding paragraphs your issue of the 6th has brought me Mr. Sprague's second letter on page 434. I am glad to find that he too wishes to arrive at an understanding of the meaning of terms. I agree with him in applying the term ether to a "hypothetical substance," "probably existent," and probably should not quarrel much with anything he says about it on page 434, except with his assumption that it can take no structure. But all this is not really to the point and only tends to confuse the issue. I shall be quite content to do for the present without using the word ether; and will not ask for any less dense medium than common air. We shall then be spared any ulterior disagreements as to what might be the

Digitized by Google

case if the space occupied by the air were empty. The question at issue, whether the energy that goes from "the source" to "the work" is conveyed longitudinally by the copper, or is not so conveyed, can be argued without complicating the matter with the ether puzzle. One thing at a time will suffice, so it be well and honestly done.—Yours, &c.,

February 7, 1891. SILVANUS P. THOMPSON.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: There is one point in Mr. Sprague's letter on the above subject in your last issue to which I would beg permission to call attention. It is his statement that the ether "can possess no momentum." This assertion is made without any indication of the grounds on which it rests. I can only surmise that it is looked upon by the writer as a necessary consequence of the ether not gravitating. If this be the case, then Mr. Sprague's argument can be summed up in the following words :—"What has no gravitation can have no inertia; what has no inertia can have no momentum; what has no momentum cannot be made the subject of mechanical reasoning. Therefore ether cannot be made the subject of mechanical reasoning. But the proof that ether exists is based on mechanical reasoning, therefore the proof is invalid." If the preceding be a correct summary of Mr. Sprague's argument, I fear it will not be generally accepted as sound reasoning.—Yours, &c.,

GAVIN J. BURNS, B.Sc.

## THE INDUCTION COIL AND DR. CALLAN, OF MAYNOOTH COLLEGE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am glad to see that Dr. Fleming, in his valuable Papers on the induction coil, brings out the fact, generally overlooked by other writers, and probably unknown to most of them, that the first induction coil was made by Dr. Callan, formerly Professor of Natural Philosophy in Maynooth College. It may be interesting to Dr. Fleming to know that at the meeting of the British Association in Dublin, in 1857, Dr. Callan read a Paper giving a short account of this invention, and of his own share in its subsequent development. This Paper he afterwards published, in a somewhat expanded form, in the *Philosophical Magazine* for November of the same year.

I may add that for some years before his death, which occurred in January, 1864, he devoted much of his time to the construction of an induction coil of colossal size, made entirely after his own ideas and embodying all his latest inventions. Though left unfinished at the time of his death, this coil was quite capable of being worked, and it remained, so far as I know, by far the most powerful apparatus of its kind in the world, down to the construction of Mr. Spottiswoode's great coil, about the year 1878. It is still preserved in Maynooth College as one of the most cherished treasures of the Physical Laboratory.—Yours, &c., GERALD MOLLOY.

Catholic University of Ireland, Feb. 9, 1891.

## RESISTANCE COILS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to the claims of priority now being advanced for the single wire method of winding resistance coils, will you allow me to state that in the early months of the year 1878 I made, and have still in use, a Wheatstone bridge, cable pattern, the coils of which were wound in the way described? The only advantages then anticipated were better insulation and greater convenience in winding, the coils in the absence of a lathe being wound with a hand winch.—Yours, &c., EDWARD W. ADAMSON.

Beachy Head Relay Station, Eastdean,
Eastbourne, Feb. 9, 1891.

## "MORE BOARD OF TRADE RULES."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Under the above heading you make a remark in your issue of the 6th inst. which I am somewhat at a loss to grasp, and though an explanation presents itself, it is one which, considering the tone of your leader, may hardly be that intended by the writer on the subject. Your words, "Little is known about inspection beyond the ridiculous salaries offered in London and Liverpool," are, to say the least of it, surprising, for the marketable value of a commodity usually fixes the price to be paid for the same, and it is but natural that where labour is in question the same principle should hold. Now, I have good means of knowing how and by what method the salary paid, or rather at the time *to be paid*, to the Electric Inspector of Liverpool was fixed, and, considering the exact and careful attention bestowed upon that question, upon the next, *i.e.*, the candidate to be appointed to the first inspector ship under the E.L. Acts, and lastly, as to the methods, facilities and powers to be vested in the office afterwards, it is rather amusing than otherwise to read of the "ridiculous" salary. True, it may be smaller than is paid in certain cases by commercial firms for similar value in labour and training, but a corporate body possesses such stability and affords such a field for training, together with the *entrée* of central stations and other works, that a post of this class does not lack advantages, apparent to some, which in part compensate for the scanty remuneration paid on appointment.

In London it is but natural, considering the vast area to be covered and the complexity of interests, that the operations of the officials of the London County Council should progress but "slowly," though those who take the trouble to follow their action notice the "surely" which qualifies a modest pace. In the provinces, where the ground is smaller in area and less difficult to master, and, most of all, where continuous currents have solely, as yet, to be dealt with, the work of electric inspectors necessarily proceeds apace, and as supply companies recognise the use and protection afforded by these officials they will, and perhaps even now are, be regarded less as a "necessary evil" than as a wholesome restraint upon the underlings actually employed in supply and in erection, and whose deeds so often fail to reach the chief of the works.

Little may be known in certain quarters of the work of officials already appointed, but that is rather for want of asking than because of nullity of effect.

One last word, and, with many apologies for occupying your valuable space, I will close. Does anyone consider that an electrician with commercial knowledge and thorough technical training capable of fulfilling the duties required under the Act could be obtained for less than salaries paid in London and Liverpool?

It must also be remembered that the individual will probably be required to act as superintending engineer on any electrical work carried out by his corporation, and in all cases with exception of the metropolis, the inspection and testing of mains when being laid, and afterwards, will fall to his lot.—Yours, &c., "IN STATU PUPILLARI."

Liverpool, February 11th, 1891.

[The salary of the inspector at Liverpool is £150 per annum, and it was seriously suggested that this should be paid by the electric supply company.—ED. *E.*]

# LEGAL INTELLIGENCE

### Dickins v. The Metropolitan Electric Supply Company (Limited).

This was an application before the Master of the Rolls, Lord Justice Bowen, and Lord Justice Fry, for a new trial. The action, a full report of which appeared in *The Electrician* of November 28, 1890, was brought by Messrs. Dickins and Jones, the well-known drapers of Regent-street, against the defendants, who were supplying them with electric light, for damages for suddenly cutting off the supply and plunging their premises into darkness. Mr. Justice Stephen, before whom the case came, non-suited the plaintiffs, holding that there was no evidence of any contract to go to the jury, and that the defendants were only supplying the plaintiffs at will, and could at any moment stop the supply of light. The plaintiffs appealed.

Mr. Jelf, Q.C., and Mr. R. A. M'Call were for the appellants, and Mr. Lumley Smith, Q.C., and Mr. R. B. D. Acland for the respondent.

The Court granted the application, and ordered a new trial of the action.

The Master of the Rolls said that he thought the learned judge had taken too strict a view of the matter. The question was whether there

Digitized by Google

was any evidence which could go to the jury of any contract between the defendants and the plaintiffs for the supply of electric light. In his opinion there was such evidence, although he would not say that the jury must necessarily find that such a contract existed. There was evidence of an agreement between Pritchett and the plaintiffs which appeared to have been adopted and acted upon by the defendants when they took over Pritchett's business. The case must therefore go for a new trial.

The Lords Justices concurred.

## TRADE NOTES AND NOTICES.

*[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.]*

TENDERS WANTED.—The Special Sub-Committee on Electric Lighting of the Glasgow Corporation invite tenders from any company or person who may be willing to become, for any period not exceeding 21 years, the transferees of the Corporation for the purpose of undertaking all the obligations which by their Electric Lighting Order are imposed on the Corporation with reference to the compulsory area of supply defined in the second schedule to the Order. Intending tenderers are referred to our advertisement pages for further particulars as to the conditions of contract. Copies of the Corporation Provisional Order and any further information may be had on application to Mr. J. D. Marwick, Town Clerk, and sealed tenders will be received by him on or before Saturday the 28th instant.

DISSOLUTIONS OF PARTNERSHIP.—The *Gazette* announces the dissolution of the partnership between Messrs. Luckhoff, Hungerbuhler and Co., electrical engineers, of 64, Holmesdale-road, Croydon. The business carried on under the name of James White, electrical and scientific instrument makers, 16, 18 and 20, Cambridge-street, and 209, Sauchiehall-street, Glasgow, will in future be divided, Mr. David Reid continuing the Cambridge-street business under the name of James White, and Mr. Mathew Hall carrying on the Sauchiehall-street business under his own name.

BENHAM AND FROUD'S INSTALLATION OF ELECTRIC LIGHT FITTINGS.—One of the latest additions to the many firms who now make a speciality of the construction, design and supply of artistic electric light fittings is the well-known firm of Benham and Froud, of Chandos-street, Strand. We recently paid a visit to Messrs. Benham and Froud's fine showrooms, where they have a varied assortment of those elaborate brass, copper and wrought-iron fittings which the advent of the electric light have rendered possible. The premises of Messrs. Benham and Froud are supplied with current from the mains of the Metropolitan Electric Supply Company, and by means of a plug switchboard any number of the devices can be lit up for the edification of intending purchasers. Among the many taking designs we noticed a fine electric sunburner, containing six 32 candle-power lamps, with a dome of lacquered brass and a fringe of glass prisms. Some 60 of these have been fitted at the Hotel Métropole, Brighton, where, also, some 300 neat little electric table lamps have been supplied by this firm. Incandescent lamps with plain shades, hung straight from the ceiling by the conducting wires, are certainly an economical style of fitting, but Messrs. Benham and Froud propose to render them somewhat more attractive by the addition of light artistic wrought-iron sprays twined round the twin conductors. Great care will, however, have to be taken to keep these sprays as light as possible, and to prevent them from fraying the insulated covering of the wires.

## PATENT RECORD.

### APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

January 17, 1891.

871. J. F. BENNETT and E. P. SLIDES. Sheffield. Improvements in telephone transmitters.

884. C. WELLS. London. Improved apparatus for the production of electricity.

887. THE ELECTRICAL INVENTIONS COMPANY (Limited) and A. ANDREOLI. London. Improvements in or relating to the electro chemical extraction of gold, silver, and other precious metals from their ores.

889. WOODHOUSE AND RAWSON UNITED (Limited). London. Apparatus for manufacturing corrugated lead boxes for electric accumulators. (J. K. Steanes, Australia.)

899. H. J. EAGER and R. P. MILBURN. London. Improvement in electric cells or batteries.

908. F. A. ROSS. London. Improvements in insulators for electric wires.

910. A. M. CLARK. London. Electro-magnetic mechanism for controlling the transmission of power. (W. H. Kilbourn, United States.)

January 19, 1891.

937. E. ATKINS and E. E. ATKINS, Handsworth. Improvements to securely attach electrical wires to ceiling roses.

January 20, 1891.

965. H. H. LEIGH, London. Improved therapeutic magneto-electric machines. (J. B. Gardiner, United States.)

980. W. WALKER, M. WALKER, J. SANSOM, and A. COLE, Luton. Improved electric signals for railways.

984. R. THEILER and G. K. B. ELPHINSTONE, London. Improvements in telegraphic transmitting apparatus.

991. A. T. SNELL, London. An improved electric percussive rock drill.

1,004. Sir W. THOMSON, Glasgow. An improved indicator for electric potentials.

1,007. E. FERRARIS, London. Apparatus for separating ores and metals by the aid of electricity.

1,035. S. W. MAQUAY, London. Improvements in primary batteries.

1,049. S. Z. DE FERRANTI, London. Improvements in the manufacture of dynamo-electric machines.

1,050. S. Z. DE FERRANTI, London. Improved means for distributing electrical energy.

1,051. S. Z. DE FERRANTI, London. Improvements in electrical transformers or converters, and in their manufacture; partly applicable to the manufacture and testing of dynamo and other insulated conductor coils and armatures.

1,053. A. NOBLE and E. W. LLOYD, London. Improved method for testing the electrical firing gear of ordnance.

January 21, 1891.

1,066. G. D. BURTON and E. E. ANGELL, London. Improvements in electric blank heaters for forging machines.

1,084. W. H. JACKSON, London. Automatic throwback for electric indicators.

1,114. A. CHURCHWARD, London. Improvements in electric railways and in apparatus for the propulsion of vehicles by electricity. (A. J. Robertson, United States.)

1,118. O. IMRAY, London. Improvements in folding lamp shades for gas and electric lamps. (L. von Orth and E. Breslauer, Germany.)

1,122. A. D. RAINE, London. Improvements in or connected with incandescent electric lamps.

1,138. W. H. MUNNS, London. An improved guard for incandescent electric light globes. (J. Mino and W. D. Wastfield, United States.)

January 22, 1891.

1,173. S. W. THOMSON, Glasgow. Improvements in appliances for the transmission of electric energy.

1,176. F. M. NEWTON and T. HAWKINS, London. Improvements in brush-holders for dynamo-electric machines and electric motors.

1,200. W. H. COLSON, London. Electric contact for locks.

1,202. M. DEVRIES, London. Improvements in electric clocks.

1,250. E. ATKINS and W. ATKINS, Birmingham. Improvements in globe holders for electric and other lighting fittings.

1,251. E. ATKINS and W. ATKINS, Birmingham. Improvements in electrical switches.

1,279. E. C. WILEY, J. A. DICKEY, and N. B. AINESWORTH, London. Improvements in and relating to electric signals for railways.

January 24, 1891.

1,318. A. W. CUTLER, London. Improved means or arrangements for electric distribution.

1,329. W. H. MUNNS, London. An improved electrical heating and cooking apparatus. (C. Talmage, United States.)

1,332. W. H. MUNNS, London. An improved insulator for electric wires. (F. Miro, West Indies.)

1,339. E. DE PASS, London. Improvements in alternating current electric clocks. (H. C. Spohr, Germany.)

1,350. C. ANDREWS, London. An improved galvanic belt.

1,359. A. J. BOULT, London. Improvements in or relating to electrical fire signals. (C. Dixon and Fowler, France.)

January 26, 1891.

1,390. F. BOEHM, London. An improved incandescent lamp.

1,396. T. M. NEWTON, London. Improvements in arc lamps.

1,425. A. J. BOULT, London. Improvements in storage batteries. (W. Roberts, Canada.)

1,432. C. BOLLÉ, Manchester. Improved manufacture of carbon filaments for incandescent electric lamps. (W. M. B. Keen, United States.)

January 28, 1891.

1,527. T. A. GARRETT, London. Improvements in and connected with apparatus for receiving electrical signals.

1,528. C. W. COX, Liverpool. Improvements in and method of cooling magic lanterns, resistance, and other optical and electrical apparatus liable to get overheated.

Digitized by Google

January 29, 1891.

1,599. W. S. ELLIOT, Glasgow. Improvements in apparatus for stopping any water wheel or other motor used in generating electricity.

1,639. J. SWINBURNE, Teddington. Improvements in or connected with distribution of power by alternating currents with the aid of condensers, alternate current motors, fuses, and electrostatic measuring instruments, and improvements in telephone systems.

## SPECIFICATIONS PUBLISHED.

1889.

20,652. EDMUNDSON and CLARKE. Incandescence, electric lamps. (Price 6d.)

1890.

3,732. HOPKINSON. Electro locomotives. (Price 6d.)

18,491. KENNEDY. Dynamo electric machines. (Price 8d.)

19,406. HARTMANN and BROWN. Electric current meters. (Price 6d.)

836. GWOSDEFF and BUNGE. Long telephonic circuit. (Price 8d.)

873. PERRY. Electric supply meters. (Price 8d.)

1,143. CHADBURN. Telegraphic apparatus for navigable vessels. (Price 8d.)

1,306. SMITH. Galvanic dry elements. (Price 6d.)

1,555. ELLIOTT. Magnetic separator. (Price 8d.)

2,091. THOMPSON (The Gibson Electric Company). Secondary batteries. (Price 8d.)

2,653. DE FERRANTI. Electric meters. (Price 8d.)

2,759. TIMMIS. Lighting railway trains by electricity. (Price 8d.)

3,841. SIEMENS BROS. and Co, (Taylor). Electric conductors. (Price 6d.)

3,842. SIEMENS BROS. and Co. (Taylor). Electric circuit breakers. (Price 6d.)

13,319. TOWNLEY. Electric bells, &c. (Price 8d.)

15,547. ILIFFE and TEAGUE. Electric current circuits. (Price 8d.)

16,064. PUMPELLY and BUTTERWORTH. Electrical batteries. (Price 6d.)

16,653. CURRIE. Measuring the strength of electric currents. (Price 6d.)

17,181. ALLISON (McGregor and Sons). Electric switches. (Price 8d.)

18,412. ROBERTSON. Electric batteries and lighters. (Price 6d.)

# COMPANIES' MEETINGS & REPORTS.

## City and South London Railway Company.

The following is the report of Directors to the shareholders at the thirteenth half-yearly ordinary meeting of the Company, to be held at Winchester House, Old Broad-steet, E.C., on Tuesday, the 24th inst., at twelve o'clock:—

It is with much satisfaction that the Directors have to report that the railway has been completed, and was opened for public traffic on December 18th last. The running of experimental trains suggested the necessity for a number of minor improvements in the tunnels and working appliances, the carrying out of which caused some delay; but on November 4th the completion of the line was graciously inaugurated by H.R.H. the Prince of Wales, accompanied by H.R.H. the Duke of Clarence. This ceremony was followed by several weeks' private running of the trains, so that the staff might be fully instructed in their somewhat novel duties, and on December 18th the railway was opened to the public. Since that date a service of trains, running at intervals of about five minutes has been maintained, and although there have been a small number of occasional delays from the failure of engines and other causes, there is every reason to be satisfied with the use of electricity as a motive power, and when the various improvements suggested by experience are all carried out, it is anticipated that the line will prove one of exceptional safety and comfort, and will be worked with economy and regularity. During the short time the railway has been working, the average number of passengers carried has been about 15,000 per day, but as the weather improves, and the line is better known, this number will no doubt steadily increase. It has been found in working such a rapid service that the siding accommodation provided is insufficient, and arrangements are now in progress for the construction of additional sidings at the Stockwell terminus, which will add greatly to the facilities for working the line.

The Board of Trade have recommended the addition of a fourth engine and dynamo to the generating plant at Stockwell Depôt, and these have accordingly been ordered, and it is intended also to add two additional trains and four additional locomotives to the rolling stock. As soon as these additions are complete, it will allow of a considerable accession to the number of trains run, and the opening of the line on Sundays, if thought desirable. The accounts for the past half-year have been made out in the form previously adopted, but as the Company is now recognised as a railway the accounts in future will be rendered in the form prescribed by the General Railway Acts. As the line was only opened a few days before the close of the half year, it has not been thought necessary to create a separate revenue account for that short period.

With the view of developing the traffic on the line, a Bill has been deposited in Parliament to authorise the construction of a branch line from King William-street to the Bank, and thence under Moorgate-street, Finsbury Pavement, and the City-road to the "Angel," at Islington. It is anticipated that this line, when made, will bring upon the existing railway a large additional traffic during that period of the day when the trains are at present not well filled, and in addition to being itself a remunerative undertaking, will add greatly to the value of the present railway, as affording access to the heart of the City traffic, and a much-needed direct communication between the northern and southern suburbs of London. The calls upon 26 shares having been long in arrear, a formal resolution will be proposed confirming the forfeiture of the shares, and authorising their being dealt with.

The Directors retiring by rotation are Mr. Walter Robinson and Mr. Sampson Hanbury, who are eligible for re-election. The auditors also retire, but offer themselves for re-election.

The extraordinary or special general meeting of the shareholders, held on the 3rd inst., stands adjourned until the 24th inst., immediately after the conclusion of the business of the half-yearly meeting.

## The Cuba Submarine Telegraph Company (Limited).

The thirty-ninth ordinary general meeting was held at the Company's offices, No. 58, Old Broad-street, on February 11, 1891, under the presidency of Mr. Thomas Greenwood.

The SECRETARY (Mr. James Scott) having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen, the report and accounts have been in your hands for some days, and I apprehend that you have made yourselves sufficiently acquainted with them so that it will not be necessary to have them read to-day. The incidents have been few in the history of the Company during the last six months of sufficient importance to be brought under your notice to-day. We have gone on in the even tenor of our way. Our income has increased considerably—that is to say, we have had an improvement on the corresponding period of the previous year of £1,450, while our expenditure has been increased about £250. That has been mainly by an unusual outlay upon our land lines. We have, therefore, a net income more than that for the corresponding period of a year ago of about £1,200. There have been no breaks in our cables in the half-year—in those cables which we have to repair, that is; and there has, therefore, been no expenditure on repairs. This has enabled us to carry to the reserve fund a much larger sum than usual—nearly £4,500—after providing for the payment of a dividend of 8 per cent. on the ordinary shares, and carrying forward an increased balance of £700. That is a satisfactory state of affairs, without doubt, and I think that the shareholders will be pleased that we have so good an account to present to them. The new cable between Batabano and Cienfuegos has been successfully laid. Our reports are satisfactory, and when the time comes for the usual tests to be applied I have no doubt that we shall find that the cable is in perfect condition, and the balance of the purchase-money will then have to be paid. The purchase-money, so far as it has been paid, has been taken out of the reserve fund, and the remainder when paid will further reduce that fund; but still it will leave a considerable amount—certainly exceeding £70,000. The 1881 cable ceased to speak last August, but as the contractor was about to go out to lay the new cable we did not press him immediately to repair it, because he would have the vessel on the other side to do both repairs and laying at the same time. It was fortunate that the vessel was out there because our own cable, the one laid in 1875, broke last month. We could not mention it in the report more definitely, but we have now repaired that cable, and the line is in full working order. The 1881 cable is now under repair at the cost of the contractor, and we expect every day to receive intelligence from him that it is in perfect order. If so, we shall then have our duplicate lines completed from end to end—from Santiago to Cienfuegos and from Cienfuegos to Batabano. There is one other point to which I ought to make reference—namely, the action we have against the Spanish Government. Our case has been under the consideration of our lawyers there, and has been very carefully drafted. It has been translated and sent over here, and been under the consideration of the secretary and myself, and with certain alterations for their consideration has gone back to Spain. Nothing very much has been done, but we hope the case will come on immediately, and we confidently expect a judgment in our favour. I can hardly expect anything else, but still there is the glorious uncertainty of the law. When we get the intelligence we shall communicate it to our shareholders. I think I have now touched upon all the points which I need refer to; but if there is anything in the accounts or anything connected with the affairs of the Company upon which the shareholders would like to be further informed, I shall be very pleased to give them all the information in my power. I will now move:

*"That the report and accounts for the half year ended December 31st last, now submitted, be received and adopted."*

Mr. ALEXANDER F. LOW: I have much pleasure in seconding that.

Mr. DEARBERG: I do not know what the action is about against the Spanish Government. Is it that they have not carried out their agreement with the Company, or given another concession to another Company?

The CHAIRMAN: I may as well answer that question, though it is usual to reply to all the questions at once. The Spanish Government have granted a concession to our rivals, the French Company, with the object of giving them the right to lay on the north side of the island parallel lines to ours, which are on the south. We contend that that is a direct violation of the concession given to us, and we have taken action in the courts with the view of preventing that from being carried out.

Mr. W. GRIFFITH: In your short but able speech you anticipated one or two questions which I had intended to ask respecting the accounts, but you were also good enough to offer to give us any information which we might desire on the general affairs of the Company. The particular questions I wish to ask are these: I find that our local traffic is somewhat under one-third of our through traffic. What are the probabilities of the local traffic moving with the through traffic in coming years.

Digitized by Google

Can you tell whether there is any likelihood of the extension of the Halifax cable to Cuba, under the sanction of the British Government, being carried out, or whether that line is likely to remain at Bermuda, and go no further? This question seems to affect both the internal and the external trade of Cuba, and with that trade the future of our prosperity.

The CHAIRMAN : In reply to the two questions just put to the Board, we have no knowledge whatever of any variation that is likely to take place between the present relative income from the local as well as from the through traffic. There is no incident within our knowledge which is likely to make any variation in what has occurred before. As regards the cable which has been laid from Halifax to Bermuda, that is *un fait accompli*, but we have had no intimation whatever, and we have no knowledge or expectation, of that being continued to the Island of Cuba. We hope to retain our traffic except it be interfered with by the French Company, who is our great opponent, and if we can stop the concession I have referred to, we doubtless shall continue to carry the traffic which they give us. I will put the resolution to the meeting. I have read it; and those in favour of it will be good enough to hold up their hands. To the contrary. That is carried. I now propose

*" That the following dividends for the half-year be now declared upon the shares of the Company, viz., at the rate of 10 per cent. per annum, subject to income tax, on the Preference shares, and 8 per cent. per annum, free of income tax, on the ordinary shares, payable on and after to-morrow."*

Mr. NEIL BANNATYNE : I beg to second that.

The CHAIRMAN put the motion in the usual way, and having declared it carried, said: The business of the ordinary meeting is at an end, and we will now commence the business of the extraordinary meeting, the notice of which will be read by the secretary.

The SECRETARY having read the notice,

The CHAIRMAN said: We have rather a larger gathering of the shareholders to day; but even now I do not suppose that we have present more than one-fiftieth part of the general body, and it is that very fact of the small attendance of shareholders at these meetings which has very largely induced us to ask you to pass the resolution which I am about to place before you. We think that in all matters of importance the whole of the shareholders should be made acquainted with what is about to be done. If we seek to make an alteration in the Articles of Association we must give you notice; if we wish to make an alteration in our capital increasing or decreasing, we must give you notice; if a Director retires and offers himself for re-election we give you notice; and we think that if there is any proposal to fill up any vacancy on the Direction the shareholders should have notice of it. In order that that may be done it is essential that the candidate should give the Directors notice in sufficient time to enable them to inform the shareholders in the report. In the resolution which we propose for your adoption to-day we have put in 21 days, but we shall be ready to reduce that time if you think it desirable. All that we want is that the shareholders should be made acquainted, through the Board, of any change it is desired to make on the Direction. You are probably aware that we have not our full complement of Directors now. We have four Directors while we may have nine. Four is quite sufficient. To increase the number would not benefit the Company the least, while it must necessarily put on the Company the expense of the additional fees which would have to be paid. We do not propose, and never have proposed, to increase the number; and I think that the shareholders generally, if being satisfied with the mode in which the business has been conducted, will be content with four Directors. Still, it is open to any shareholder here, or at any future meeting, unless you pass this resolution which I am about to submit, to propose any gentleman, and, without notice to absent shareholders, fill up a vacancy which we might think ought to remain open. This resolution, as far as my knowledge is concerned, is an ordinary one, and it would probably have been put in the Articles of Association when they were drawn up had the matter been understood. Our Articles of Association were drawn up 20 years ago, and that goes for something in explaining the omission of this clause. Everyone who draws up Articles of Association has a knowledge of antecedent experience, and draws them accordingly. I will now move the proposed alteration in the following resolution :—

*" That the Articles of Association of the Company be altered by the addition of the following Article, and the same is hereby adopted as one of the Regulations of the Company :—*

*" ' No person, not being a retiring Director, shall be eligible for election to the office of Director at any general meeting, unless he or some other member intending to propose him has, at least twenty one clear days before the meeting, left at the offices of the Company a notice in writing under his hand, signifying his candidature for the office, or the intention of such member to propose him.' "*

Mr. LOW : I beg to second that.

Two amendments were successively put to the meeting by Mr. Cochran, but lost, and the original resolution (modified, as regards notice, to 14 clear days) was subsequently carried.

Mr. COCHRANE : I have been rather opposing the Directors, but I should always oppose them if I thought they were bringing forward anything against our interests. I do not, however, think that we should separate without passing a vote of thanks to the Chairman and the Directors.

Mr. GRIFFITH : I have much pleasure in seconding this motion. The resolution has been thrashed out thoroughly; everyone has had an opportunity of saying what he thought on the matter, and the discussion has been conducted with the greatest courtesy on both sides.

The resolution was carried unanimously.

The CHAIRMAN : We thank you very cordially for the handsome way in which you have acknowledged our services.

The proceedings then terminated.

## Hastings and St. Leonards-on-Sea Electric Light Company (Limited).

The annual meeting of this Company was held last week at the Works, Mr. H. M. Baker presiding.

The Directors' report stated that the accounts for the nine months ending December 31st were of a very satisfactory character. After paying all working expenses and charging to the revenue account all additions to plant and paying interest on mortgage and Debentures there remained a net profit of £543. 13s. 5d., out of which it was proposed to pay a dividend at the rate of 5 per cent. per annum, leaving a balance of £286. The Directors hoped that the time had now arrived when their services should receive some remuneration.

In moving the adoption of the report, and payment of the dividend, the Chairman remarked upon its satisfactory character, and said the three remaining months of the financial year were three of the best months on account of the short days. New plant was required for the incandescent lighting, and, to meet the expense, £2,000 worth of Debentures had been issued. Mr. Robert Hammond, who had already taken £500 in Debentures, as well as being one of the largest shareholders, had offered to take up £500 of the amount, and to supply extension of plant on favourable bonuses to the Company. Without any extension of the premises they would be able to supply five times their present custom, and there were several churches at the present time in treaty for the light.

The motion was agreed to; and on the proposition of the Rev. J. W. Tottenham, seconded by Mr. B. Bray, the sum of £200 was voted to the seven Directors for their services during the past eight years.

Messrs. F. A. Langham, J. Reeves, and J. Woodhams, the retiring Directors, were re-elected, and the proceedings terminated.

PATENT

SILICIUM BRONZE AND SILICIUM COPPER WIRE.

The best for overhead Telephone and Telegraph Lines,

AND ALL ELECTRICAL PURPOSES.

Hard Drawn High Conductivity Copper Wire.

ROLLED AND DRAWN PHOSPHOR BRONZE.

PHOSPHOR BRONZE VULCAN DURO METAL PHOSPHOR

PHOSPHOR BRONZE BEARINGS, BUSHES, AND OTHER PARTS OF ELECTRICAL MACHINERY

*SOLE PROPRIETORS of the British, Indian and Colonial Patents,*

THE PHOSPHOR BRONZE COMPANY (Limited),

*87, Sumner Street, Southwark, London, S.E.*

WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

Digitized by Google

## India Rubber, Gutta Percha, and Telegraph Works Company (Limited).

The following is the Directors' report for the year ending December 31, 1890, to be presented at the 27th ordinary general meeting of the shareholders, to be held at the Cannon-street Hotel, E.C., on Thursday, the 19th inst., at 12 o'clock :—

The accounts show the net profit for the past year to be £65,334. 11s. 2d. Adding £41,236. 6s. 8d. brought forward, and deducting £20,800 interim dividend paid in July, there remains a disposable balance of £85,770 17s. 10d. The Directors have added £25,000 of this balance to the reserve fund (raising it to £300,000), and recommend the distribution of a dividend of 10s. per share, free of income tax, amounting to £20,800, making, with the interim dividend, a total payment for the year of 10 per cent., and leaving £39,970. 17s. 10d. to be carried forward.

During the past year the Company has done a much larger general business than in any previous year, and a fair amount of cable work ; but keen competition and increased cost of material continue to reduce the rate of profit. The works and machinery are maintained in a thoroughly efficient state.

Mr. Bannatyne and Mr. Henderson, the Directors retiring by rotation, offer themselves for re-election. Mr. Weise is re-eligible as auditor.

## Liverpool Overhead Railway Company (Limited).

The half-yearly meeting of shareholders of this Company was held at Liverpool on Tuesday, and we take from the *Financial News* the following report :—

Sir W. B. FORWOOD (the Chairman) explained that the delay in construction had taken place mainly through non-delivery of material. Progress now, however, was fairly rapid. The line, which is to be 5½ miles in length along the dock line, is complete for one mile from its northern extremity, and foundations have been laid to the centre of the city. It was hoped the northern section would be at work by October. Electricity was proposed as the motive power, and tenders from four engineering firms were to be in by the end of the present month, being both for equipping the railway and working it. Quoting from American experience, he showed the probable enormous growth of traffic on the line, and anticipated no difficulty in paying a good dividend. Further calls of £1 per share would be made in April and July.

The report and accounts were adopted, and the retiring Directors were re-elected.

The CHAIRMAN, replying to a vote of thanks, expressed the opinion that in not many years the Overhead Railway would be looked upon as the best railway property in Lancashire.

## NEW COMPANIES REGISTERED.

**SHROPSHIRE ELECTRIC LIGHT AND POWER COMPANY (LIMITED).**—Registered by Chester and Co., 35, Bedford-row, with a capital of £25,000 in £10 shares. Object : To carry on the business of an electric light and power company. Registered Office, 9, the Square, Shrewsbury.

**TEWKESBURY AGRICULTURAL AND GENERAL ENGINEERING COMPANY (LIMITED).**—Registered by Jordan and Sons, 120, Chancery-lane, W.C., with a capital of £10,000 in £10 shares. Object: To acquire the business of James Savory of 103 and 104, High-street, Tewkesbury, and to carry on generally the business of engineers, machinists, ironfounders, &c.

## CITY NOTES, &c.

**BELL'S ASBESTOS COMPANY (LIMITED).**—A final dividend of 5 per cent., making 15 per cent. for the past year, is recommended by the Directors.

**BRAZILIAN SUBMARINE TELEGRAPH COMPANY.**—The traffic receipts of this Company for the week ended February 6th amounted to £5,956.

**CITY AND SOUTH LONDON RAILWAY COMPANY.**—The traffic receipts of this Company for the week ended February 7th amounted to £702. Aggregate receipts for half-year to date, £4,038.

**CITY OF LONDON ELECTRIC LIGHTING (PIONEER) COMPANY (LIMITED).** On Friday last the prospectus was issued of this Company, inviting subscriptions for a present issue of 1,000 shares of £50 each, being half the full capital of £100,000. The Company is formed to initiate the supply of electricity for public and private lighting and for motive power within the City of London, and with the intention of forming a larger company, with adequate capital, to acquire various undertakings which will secure to such larger company the electric lighting of the whole of the City of London. The prospectus states that, besides lighting the public thoroughfares, the Company will have a virtual monopoly of the private lighting of the City. The Right Hon. the Lord Mayor of London is the Chairman of the Company ; Major-General C. E. Webber, C.B., is the consulting engineer ; and Mr. J. Cecil Bull, 1 and 2, Great Winchester-st, London, E.C., is the secretary. The lists were only open from 10 a.m. till 4 p.m. on Monday last. Letters of allotment and regret were posted on Wednesday.

**CUBA SUBMARINE TELEGRAPH COMPANY.**—The estimated traffic receipts of this Company for the month of January were £2,400, as compared with £3,176 in the corresponding month of last year. The decrease is owing to an interruption during the latter half of the month.

**EDISON AND SWAN UNITED ELECTRIC LIGHT COMPANY.**—The Directors of this Company have decided to pay an *ad interim* dividend for the half-year ending December 31, 1890, at the rate of 7 per cent. per annum upon the "A" shares, to be distributed in accordance with the Articles of Association. It is intended to issue the dividend warrants on the 20th inst.

**GREAT NORTHERN TELEGRAPH COMPANY (LIMITED).**—The traffic receipts of this Company for the month of January, 1891, amounted to £20,800, as compared with £19,600 in the corresponding month of last year. The receipts for the month of January, 1889, were £22,400.

**TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY.**—The Directors of this Company propose paying a further dividend of 15 per cent., making 20 per cent. for the past year.

**UNITED ALKALI COMPANY (LIMITED).**—This Company, formed for the purpose of purchasing and consolidating into one undertaking some 48 chemical works and salt mines and works in the United Kingdom, issued its prospectus last week. The share capital is £6,000,000, divided into 300,000 Seven per Cent. Preference Shares of £10 each and 300,000 ordinary shares of £10 each ; and there is also £2,500,000 Five per Cent. Mortgage Debenture Stock, redeemable at £110 per cent., at the option of the Company, after 10 years, on six months' notice. Large portions of the share capital and of the Debenture stock have been taken by the vendors in lieu of purchase money or have been otherwise allotted, and the balance is now offered for public subscription, viz., £302,650 in ordinary shares of £10 each, £659,970 in Preference Shares of £10 each, and £371,930 Mortgage Debenture Stock. Sir Charles Tennant, Bart., is the honorary president, and John Brock, Esq., the Chairman of the Board of Directors ; and the secretary is Mr. Eustace Carey, with offices at Exchange-buildings, Liverpool. The lists opened on Monday last, and closed yesterday (Thursday).

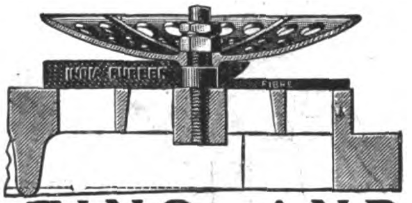
**WEST COAST OF AMERICA TELEGRAPH COMPANY.**—The traffic receipts of this Company for the month ending January 31, 1891, amounted to £3,925.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY.**—The traffic receipts of this Company for the week ending February 6, 1891, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brasilian Telegraph Company (Limited), were £4,858.

**WESTMINSTER ELECTRIC SUPPLY CORPORATION (LIMITED).**—Notice is given that at a meeting of the Directors held on the 4th inst., a call of £1 per share was made upon the shareholders, and that the same will be payable at Messrs. Barclay, Ransom and Co's Bank, No. 54, Lombard-street, E.C., and 1, Pall Mall East, S.W., or at the Office of the Corporation, on or before the 15th day of April, 1891.


# NEW VALVE

**No Rubber, Percha, or Leather.**




**One-half the price of Rubber or Metal.**

# FOR CIRCULATING AND AIR PUMPS.

**Unaffected by any Lubricating Oils. Does not Expand in diameter. Feed Water may be worked at any temperature Suitable for any shaped guards. Only one quality manufactured.**

"12, John-street, Sunderland, 20th Sept. 1885.

"DEAR SIRS,—In reply to your letter of the 25th inst., the Valves I got from you have done their work well, and ARE AN UNQUALIFIED SUCCESS. I will continue get them from you as required.—Yours faithfully, JAMES WESTOLL."

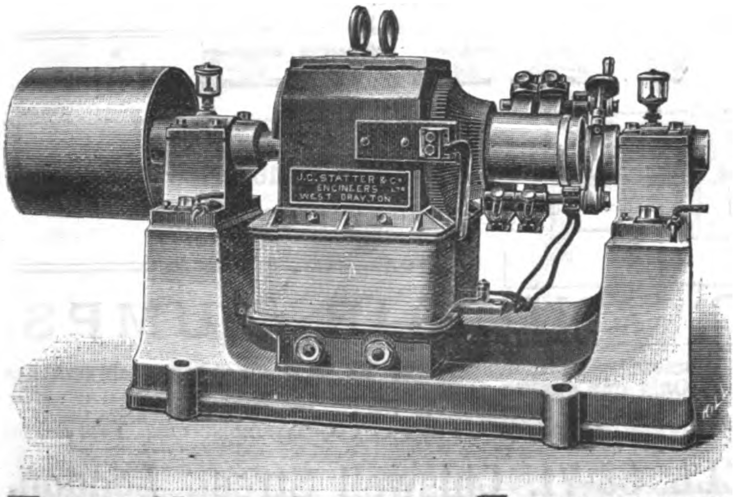
For further Testimony and Prices, apply to **MOSSES & MITCHELL, 68-71, Chiswell Street, London.**


Digitized by Google

# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name. | Previous Week's Price, Feb. 4. | | Price Wednesday, Feb. 11. | | Rate per Cent. Yielded. | Dividend Due. | Business Done During Week Ending Feb. 4. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **TELEGRAPHS.** | | | | | £ s. d. | | Highest. | Lowest. |
| £1,381,330 | Stock | 15/0 | Anglo-American | 48½ | 49½ | 48½ | 49½ | 5 16 2 | Jan., Apr., July, Oct. | 49 | 48½ |
| £2,809,310 | Stock | 30/0 | Do. Preferred | 85½ | 86½ | 86 | 87 | 6 12 2 | " " | 87 | 85½ |
| £2,809,310 | Stock | .. | Do. Deferred | 12½ | 13 | 12½ | 12¾ | .. | | 12⅞ | 12½ |
| £250,000 | 100 | 4% | African Direct, Telegraph 4% Debentures | 99 | 102 | 99 | 102 | 3 18 5 | January and July .. | .. | .. |
| 180,000 | £10 | 3/0 | Brazilian Submarine | 11¾ | 12¼ | 11¾ | 12¼ | 6 2 5 | Mar., June, Oct., Dec. | 12¼ | 11⁵⁄₁₆ |
| £84,500 | £100 | 5% | Do. 5 per Cent. Bonds | 100 | 103 | 100 | 103 | 4 17 1 | January and July .. | .. | .. |
| £75,000 | £100 | 5% | Do. 5 per Cent. Bonds (2nd Series, 1906) | 103 | 107 | 103 | 107 | 4 13 6 | June and December | .. | .. |
| $7,216,000 | $100 | 7% | Commercial Cable Capital Stock | 104 | 106 | 104 | 106 | 6 2 8 | April and October .. | 106½ | 105 |
| 16,000 | 10 | 8/0 | Cuba Submarine | 11 | 12 | 11 | 12 | 7 1 8 | February and August | .. | .. |
| 6,000 | 10 | 10% | Do. Preference 10% | 16½ | 17½ | 16½ | 17½ | 5 14 3 | " " | 16¾ | .. |
| 12,931 | 5 | 2/4½ | Direct Spanish (£4 paid) | 3½ | 4 | 3½ | 4½ | .. | April and October.. | 3¾ | .. |
| 6,000 | 5 | 10% | Do. Preference 10% | 9 | 10 | 9 | 10 | 5 0 0 | " " | .. | .. |
| 60,710 | 20 | 3/6 | Direct United States | 10½ | 10⅞ | 10½ | 10¾ | 6 10 3 | Jan., Apr., July, Oct. | 10⅝ | 10½ |
| 400,000 | 10 | 2/6 | Eastern | 14⅛ | 14⅜ | 14⅛ | 14⅜ | 4 10 5 | " " | 14⅜ | 14⅛ |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference | 15 | 15½ | 15 | 15½ | 3 17 5 | " " | 15½ | .. |
| £1,200,000 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock | 105 | 108 | 106 | 109 | 3 13 5 | May and November | 108½ | .. |
| £200,000 | 100 | 5% | Do. 5 per Cent Debentures, 1899 | 106 | 109 | 106 | 109 | 4 11 9 | February & August | .. | .. |
| 250,000 | 10 | 2/6 | Eastern Extension | 14½ | 15 | 14¾ | 15¼ | 4 11 10 | Jan., Apr., July, Oct. | 15 | 14⅝ |
| £320,000 | 100 | 6% | Do. 6 per Cent. Debentures, 1891 | .. | | .. | | .. | February & August | .. | .. |
| .. | £100 | .. | Do. 4 per Cent. Debentures Stock | 103 | 105 | 105 | 107 | .. | .. | .. | .. |
| £91,800 | 100 | 5% | Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900 | 102 | 105 | 102 | 105 | 4 15 3 | January and July .. | 105 | .. |
| £145,300 | 100 | 5% | Eastern & S. African 5 per Cent. Mor. Deb., 1900 | 102 | 105 | 102 | 105 | 4 15 3 | " " | .. | .. |
| 180,227 | 10 | 1/9 | Globe Telegraph and Trust | 9 | 9½ | 9 | 9½ | 5 5 6 | Jan., Apr., July, Oct. | 9½ | 9⁵⁄₁₆ |
| 180,042 | 10 | 6% | Do. 6 per Cent. Preference | 14⅞ | 15⅛ | 14⅞ | 15⅛ | 3 19 4 | " " | 15⅛ | 14⅞ |
| 150,000 | 10 | 5/0 | Great Northern | 16½ | 17 | 16¾ | 17¼ | 4 6 11 | Jan., April, and July | 16¹³⁄₁₆ | 16¹¹⁄₁₆ |
| £230,000 | 100 | 5% | Do. 5 per Cent. Debentures, 1883 | 105 | 108 | 105 | 108 | 4 12 7 | March & September | 106½ | 105½ |
| 17,000 | 25 | 12/6 | Indo-European | 35 | 37 | 36 | 38 | 6 11 7 | May and November | .. | — |
| 38,348 | 10 | 4/0 | London Platino-Brazilian | 6 | 7 | 6½ | 7½ | 5 14 4 | " " | .. | .. |
| £100,000 | 100 | 6% | Do. 6 per Cent. Debentures | 107 | 110 | 108 | 111 | 5 8 1 | March & September | .. | .. |
| 9,000 | 8 | 4/0 | Reuter's | 8½ | 9 | 8½ | 9 | 5 11 1 | April and October.. | 8¾ | 8⅝ |
| 8,381 | £100 Cert. | 6% | Submarine Cables Trust 6% | 112 | 115 | 112 | 115 | 5 4 4 | " " | 115½ | .. |
| 15,609 | 10 | 4/0 | West African Telegraph | 8 | 9 | 8 | 9 | 5 11 1 | January and July .. | .. | .. |
| £290,900 | 100 | 5% | Do. 5 per Cent. Debentures | 98 | 101 | 99 | 102 | 4 18 0 | March & September | 101½ | 100¾ |
| 30,000 | 10 | 3/0 | West Coast of America | 2 | 4 | 2 | 4 | .. | January and July .. | .. | .. |
| £150,000 | 100 | 8% | Do. Debentures 8% 1902 | 95 | 100 | 95 | 100 | .. | June and December | .. | .. |
| 88,321 | 10 | .. | West India and Panama | 2¾ | 3 | 3½ | 3⅜ | .. | .. | 3⅟₁₆ | 2⅞ |
| 34,500 | 10 | 6/0 | Do. 1st Preference 6% | 11½ | 11¾ | 11½ | 11¾ | 5 2 2 | May and November | 1 8 | 11⅝ |
| 4,669 | 10 | £3 | Do. 6 p. c. 2nd Pref. | 11 | 12 | 11 | 12 | 5 0 0 | " " | 11¹¹⁄₁₆ | .. |
| 64,174 | 15 | 6/0 | Western and Brazilian | 11¾ | 12¼ | 12¼ | 12¾ | 4 14 2 | " " | 12³⁄₁₆ | 12¼ |
| 27,873 | 7½ | 6/0 | Do. 5 per Cent. Cumulative Preferred | 6½ | 7 | 6¾ | 7¼ | .. | — | 7 | 6¾ |
| 27,873 | 7½ | 4/6 | Do. 5 per Cent. Deferred | 5½ | 5¾ | 5½ | 6 | .. | .. | 5¹³⁄₁₆ | 5½ |
| £200,000 | 100 | 6% | Do. 6 per Cent. Debs., Series "A" 1910 | 102 | 106 | 103 | 106 | 5 13 2 | February & August | .. | .. |
| £250,000 | 100 | 6% | Do. 6 per Cent. Mort. Debs., Series "B" 1910 | 102 | 105 | 103 | 106 | 5 13 2 | " " | .. | .. |
| $1,336,000 | $1,000 | 7% | Western Union 7 per Cent. 1st Mortgage | 120 | 125 | 120 | 125 | 5 12 0 | May and November | .. | — |
| £175,100 | £100 | 6% | Do, 6 per Cent. Sterling Bonds | 99 | 103 | 99 | 103 | 5 16 0 | March & September | .. | — |
| | | | **TELEPHONES.** | | | | | | | | |
| 224,850 | 14/0 | 0/1½ | Consolidated Telephone Const. & Maintenance. | ⁷⁄₁₆ | ⁹⁄₁₆ | ⁷⁄₁₆ | ⁹⁄₁₆ | .. | May and November | .. | ½ |
| 220,000 | £1 | 3% | Oriental (11s. paid) | ³⁄₁₆ | ⁵⁄₁₆ | ³⁄₁₆ | ⁵⁄₁₆ | 5 5 9 | Yearly | ⁵⁄₁₆ | .. |
| 438,984 | 5 | 2/6 | National | 4⅜ | 4⅝ | 4⅜ | 4⅝ | 5 12 10 | June and December | 4⅝ | 4⁹⁄₁₆ |
| 15,000 | 10 | 6/0 | Do. 6 per Cent. Cumulative 1st Pref. | 12½ | 13 | 12½ | 13 | 4 12 4 | " " | 13 | .. |
| 15,000 | 10 | 4/9¾ | Do. 6 per Cent. Cumulative 2nd Pref. (£8 pd) | 10 | 10½ | 10 | 10½ | 4 12 1 | " " | 10½ | .. |
| 209,750 | 1 | ½% | South of England, Ordinary | ⅛ | ⅜ | ⅛ | ⅜ | .. | — | .. | .. |
| 20,000 | 5 | 2/1 | Do. 6 per Cent. Cumulative Pf. (£3 10s. pd) | 2¾ | 3¼ | 2¾ | 3¼ | 6 0 0 | .. | .. | — |
| 58,000 | 5 | 1/0 | United River Plate | 3 | 4 | 3 | 4 | .. | January and July .. | .. | — |
| £146,128 | Stock | 5% | Do. 5 per Cent. Debenture Stock | 90 | 95 | 90 | 95 | 5 5 3 | .. | .. | .. |
| £3,200 | 100 | 7% | Do. 7 per Cent. Debentures | .. | | .. | | .. | — | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | | | |
| 200,000 | 5 | .. | London Electric Supply | 1¼ | 1¾ | 1⅜ | 1⅝ | .. | — | 8 | 7½ |
| 43,900 | 10 | .. | Metropolitan Electric Supply (£8 paid) | 7½ | 8 | 7¾ | 8¼ | .. | — | 3⅞ | .. |
| 42,858 | 5 | .. | Westminster Electric Supply (£3 paid) | 3½ | 4 | 3¾ | 4¼ | .. | — | | .. |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | | | |
| 63,416 | 3 | .. | Brush Electrical Engineering | 2⅜ | 2⅝ | 2⅜ | 2⅝ | .. | .. | 2⁷⁄₁₆ | 2½ |
| 63,416 | 2 | 0/10 | Do. 6 per Cent. Preference | 1½ | 2 | 1½ | 2 | 6 0 0 | June and December | 1⅞ | 1⅞ |
| 20,000 | 5 | 3/6 | Crompton and Co., 7 per Cent. Pref. Shares | 5 | 5½ | 5 | 5½ | 6 7 3 | January and Jul .. | .. | .. |
| 17,130 | 5 | .. | Edison and Swan United | .. | | .. | | .. | .. | .. | .. |
| 45,000 | 10 | 6% | Electric Construction | 6½ | 7 | 6½ | 6¾ | .. | .. | 4¼ | 8¾ |
| 70,000 | 2 | 10/0 | Elmore's Patent Copper Depositing | 3¾ | 4¼ | 6¾ | 4¼ | .. | .. | 3⁵⁄₁₆ | .. |
| 20,000 | 5 | .. | Fowler-Waring Cables (£4 paid) | 2½ | 3½ | 2½ | 3½ | .. | .. | | |
| 41,600 | 10 | 10/0 | India Rubber, Gutta Percha & Telegraph Works | 18½ | 19½ | 19 | 20 | 5 0 0 | February & August | 19½ | 19½ |
| £300,000 | 100 | 4½% | Do. 4½ per Cent. Debentures, 1896 | 103 | 105 | 103 | 105 | 4 5 9 | March & September | .. | .. |
| 11,334 | £10 | 6/4 | International Okonite Limited Ordinary | 9½ | 9¾ | 9½ | 9¾ | .. | .. | .. | .. |
| 11,334 | £10 | 5/0 | Do. Preference | 9½ | 9¾ | 9½ | 9¾ | .. | .. | .. | .. |
| 78,949 | 5 | 4/10½ | Swan United (£3. 10s. paid) | 4½ | 5 | 4½ | 5 | .. | May and November | 4⅜ | 4¾ |
| 37,350 | 12 | 12/0 | Telegraph Construction and Maintenance | 46 | 48 | 47 | 49 | 4 18 0 | March and July | 48½ | 46½ |
| £150,000 | 100 | 5% | Do. 5 per Cent. Bonds, red. 1894 | 102 | 105 | 102 | 105 | 4 15 3 | January and July .. | .. | .. |
| | | | **RAILWAYS.** | | | | | | | | |
| 50,000 | £10 | .. | City and South London Railway | 7 | 8 | 6 | 7 | .. | .. | 6¾ | 6⅝ |


# IMPROVEMENTS IN DYNAMOS.




## STATTER-BRUNTON DYNAMO.

**The latest design in the market, made with all the advantages of the latest scientific knowledge and the highest mechanical skill.**

The woodcut represents our B TYPE DYNAMO. A most efficient machine, working noiselessly, and without sparking or overheating; is highly finished and well proportioned. The output is so rated in our Catalogue that the machines may be worked very much in excess of their stated full output for short periods.

**STOCK SIZES UP TO 77 KILOWATTS.**

**MACHINES BUILT TO 500 KILOWATTS.**

## THE ELECTRICAL ENGINEERING CORPORATION, LIMITED,

[STATTER'S] [UNITED

68, Victoria Street, London, S.W. Works:—ALLIANCE ENGINEERING WORKS, WEST DRAYTON, NEAR LONDON.

# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 666.—Vol. XXVI. FRIDAY, FEBRUARY 20, 1891. Price Fourpence.

## NOTES.

On Monday last the supply was recommenced from Deptford, after having been shut down for three months. At present the current is on only between 4 p.m. and 2 a.m., as the distributing stations are not yet complete, and the engineers, who have thoroughly appreciated the facilities which the cessation of supply has afforded for carrying out the permanent work, naturally prefer to make good the constructive work without having 10,000 volts at their elbows. The present supply has shown that the London Electric Supply Corporation still exists, and their old customers are returning as fast as they can be dealt with. The first few were rather shy, each wanting to see how the other liked being connected to the new system with its enormous pressure; but finding that the lamps burned steadily at their accustomed 100 volts, the others came in freely. It is hardly necessary to state that before starting everything was tested on open circuit, the mains and transformers being subjected to 17,000 volts, and all the house connections and fuses being carefully overhauled. The overhead circuits have been entirely abandoned, and Siemens and Fowler-Waring concentric sheathed cables alone are used, the few lengths of ordinary cable previously in use have been drawn out and will be made into concentric cables. Mr. Ferranti is strongly opposed to the use of ordinary cables for anything over 200 volts, and instances the slight accident which occurred some months ago in Piccadilly, and which could not have occurred with a concentric cable.

On Wednesday last we visited the Grosvenor Gallery distributing station, and found four 150 horse-power transformers situated in a room in the basement. Two Ferranti mains, working at 10,000 volts, enter near the ceiling, and are connected with switches which allow any transformer to be put on to either main. The Cardew voltmeters were reading 105. Passing through the rooms once occupied by the machinery, and from which the boilers were being removed, a subway leads to the site of the new building. Here are established a number of switches and cut-outs on the intermediate system, distributing at 2,400 volts; and alongside this will be arranged ten 150 horse-power transformers, in two sets of five on each side, and supplied from two mains. The switches will be arranged so as to secure complete duplication. A similar set of ten transformers will be placed at Trafalgar-square, behind the P. and O. office; eight others will be laid down at Victoria Station, six at Blackfriars, besides a set at Deptford for the supply of the neighbouring district, where application has been made for some 10,000 eight-candle lamps.

The machinery actually ready for running at Deptford consists of two dynamos of 1,500 horse-power, and two of 650 horse-power. Four complete sets of mains are laid up to London, the two running to the Grosvenor Gallery being about 16 miles in length. All the sub-stations will be connected by several trunk mains, capable of conveying 2,500 horse-power at 2,400 volts. Each station will be fitted with a complete system of inter-locking switches, so that no mistake can be made. The whole group may be expected to be in working order within the next three or four months.

Most figures hitherto published in connection with that much-discussed question, the actual cost of accumulator traction, have been based upon insufficient or misleading data. The figures with regard to the first year's working of the Barking road cars, which Mr. Kapp was able to make public at the Society of Arts on Monday, are, however, of a very different character. They are the outcome of hard, practical experience, and are, moreover, given in such detail as to render them extremely valuable.

It will be doubtless within the recollection of most of our readers that, a little more than a year ago, the General Electric Power and Traction Company, after considerable preliminary experimenting, entered into a contract with the North Metropolitan Tramways Company to work the Barking-road section of their system at 4½d. per car mile by means of accumulator cars. A charging station was erected, and six cars, five of which were in constant service, were duly equipped, at a total cost of close upon £6,200. The running of these cars has been very regular, and has given satisfaction to the Tramway Company. Considerable doubt was at the time expressed in these columns and elsewhere as to the possibility of accumulator traction proving remunerative at 4½d. per car mile, and we pointed out that although the margin of profit might not indeed be very large, the meagre figures then at our disposal did not necessarily lead to the conclusion that the thing was impossible.

Mr. Kapp's figures, however, show that the cost of running 100,844 car miles per annum on the Barking-road line amounts to £3,390 4s. 4d., or 8.068d. per car mile, involving a loss

Digitized by Google

to the contractors therefore of £1,470 a year. The *total* cost of horse traction in London averages, we believe, about 10d., the haulage expenses alone amounting to 6d. Haulage by accumulators has consequently proved to be 2d. dearer than by horses. Moreover, on examining the various items which go to make up this 8·068d. per car mile, we do not exactly see where the minimum saving of 3d. necessary to render accumulator traction profitable to *contractors* is to come from. The five most formidable items are:—Wages at depôt, £677. 6s., or 1·612d. per car mile; drivers, £601. 14s. 1d., or 1·432d. per car mile; fuel, £433. 19s. 9d., or 1·033d. per car mile; batteries (depreciation and repairs), 66 per cent., £1,184, or 2·818d. per car mile; motors (depreciation and repairs), 33 per cent., £180, or ·428 per car mile. Further experience may somewhat reduce the rapid deterioration of the batteries, and when working on a larger scale wages at depôt and fuel would not contribute so markedly to the total cost; but we should be very glad to learn how it is proposed to effect any sensible reduction on these items, and whether Mr. Kapp's figures are taken from the most recent returns.

A dispute has arisen in connection with the electric lighting of Dublin, with regard to the property which an engineer has in designs submitted by him with a tender. As a matter of fact, no harm appears to have been done, since, as we reported in our last issue, the contract has been given to the Electrical Engineering Company of Ireland, in connection with the Irish House-to-House Company, and their plans have in no way been altered. But at one stage of the protracted negotiations a scheme put forward by Mr. J. E. H. Gordon somewhat fascinated the Corporation, since it was backed up by several opinions, and was endorsed by their consulting engineer. The versatility and originality of Mr. Gordon, being so well known, it was not surprising that the scheme was one that has never yet been tried in this country. Why Mr. Gordon's tender was not adopted we do not know, but we understand that it was stated that it would save £1,500 a year in working expenses, and that it was suggested to other contractors by the committee that they should amend their tenders, and adopt the chief features of this scheme.

We hoped to have placed before our readers a brief account of the new system, but we have received no information other than that large transformers were to have been used for feeding into a three-wire network, and that smaller transformers were to have been used during light loads. The idea of large transformers on a network was dealt with by Mr. Kapp in *Industries*, December 2, 1887, and was exhaustively examined by Mr. Crompton in his historical Paper on "Central Station Lighting" (*Electrician*, Vol. xx., p. 634). Numerous methods of cutting in small transformers to replace large ones have been patented, and Mr. Ferranti had a patent for the whole combination, or something very like it.

If Mr. Gordon's scheme was thoroughly protected by patents, he could, of course, have obtained an injunction to restrain the Corporation from using it, either in its entirety or in any details, but we are not aware that any other rights can be claimed. As, however, the idea of employing the scheme has been abandoned, it is unnecessary to enter into the personal questions which have arisen in connection with it. The only safeguard against such appropriation of an idea is afforded by Patent Law, but any temptation should be avoided by providing a proper specification, or if it is considered that contractors know more about the work than consulting engineers, he well-known system of competitive designs, so largely employed in architectural work might be adopted, a good premium being paid for the best designs, which might, by agreement, remain the property of the contractor as in architect's practice.

From the article we publish this week, our readers will see that Mr. Tesla has effected a further improvement in his alternating motor. The two currents, differing in phase by a quarter of a period, needed for working this motor, were at first produced by a specially wound dynamo, and needed at least three leads to conduct them. These requirements were done away with subsequently by using a transformer to produce the second current, and it is in the employment of part of the motor itself as a transformer that the novelty of the present design consists. In spite of the ingenuity of the arrangement, it does not appear hopeful from a practical point of view. The efficiency of the new motor must necessarily be less than that of the original one, since an extra transformation of energy occurs. The winding of the field magnets cannot be so effectively carried out, owing to the space occupied by the secondary coils. There will also be a large amount of waste heating, not only in the regulating resistance, but in the coils themselves, because, as in all transformers, the magnetic effects of the primary and secondary currents are opposing each other, so that it is necessary for larger currents to flow to exert the requisite magnetic influence than would otherwise be the case. The consideration of alternate current motors is very important, but alternating currents lend themselves so readily to complex arrangements whose working is of a debateable nature, that it is unfortunate that the mention of new devices is so rarely accompanied by experimental data as an aid towards a correct judgment.

Electricity already plays a sufficiently important part on a modern man-of-war, and it is destined before many more years have elapsed to greatly enlarge the sphere of its operations afloat. On land, if we may judge from Major Hippisley's Paper, which will be found in another column, the utility of the electric lightin military operations has also not been overlooked. That search lights would in future form part of the regular equipment of the defenders and assailants of first-class fortresses was to be anticipated; but portable electric light plants are, it seems, indispensable adjuncts to the defence, if not to the attack, of positions, and to the other operations of an army in the field. At present the excessive weight (4 tons) of these plants alone prevents their general introduction by the military authorities. The difficulty of hitting projectors has long been proverbial, but the experiments referred to by Major Hippisley make projectors appear so extraordinarily invulnerable that those in charge of them certainly ought to be able to secure life-policies at a lower rate than is usual.

Digitized by Google

If re-invention be any proof of the importance of a discovery, Mr. Blakesley is to be congratulated upon the number of times which his method for determining the difference in phase of two alternating currents has been independently devised by electricians. The method in question depends on the use of what Mr. Blakesley calls a "split dynamometer," the fixed and movable coils of which are traversed by the two currents under examination. The reading of this instrument is proportional to the product of the two currents, and to the cosine of the phase angle between them; so that the latter quantity can be found if the magnitude of each current is determined by any ordinary process. This method, which has been successfully applied by its author to the measurement of the power given to the primary coil of a transformer, was first published in *The Electrician* for October 2, 1885, and was afterwards reprinted in Mr. Blakesley's well-known book on Alternating Currents. It was re-invented in 1888 by Signor Ferraris, of Turin, and in the *Electrical Engineer* of New York of February 4th Mr. Chas. Steinmetz describes the same method without any reference to the work of Mr. Blakesley, and in apparent ignorance that the method is quite old. A suggestion is made at the end of the article to the effect that the method can be applied to measure the difference of phase between current and potential, or that between two electromotive forces, by using one or two fine wire coils shunted to the potentials to be tested. This suggestion is, however, of but little value, as the currents in the fine wire coils cannot be in the same phase as the potentials producing them, owing to self-induction, while the impedance of the coil, and hence the constant of the instrument, will vary with the frequency of the current.

We call the attention of our readers to the fact that the 1891 Edition of our Electrical Trades' Directory will be ready on Monday. Owing to the growth of the electrical industry the compilation of this Directory has become a task of considerable magnitude, and without the cordial assistance which is afforded on all sides the work of the compilers would be exceedingly onerous. The 1891 Directory will, we think, be found as accurate as those of previous years, and even more replete with useful information.

**The Trinidad-Demerara Cable.**—This cable is now interrupted.

**Coventry.**—At the last meeting of the Town Council it was resolved that application be made to the Board of Trade for a provisional order.

**Honour to Professor Helmholtz.**—The French Government have decorated Prof. Helmholtz with the Grand Cross of the Legion of Honour.

**Commercial Cable Company.**—The general offices in London of this Company have been removed from 29, Threadneedle-street, to 18, Bishopgate-street Within, E.C.

**Waterpower at Tivoli.**—The Italian Minister for Public Works has reported in favour of a scheme for utilising the waterfall at Tivoli and conveying the power derived therefrom to Rome.

**The Inventors of the Electric Motor.**—In the *Electrical Engineer* of New York of February 4th, Mr. Franklin Leonard Pope concludes a very interesting series of articles on "The Inventors of the Electric Motor," in which he has placed on record the work of Thomas Davenport, "the Green Mountain village blacksmith," in the field of electric motor invention.

**The New Calcutta-Bombay Telegraph Line.**—The new telegraph line from Calcutta to Bombay (1,000 miles), *viâ* the Bengal-Nagpur Railway, will be opened for traffic in the end of February.

**University College and King's College Extension Funds.**—A meeting in connection with these funds will be held at the Mansion House on Monday next at 3 p.m., under the presidency of the Lord Mayor.

**Eisenach.**—The Town Council of Eisenach has entered into arrangements with the Allgemeine Elektricitäts Gesellschaft of Berlin, for the erection of a 2,000 light central station. The estimated cost is £15,000.

**Celluloid Covered Wire.**—The Buda-Pest *Anzeiger fur die Beleuchtungs Industrie* gives an account of a new wire for electrical purposes called Hungaria wire, which is covered with two coats of thread and two coats of celluloid.

**Colliery Lighting in India.**—Charanpur Colliery, the property of Messrs. Apcar and Company, has, says *Indian Engineering*, just been lit up with the electric light. This is the first colliery in the district ever lighted by electricity.

**Electric Launches.**—The four electric launches which during the Edinburgh Exhibition season conveyed 98,000 persons along the canal between the city and the exhibition are shortly to be brought to Windermere, and will ply for hire on the lake.

**Royal Society.**—Among the Papers down for reading yesterday were—"On the Sensitiveness of the Bridge Method in its Application to Periodic Currents," by Lord Rayleigh, and "On the Focometry of Lenses and Lens-combinations," and "On a New Focometer," by Prof. Silvanus Thompson.

**Electrically Welded Shells.**—The experiments which the United States Government have for the past 18 months been conducting in connection with shell welding by electricity have resulted in the Government entering into an arrangement with the Thomson Electric Welding Company to furnish a large quantity of electrically welded shells. A new factory will be erected for the purpose, in charge of specially trained men, with every facility for producing the shells.

**The Institution of Electrical Engineers.**—The annual general meeting of the students of the Institution was held on Friday last at the offices of the Institution, when the following gentlemen were elected to serve on the Committee:—Messrs. F. A. Jones, J. H. Garret, P. Matthews, — Locke, H. B. Little, H. C. Haycroft, and A. G. Seaman, hon. sec. At the next meeting to be held on Friday, Feb. 27th, at 8 p.m., a Paper on "Electric Lighting Safety Apparatus" will be read by Mr. Stanley Bone.

**Electrical Bills in Parliament.**—Several petitions have been lodged against the Central London Railway and the extension of the Electric Railway to Islington, amongst others, by the Metropolitan Railway Company, the Dean and Chapter of St. Paul's, the Governor and Bank of England, and various persons affected on the line of route. The London County Council Overhead Wires Bill is opposed by the Honourable Societies of Lincoln's Inn, the Inner Temple, and the Middle Temple, as well as by the East London and Metropolitan District Railway Companies.

**Village Lighting.**—The local authorities of Lockstedt, near Altona, have decided to introduce a system of electric lighting in the streets. The carrying out of the installation has been entrusted to the Thomson-Houston International Electric Company of Hamburg.——The village of Fardo, on the St. Gothard line, also has a small electric light plant, driven by water-power under a head of 480ft. Current is supplied by two dynamos, each capable of giving 160 amperes at 140 volts. The village is lighted by 360 glow lamps, those in the streets being of 25 candle-power.

**Electric Lighting Legislation in Germany.**—The electric lighting and allied industries in Germany have developed so considerably during the past few years that the German Government has decided to bring them under legislative control. An Electric Lighting Bill has, therefore, been introduced into the Bundesrath. It contains 15 clauses, referring to the erection and working of central lighting stations, the distribution, and application of electricity for the purposes of light and power, underground conductors, and the working of private installations, &c.

Digitized by Google

**The Abridgement of Patent Specifications.**—In answer to Mr Leng, Sir M. Hicks-Beach stated in the House of Commons last week that the abridgement of specifications in the Patent Office had only been commenced within a comparatively recent period; but it is being now pushed forward as speedily as possible. He estimated that during the financial year ended March 31st 16,000 specifications would have been abridged, and that approximately the same rate of progress would be maintained until the arrears were overtaken. Abridgements of only three classes were out of print, and he was not aware of any large demand for a reprint of these.

**Secondary Battery Plates.**—The following process of secondary battery plate construction has lately been brought out by Mr. C. F. Brush. It consists in producing upon the grid an electro deposited active coating; then immersing the plate in an electrotype in which the coating is insoluble, and afterwards peroxidising the coating by electrical action. The spongy lead is deposited upon the grid as in any ordinary process of electro-plating, the plating solution consisting of acetate or nitrate of lead, or of sulphate of lead dissolved in any suitable neutral saline solution. The spongy metal is deposited very slowly, in order that it may have sufficient compactness to retain its position.

**Electric Lighting in Victoria.**—The *Building and Engineering Journal* of December 27, 1890, contains an illustration and description of the central lighting station of the A. U. Alcock Electric Light and Motive Power Company at Richmond (Vic.), which is now in course of erection. The building will cover an area of about 1½ acres. The station when completed will supply about 250,000 incandescent lamps, and the portion now being erected will contain machinery equal to the supply of 20,000. When completed and fitted with the necessary machinery the station will be the largest in the Southern Hemisphere, and it is estimated to cost over £250,000.

**Electrical Transmission of Power in Switzerland.**—The Oerlikon Machine Works have acquired water power at the village of Hochfelden, in the Glatt valley, sufficient for driving two turbines, each of from 200 to 300 horse-power. Electricity, says *Industries*, will be generated at Hochfelden, the pressure being 25,000 volts, and transmitted to Oerlikon, a distance of twelve miles, by means of overhead wires supported on 40ft. poles, alongside the railway and the country roads. There will be four cables, each 4mm. in diameter, of which one will serve as a reserve. At the works the pressure will be reduced to 50 volts, and the power will be utilised for driving the whole of the machine tools in the establishment.

**The Australian Cable Rates.**—The following letter from the Secretary of the Eastern Telegraph Company appeared in the *Financial News* of Thursday last week:—"Sir: In your issue of this date (February 12th), quoting from a statement in the *Melbourne Age* you state that 'the Company says it is not only unprepared to introduce the new tariff offhand, but cannot even name a date when it will be able to do so.' I am instructed to say that in the agreement which has been arrived at with the interested telegraph administrations, now before the Australian colonies, it is stated that we can reduce the tariff in 15 days after the Australian Governments have accepted the conditions. So far as we know, there is no suggestion of any disagreement up to this time."

**The Electric Lighting of the Brighton Grand Hotel.**—At the thirty-first ordinary general meeting of the Brighton Grand Hotel Company on Wednesday. The Chairman complained of the way in which the Directors had been treated by the Electric Light Company who had endeavoured to force upon them an engagement for three years, and had cut off the light after a few days' notice because they had refused to enter into it. But for their foresight in providing gas connections when electricity was put in they would have been left in darkness. However, they had now put in an electric lighting installation of their own at a cost of about £6,000, which, calculated at 5 per cent., meant £300 a year, whereas they had been paying £2,000 a year for electricity hitherto.

**New Thomson-Houston Street Railway Motor.**—During the past year the Thomson-Houston Electric Company have been experimenting with a new slow-speed motor for street railway service. The new motor is nearly iron clad, having two internal pole pieces of ample spread, carrying two field coils, which partially surround the armature core. The armature is of the Gramme ring, instead of the drum type formerly used by the company. The spur pinion on the armature shaft is of steel, 4½in. face, and has 14 teeth. The split gear, which is bolted on the car axle, is of cast iron, with the same width of face, and has 67 teeth. The speed of the armature shaft relative to that of the car axle is nearly 4·8 to 1, and when the car is running 10 miles per hour the armature makes 530 revolutions per minute.

**European Telegraph Statistics.**—In its review of the past year, the *Journal Télégraphique* gives the following figures:—According to the latest statistics, the European telegraph administrations now place 353,400 miles of line and 1,023,000 miles of wire at the disposal of the public, an increase respectively of 4·6 per cent. and 3·1 per cent. upon previous returns. The increase in the number of telegraph offices has been very marked of late. In the seventh edition of the "Nomenclature des Bureaux," which appeared in 1887, 60,000 names were given, the eighth edition contains 75,000 names, or 25 per cent. more. The number of telegrams transmitted also continues to increase. Last year 200,000,000 messages were despatched in Europe, of which 45,000,000, or 22·5 per cent., were international.

**A Century of the American Patent System.**—The *Electrical Engineer* of New York has the following remarks with regard to the proposed celebration of the forthcoming centenary of the American Patent System:—"It is proposed, and all the preliminary arrangements have now been completed for the purpose, to celebrate next April, in Washington, the completion of the first century of the American Patent System. Such an occasion as this will be a most favourable one for impressing upon the public mind the enormous benefits that the system has conferred upon American civilisation and development. If we wish to stop the present rapid rate of advance in the arts and sciences, in general welfare and individual comfort, all that is necessary is to abandon the system. The system is not perfect, far from it, but it is one of the most useful and praiseworthy of our institutions, unsurpassed as a creator of property and values and blessings common to all."

**Elliott's Smoke Annihilator.**—In the House of Commons, on Tuesday last, the First Lord of the Treasury was asked whether his attention had been drawn to Mr. Elliott's invention for the annihilation of smoke, now on view on the Thames Embankment; and whether it was the intention of the Government to give the invention a trial, with a view to the possibility of taking some steps to abate the smoke nuisance in the metropolis. Mr. W. H. Smith replied that he was not personally acquainted with the apparatus in question, but he was informed by the Metropolitan Police, whose duty it was to enforce the Acts relating to the smoke nuisance in the metropolis, that smoke had been observed to issue from the chimney on the Thames Embankment, from which it might be inferred that the apparatus was not at all times successful. Referring to this statement, Mr. Samuel Elliott says that in order conclusively to demonstrate the effectiveness of his system large quantities of smoke are generated which directly his machine is set in motion disappear.

**Electricity on the Stage.**—It is prophesied, says the *Western Electrician*, that the stage will soon become one of the most profitable fields in which the electrician may exercise his ingenuity. Mr. Neil Burgess believes that electricity will revolutionise stage management in a few years. He says that by the use of electric motors the whole mechanism of a complicated play can be put under the control of a single man, and manipulated with such facility and rapidity as to very much reduce the waits between acts, and entirely obviate any of the exasperating hitches which otherwise might sometimes occur. He proposes still further to increase the application of motors to his own stage setting, so that as far as possible all mechanical devices and movable scenery, curtains and the like, will be handled by motors from one point with great rapidity, and without the danger from careless attendants. The Universal Arc Lamp Company of New York make an arc lamp for

Digitized by Google

theatrical purposes. This is described in the *Electrical Engineer* of New York. It is provided with lenses and coloured screens, and works at 45 volts.

**Electrical Mutual Insurance.**—About a year ago the owners of central lighting stations in Massachusetts, and others, being of opinion that the existing insurance companies' premiums were unwarrantably high, formed themselves into a mutual insurance company, and a very instructive report has just been published. The company issued its first policies on May 15th. The report covers the operations to December 31, 1890—7½ months. The outstanding risks amount to $2,897,587, the premium on which is $30,320.71—an average rate of about 1⅓ per cent. The average amount of policies is $9,055. Not a dollar of loss has occurred on any station insured. The average rate prevailing previously was about 2 per cent. The report concludes as follows:—"Your Board feels that you and those engaged in electrical development generally will not fail to appreciate the good results that will follow, and the fire losses that may be avoided by, the dissemination of practical and valuable ideas pertaining to safety, through the intelligent inspection of its risks by an assurance association devoting itself especially to the electrical business."

**Gas and Electric Light Undertakings in Massachusetts.**—The following is from the sixth annual report of the Gas and Electric Light Commissioners of Massachusetts—embracing the twelvemonths ending in June last:—Although there has been a steady progress of electric lighting, there has been in most places a gradual increase in the consumption of gas. Electric motors are coming into more general use, although their cost has not been much lessened. It is suggested that the Board should have power to call on the State Gas Inspector to test the candle-power of the electric light. In twenty-four cities and towns the companies furnish both gas and electric light. During 1890 five persons were injured, three fatally, by electric light plants; and 23 persons were injured, eight fatally, by illuminating gas—two of the latter being suicides. During the year there were 12 electric light companies incorporated, with a total capital of $267,000. The electric light companies paid dividends of $153,708; but only 21 out of 60 did so. The electric light central stations showed receipts of $1,920,702, and a balance of $579,887; the gas companies receipts of $5,270,991, and a net balance of $1,608,618.

**Electrical Purification of Sewage.**—The Salford Corporation instituted an exhaustive series of experiments last year on the treatment of sewage with a view to the adoption of the most suitable system for the purification of the Salford sewage. Trials were made at the local sewage works with four methods, namely, the International, the Electrical, the Aluminoferric, and the Barry systems. The services of Mr. Carter Bell, the borough analyst, Mr. J. Newton, C.E., Dr. Burghardt, and Mr. O. Giles, of Messrs. Mather and Platt, were secured to investigate the systems and draw up a report. This has now been presented to the Corporation. The Aluminoferric and the Barry systems are considered to be less satisfactory than the International and the Electrical. Mr. Carter Bell, in summing up his report on the chemical aspects of the two latter systems, states:—"If the International or the Electrical Company will guarantee the Corporation of Salford to produce an effluent from the whole of the Salford sewage which shall equal the effluents they have produced during the last few months, then I think the Corporation will be justified in expending the large amount of money that would be involved in purifying the sewage."

**Telegraphic Communication with Hawaii.**—The United States Senate spent three hours on Monday in secret session debating the following amendment to the Diplomatic and Consular Appropriation Bill:—"In order to enable the President of the United States to enter into an engagement with any citizen or corporation of the United States, as shall appear to possess the means and facilities necessary to that end, for the establishment of telegraphic communication between the United States and the kingdom of Hawaii, which engagement shall contain provisions sufficient in the judgment of the President to secure to the Government and citizens of the United States early and equal communication by telegraph with the kingdom of Hawaii, on reasonable terms, for a period of not less than 14 years, a sum not exceeding $250,000 is hereby appropriated for each year during which the engagement shall be in operation, the term during which such engagement shall be so in course of execution not to exceed 20 years. The sum total to be paid under this authority shall not exceed $3,000,000." The amendment was agreed to at the secret session; but the actual voting upon it was reserved for the open session, when it was re-adopted by 35 to 22.

**Electric Traction at Buffalo (N.Y.).**—The various street railway companies in Buffalo (N.Y.) have recently amalgamated, and, in addition to the adoption of electric traction, considerable extensions are in progress. When the system is complete it will comprise 106 miles of track, over which 300 cars will be in daily operation. The power house will contain plant having a final aggregate capacity of 5,500 horse-power. About one-third of the line will be centre-pole construction, with tracks spread to 6ft. In order to make the line more secure, and less cumbersome in appearance, the feeders will be generally run in underground conduits. Babcock and Wilcox boilers, 250 horse-power Ball engines, and 225 horse-power Edison dynamos are being installed. All the engines have heavy fly-wheels, weighing seven tons, and running at 210 revolutions. The feed wires are connected up to the trolley wire from the underground conduit at every eight poles, or about every 1,000ft., all connections being made from man-holes. Two styles of underground tubing have been used, about one-half of each, namely, the wood pulp pipe of the Indurated Fibre Pipe Company and the cement-lined pipe of the Standard Underground Company. The best insulated lead and jute covered cables are used throughout in the conduits. All the track of the company is being reconstructed and built in the most substantial manner.

**The Electrical Standardising, Testing, and Training Institution.**—A *conversazione* was held at Faraday House, Charing Cross-road, on Monday evening last, by Mr. and Mrs. Robert Hammond, in connection with the Electrical Standardising, Testing, and Training Institution, which has recently taken up its quarters there. This Institution, which is under the management of Mr. Hugh Erat Harrison, formerly Principal of the "Hammond College," is well equipped with apparatus, and is provided with a number of laboratories, lecture rooms, workshops, &c. The work undertaken by the Electrical Standardising, Testing, and Training Institution, as its title implies, comprises the standardising and testing of electrical instruments and apparatus, the inspection of installations, the testing of inventions, and the training of electrical engineers. The course is spread over two years, one of which is devoted entirely to practical engineering work. It is the intention of the Institution to affiliate itself with some of the principal electricity supply companies, and this has already been done in respect of the London Electric Supply Corporation, the House-to-House Company, and other companies. By this means it is proposed to give students an insight into the actual working of large generating plants. The proper training of electrical engineers is undoubtedly a matter of considerable importance, and the degree of success which attends this somewhat novel Institution will be watched with interest.

**The Lieb Elastic Trolley Wheel.**—The operation of electric railways has, says the *Electrical Engineer* of New York, developed the fact that while the trolley wheel is a most simple device for taking off the current from the overhead conductor, it labours under the disadvantage of affording only a small surface contact for the passage of the current being reduced, in fact, to a mere tangent point. As a result, the resistance of the contact entails a loss of energy, and at the same time causes a decided heating of the trolley wheel, which, in consequence, requires copious lubrication to keep it in good running order. Again, the solid trolley wheel at present employed has a tendency to jump, causing sparking, as well as noise and wear. To obviate these difficulties, Mr. Lieb has designed an elastic trolley wheel. This wheel is provided with a lining of brass in which springs are cut and curved outwards away from the plane of the sheet and having their ends curved inward again. The pressure of the trolley-wire on the springs compresses them

Digitized by Google

so that there is relatively no shock or jar of the trolley against the wire, and separation of them is largely avoided; the shock of the trolley also, when it comes in contact with the clamps by which the trolley-wire is suspended, is largely avoided Thus the movement of the trolley along the trolley-wire is smooth and even, and sparking, wear on the parts, and noise are much reduced. In the usual form the trolley-wire comes in contact with only a very small arc of the trolley-wheel and at one point through which the contact must be made, in the new construction the flattening or compressing of the yielding surface of the wheel upon pressure by the wire or its attachments greatly enlarges the area of contact.

**Boiler Compositions.**—In the whole range of this country's industries, says the *Chemical Trade Journal*, we question if there is any one branch which yields such enormous profits as that of boiler composition making. Not that the price of these commodities is ruinously heavy, but rather because the cost of production is almost incredibly small. In point of fact, when once a composition has been forced on the market, the fortunate maker may charge pretty much what he pleases. . . . We still hold to the grand old maxim that "prevention is better than cure." A thousand times better keep lime salts out of one's boiler than proceed to cure their effects once they have got in. We are well aware that this is a difficult thing to do, but it can be done if people will only go to the trouble and bear the first cost of the necessary plant, which would in a large number of cases save many hundreds of pounds sterling every year by the abolition from one's works of these delusive boiler compositions, which, in the long run, constitute about the most expensive method of boiler cleaning that could well be devised. We admit that in some cases the proper cleaning of feed-water before it enters the boiler is impracticable, owing to want of accommodation, boiler-power not large enough to warrant the erection of softening plant, and other reasons, in which cases the simpler the remedies the better. Ordinary tanner's sumac cannot be beaten for this purpose, and it can be obtained in almost any part of the country at a very cheap rate. The excessive use of this substance must, however, be avoided, as it then acts slightly on the boiler plates, but with ordinary and intelligent usage one need have nothing to fear. In conclusion, we would again impress upon all steam users the advisability of having their feed-water properly softened before being used in the boilers.

**An Indicator of Acidity in Boiler Waters.**—As is well known, water containing magnesium chloride is injurious to boilers, as the salt dissociates with the production of hydrochloric acid which attacks the plates. In large installations says *Industries*, where systematic purification of the feed water can be adopted, this evil is prevented, but in most cases the treatment in vogue consists in adding caustic soda to keep the contents of the boiler alkaline. An excess of the soda is wasteful and otherwise objectionable, and it becomes desirable to be able readily to ascertain when the water in the boiler ceases to contain alkali and needs a further supply. The handiest way to do this would be to have a certain quantity of some indicator always present in the boiler, but unfortunately all the usual indicators, such as litmus and turmeric, become decolorised under the influence of water at high temperature and pressure; the same objection applies to Congo red. Dr. Goldberg has, however found that the sodium salt of paranitrophenol is entirely unaffected either by these conditions or by the salts usually present in feed waters. It is therefore possible, by introducing a sufficient quantity into the boiler, to judge of the alkalinity or acidity of its contents at any given moment by merely blowing the water out of the gauge glass and allowing it to refill. To give a distinct yellow colour (the evidence of alkalinity) to the water, so that it may be seen in the small quantity of water in the gauge glass, about 30 to 50 grammes per cubic metre are requisite. The high price of the substance is the bar to its general use at present. As its successful application is not dependent upon its purity, a crude variety could doubtless be produced much more cheaply if a demand arose for it.

**Metallic Thermometer with Electric Recording Gear.**—M. Chibout, says *Le Génie Civil*, has brought out a very sensitive metallic thermometer, constructed so that readings can be taken at a distance. It consists of a transmitter, or thermometer proper, and an electrical receiver. The transmitter consists of a bar of metal which easily expands, such as zinc in thin plates, but of such a section that it possesses the greatest rigidity possible. This bar is fixed at one end to a marble support, and at the other is joined to the short arm of a lever; to the long arm of the same lever, and at the same side of it, is fixed another similar bar, and the other extremity of the second bar acts on a similar lever, to the long arm of which is fixed a rack-gearing with a small pinion, on the axis of which is carried a pointer working over a dial, which registers in degrees the movement caused by the expansion of the two bars. Each joint between an expansion rod and a lever is made by means of a piece of spring steel, so as to avoid friction and still allow perfect play. Upon the last lever is fixed a radial contact-maker, which moves over a sector consisting of contact pieces insulated from each other. The receiver consists of a solenoid, in the centre of which is a spindle carrying a pointer travelling over a circular dial. The pointer carries at one end a small piece of soft iron, which, in the normal state, rests against another stationary piece of soft iron. Under the influence of the current, which proceeds from the distant apparatus, the two pieces of soft iron become magnetised with the same polarity and repel one another, and the needle travels through an angle proportional to the intensity of the magnetising current, so that a record is given on the receiver similar to that on the thermometer dial itself. The instrument is specially intended for allowing the temperature of distant rooms, where a constant heat must be maintained, to be read in the office. The above description is from the abstracts of Foreign Papers, published by the Institution of Civil Engineers.

**Overhead Wires as a Permanent Investment.**—The destructive storm of January 25th still continues the subject of much comment in the American technical press, and under the above heading Dr. S. Schuyler Wheeler, Electrical Expert to the New York Board of Electrical Control, makes some interesting remarks in the *Electrical Engineer* of February 4th. The collapse of the wires, he says, presents many curious and suggestive features. Some of the finest line construction in the world went by the board in an hour or two. A simple calculation will furnish the explanation. The snow as it fell and clung to the wire, fanned out beneath until each wire soon looked like a three-cornered ruler slightly rounded, the wire forming the upper edge. Each foot of that wet snow weighed about one pound. The extra weight thus suddenly thrown on was not less than 8½ tons per pole, applied at the height from the ground of 80 or 90 feet. Another striking feature was the variation in the manner of break-down. About two-thirds of the poles were broken, and about one-third were uprooted. Those uprooted were earthed only three or four feet. In all the best construction now, such as the long distance telephone line, the poles are set to a depth of 8ft. or 9ft., and in new soil even deeper. One method of construction carried out under the direction and approval of the Board of Electrical Control, pending the completion of the subways, came through the ordeal successfully. Hitherto it has been the practice to place the electric light wires bottom of all, although they are the strongest and least liable to break. On First Avenue, the electric light circuits of the Manhattan Company have been put away up above everything, at a height of 80ft. That pole line stood without a scratch. The Metropolitan Telephone Company, upon whom the heaviest blow fell—3,897 subscribers being disconnected—are more than confirmed by the storm in their intention to get every wire underground as quickly as possible. Even where the incompleteness of the subway system might allow them to rebuild, they will not attempt it, feeling that the permanence of the old overhead system is not great enough. The exhibition of destructive power made by a quiet little snow-storm that lasted barely nine hours ought to suggest, in interested quarters throughout the country, some weighty reflections on overhead lines as a permanent investment where a large number of circuits are to be run together, and to point the moral that, imperfect as subway systems and methods may yet be, they alone answer the requirements of the situation, and are equal to the emergency in a great city.

Digitized by Google

## THE MAGNETIC CIRCUIT OF TRANSFORMERS: CLOSED VERSUS OPEN.

BY S. EVERSHED.

(1) The alternate current transformer has led a curious dual existence since its appearance in this country, some ten years ago. Not having had the advantage of English parentage, it was necessarily regarded somewhat askance, especially as claims were made for it amounting to thinly veiled perpetual motion. However, when it occurred to someone to use transformers in parallel we quickly adopted it, and since that time it has been a mainstay in all lighting schemes covering large areas. Having adopted it as one of our own children, the first thing to be done was to provide it with a complete suit of mathematical clothing; accordingly Prof. George Forbes supplied his "Formulæ for Converters," Mr. Kapp settled the proportions of iron and copper, and nothing remained to be done. Practical men for the most part took no notice of these more or less mathematical essays, or, if they did, declared the clothing to be a misfit; while the mathematicians urged that the transformer ought to be squeezed into the garments provided for it at any cost. Future students of the history of the transformer at this time will probably recognise two entirely distinct types: the ideal or phantom transformer, and the transformer which runs lamps; the phantom being chiefly remarkable for the number of its constant co-efficients and for its usually immaculate iron core, while the transformer engaged in actual work, haply unconscious of L and M, could not keep its iron cold, and showed a distinct tendency to weakness in insulation. In short, the phantom and the real have developed side by side without any clearly apparent relation between theory and practice as cause and effect.

(2) Quite recently an interesting volume has appeared from the pen of Dr. Fleming, in which simple harmonic currents are largely dealt with, and several steps are taken to reconcile the phantom with the real by admitting that there are not one but three sorts of self-induction coefficient, mostly variable, besides a variable coefficient of mutual induction. This is indeed a welcome advance, and goes some way towards the final abandonment of such coefficients altogether in this connection. Matters being in this condition Mr. Swinburne, who already had a considerable reputation as a maker of paradoxes, electrified the B. A. meeting of 1889 by telling section G that the closed magnetic circuit was a mistake, and that for his part he intended to make open circuit transformers, they being both cheaper and more efficient under all usual conditions as to load. No one being inclined to discuss such a revolutionary proposition, Mr. Swinburne retired to Teddington to prepare "Hedgehogs" and more paradoxes. But he left behind him an uncomfortable suspicion that the "all-day efficiency" of most real transformers was lamentably low, and it cannot be supposed that the matter will be allowed to rest. In fact, the financial success of every alternate current supply company depends, to a large extent, on the all-day efficiency of its converters, so that it is of vital consequence to them to know what design to adopt for any given condition of load. It may be said at once that the problem of determining the best design for a given load is too complex to admit of ready solution, and the writer cannot hope to do more in the present articles than clear the ground by discussing the relative merits of closed and open transformers considered as part of a distribution system.

(3) The waste of energy in the transformers themselves being the key to the whole problem, we will first determine the amount of the various losses which go to make up the daily waste. The only losses of any practical importance are those caused by (1) Hysteresis in the core, (2) Eddy currents in the core, (3) Eddy currents in the coils, and (4) $C^2R$ loss in the coils. Of these the first two are now generally admitted to be the most serious. Having discussed the question of waste in the case of one or two closed and open transformers, quite apart from any consideration as to phases of induction, current and E.M.F., we shall next describe a method by which the periodic curves of these quantities may be drawn so as to give a true diagram of what is going on in a transformer under varied conditions of load.

The mathematical reader will do well to abandon the writer at this point, as in all probability L, M, and other such attributes of the phantom will not be mentioned.

(4) As an illustration of the method adopted in calculating the waste, we will take a 30 horse-power Goolden-Ravenshaw closed transformer, and determine the losses in it at full load. The writer has no reason to suppose this particular type to be either better or worse than others of its class; he simply takes it as an example because, in addition to the dimensions and other data, given in Table I., he has in his possession several cyclic **B-H** curves taken from specimens of the iron from which the cores of these transformers are made.

**Table I.**—*Thirty horse-power Closed Transformer.*

| | | | |
|---|---|---|---|
| Full load output ........................ | = | 22·4 | kilowatts. |
| Frequency = F ........................ | = | 70 | per second. |
| Total volume of iron in core ...... | = | 13,700 | cc. |
| Sectional area of iron in core ...... | = | 95 | sq. cms. |
| Mean length of magnetic circuit.. | = | 145 | cms. |
| Width of core plates = $b$ .......... | = | 15·2 | cms. |
| Thickness of core plates = $t$......... | = | ·05 | cm. |

| — | Primary. | Secondary. |
|---|---|---|
| Volts........................................ | 2,000 | 100 |
| Turns on coil .............................. | 680 | 34 |
| Resistance .................................. | ·97$\omega$ | ·003$\omega$ |

*Hysteresis Loss.*—This is found from the area of the **B-H** curve, taken between the maximum **B** on each side of zero, and

$$\text{maximum } \mathbf{B} = \frac{9\,\text{E}.10^8}{10.4\,\text{N A F}} \quad . \quad . \quad . \quad . \quad (1)$$

here, and throughout these articles E is *effective* E.M.F. in volts; so also C will always stand for *effective* current in amperes.

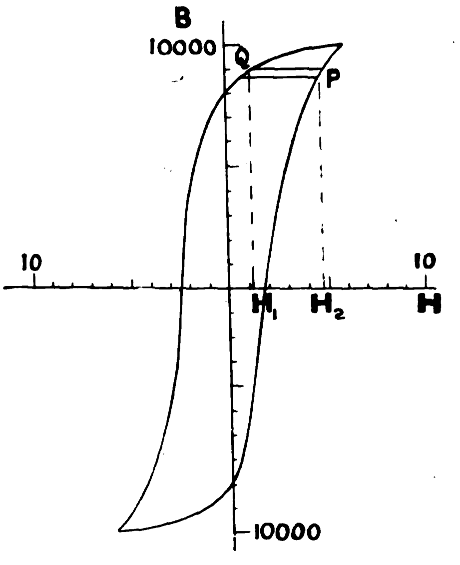



FIG. 1.—**B H** Curve taken from Charcoal Iron used in Ravenshaw Transformer.

E and N may be either the primary or secondary E.M.F. and turns; preferably the latter, the secondary being nearest the core. To reduce E to average E.M.F. we have used the coefficient $\frac{9}{10}$.

Putting the values given in the table into (1) we find maximum **B** = 10,000 gausses. The cyclic **B-H** curve between + and − 10,000 gausses is given in Fig. 1. Its area, measured by a planimeter, is 81,600 gauss-dynes, which, divided by the ubiquitous $4\pi$ gives the loss in ergs per cubic centimetre per cycle.

Digitized by Google

(5) An elementary proof of this well-known relation between the area of a cyclic **B-H** curve and the loss of energy may not be amiss. Suppose such a cyclic curve as that shown in Fig. 1 to be taken from a ring of iron one square centimetre in sectional area, and $l$ cms. in mean length. Let the magnetising coil have N turns, so that

$$\mathbf{H} = \frac{4\pi N C}{10\, l}$$

where C stands for current in amperes, take any point, P, on the rising curve, and consider what happens when **B** increases by a small amount $\delta \mathbf{B}$ during a short time $\delta t$; **H** has the value $\mathbf{H}_2$ during this change. What is the work done by the current on the iron during the time $\delta t$? The back E.M.F. in the magnetising coil is $N\frac{\delta \mathbf{B}}{\delta t}$; the current corresponding to $\mathbf{H}_2$ is $\frac{\mathbf{H}_2 l}{4\pi N}$; the product of these factors multiplied by the time is the work done, or

$$\text{work done} = \frac{\mathbf{H}_2 l}{4\pi N} \times N\frac{\delta \mathbf{B}}{\delta t}\delta t = \frac{\mathbf{H}_2 l}{4\pi}\delta \mathbf{B}.$$

Now when, during the time the current is falling, the induction diminishes by $\delta \mathbf{B}$ at the point Q, **H** is only $\mathbf{H}_1$, and the energy returned by the iron to the circuit carrying the current is $\frac{\mathbf{H}_1 l}{4\pi}\delta \mathbf{B}$, so that $\frac{l}{4\pi}(\mathbf{H}_2 - \mathbf{H}_1)\,\delta \mathbf{B}$ is lost in the iron. When $\delta \mathbf{B}$ is very small $(\mathbf{H}_2 - \mathbf{H}_1)\,\delta \mathbf{B}$ is the area of the little parallelogram P, Q; and as the whole cyclic curve can be divided into such little areas, the whole loss in the ring is

$$\frac{l \times \text{area of } \mathbf{B\text{-}H} \text{ curve}}{4\pi};$$

and since there are $l$ cubic centimetres of iron in the ring, the loss per cubic cm. is clearly

$$\frac{\text{area of } \mathbf{B\text{-}H} \text{ curve}}{4\pi} \text{ ergs. per cycle.}$$

It will be noticed that no distinction is made between the induction in the iron and the induction which would have threaded the coil if the iron were absent, thus departing from the highly artificial and confusing custom of dividing **B** into **H**, plus another quantity, the meaning of which in the case of a closed iron ring is not clear. To be consistent, those physicists who write $\mathbf{B} = \mathbf{H} + 4\pi\mathbf{I}$ ought, perhaps, when speaking of a copper wire carrying six amperes, to tell us, "the current in that wire is one ampere, which would be there if the wire were iron, plus five amperes 'induced' in the wire because it is not an iron but a copper wire." Or again, of a mica condenser, "that condenser holds five micro-coulombs at one volt; but it would hold one micro-coulomb if the mica were absent so that the total induced charge is only four micro-coulombs." Therefore its capacity is four microfarads!!

To resume. The area of the curve in Fig. 1 being 81,600, the loss per cub. cm. is $\frac{81{,}600}{4\pi} = 6{,}500$ ergs per cycle. The volume of iron is 13,700 cub. cm., the frequency 70, so we have for the *power* wasted on hysteresis,

$$W_h = \frac{6{,}500 \times 13{,}700 \times 70}{10^7} = 625 \text{ watts.}$$

(6) In this calculation we have made two assumptions, which we will now justify, if we can. First, we got the average E.M.F. by multiplying E by $\frac{9}{10}$, thus tacitly assuming the E.M.F. wave to be sinusoidal. The E.M.F. is tolerably certain to lie between the two limiting forms ⋀⋀⋀ and ⊓⊔⊓⊔; in the first or zig-zag, the proper coefficient would have been ·86; in the second, it would be 1; so that the 625 watts cannot be more than 4 per cent. too high, nor 10 per cent. too low; always supposing the generator to give a smooth curve of some sort. We need hardly observe that an error of 5 or 10 per cent. in estimating a loss will make practically no difference when we come to add up all the losses.

Next we assumed a **B-H** curve taken by the ordinary ballistic galvanometer methods to be a faithful representation of what goes on in a transformer core under rapid reversals of magnetic force. In taking **B-H** curves from laminated iron rings of small size, it is obvious that the time taken by the exciting current to reach, say, 98 per cent. of its steady value, must be very short; and, in fact, in obtaining the particular **B-H** curve used in the foregoing calculation, the current necessary to produce an induction in the ring equal to 10,000 gausses must have reached 98 per cent. of its steady value in about one-hundredth second, corresponding with a frequency of 25. This is sufficiently near the frequencies used in practice to make it in the highest degree improbable that the curve so obtained is seriously different from what it would be at three or four times the frequency. Moreover, Prof. Ewing's "model" having put the Weber-Maxwell theory of molecular magnets on a tolerably secure and simple basis, it certainly seems well-nigh incredible that molecular magnets should be incapable of executing forced vibrations at what must, from a molecular point of view, be a very leisurely pace.

(7) At this point we may just touch on the question of the so-called *viscous* hysteresis. It is alleged that quite apart from eddy currents and static hysteresis there is a true *time-lag* of induction behind magnetising force. Prof. Ewing has, indeed, observed a time-lag for very small values of **H**, the lag amounting to several minutes; but has such a lag as this anything whatever to with transformers? No, and for a very good reason. When a **B-H** curve is taken, as was that in Fig. 1, by the ballistic method, the galvanometer gives us the almost *instantaneous* value of **B** for any value of **H**, and these are the

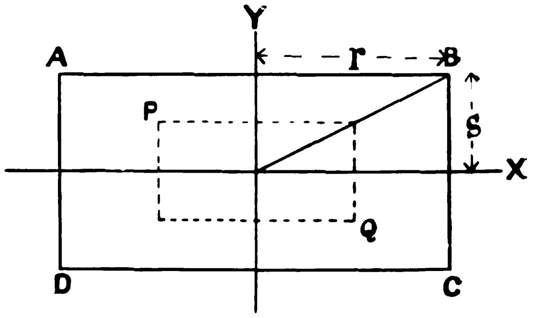



Fig. 2.—Section through Core Lamina normal to Induction Path.

values used in determining the hysteresis loss. As to a lag comparable with such short times as one-tenth to one-hundredth of a second, there is no evidence whatever of its existence, and never will be until eddy currents are entirely eliminated from experimental results.

It is interesting to note that the loss per cub. cm. per cycle in the iron used for the cores of these transformers is only 25 per cent. higher than that given by Prof. Ewing, so that in practice it is possible to get large quantities of excellent iron requiring no annealing before use.

(8) *Eddy Current Loss.*—In determining this loss in the core of a transformer, we are obliged to fall back on approximate calculation, as so far as the writer is aware no reliable experimental determinations have yet been made. In Fig. 2 let the rectangle A B C D be a section through a single lamina of the core, at right angles to the induction path. Assume the direction of the resultant E.M.F. and current in the lamina to be parallel to the edges of the section, then the dotted line P, Q will be an elementary current path cutting the axes at the values $+x+y$ and $-x-y$, in succession.

Let $\dot{\mathbf{B}}$ be the time rate of change of induction in the lamina, that is $\frac{d\mathbf{B}}{dt}$.

$\rho$ be the specific resistance of the iron.

$l$ be the length taken along the induction path.

Then the E.M.F. round P Q is, of course, $\dot{\mathbf{B}}$ (area P Q), or $4\dot{\mathbf{B}}xy = 4\dot{\mathbf{B}}\frac{s}{r}x^2$ by the assumption we have made with respect to the direction of E.M.F.

Digitized by Google

The resistance of the elementary path P Q is

$$dR = 4\frac{\rho}{l}\left(\frac{x}{dy} + \frac{y}{dx}\right) = 4\ \frac{\rho r x}{l s d x} \quad \text{or}$$

we can safely neglect the term $\frac{s}{r}$ in any lamina whose width is, say, 20 times its thickness. The element of power—

$$dw = d\ \frac{E^2}{R} = 4\dot{B}^2 \frac{s^3 l}{r^3 \rho} x^3\, dx$$

and the power in $l$ cms. of lamina is

$$W = \int_0^r 4\ \dot{B}^2 \frac{s^3 l}{r^3 \rho} x^3 dx = \frac{\dot{B}^2 s^3 l r}{\rho}$$

but as $s = \frac{t}{2}$ and $r = \frac{b}{2}$ expression is equivalent to

$$\frac{\dot{B}^2\, t^2.t\, l\, v}{16\,\rho}$$

for a volume of $t\,l\,b$ cms., and finally the loss is

$$\frac{\dot{B}^2 t^2}{16\,\rho} \quad . \quad . \quad . \quad (2)$$

watts per c.c. of iron in the core provided $\dot{B}$ is reckoned in volts and $\rho$ in ohms.

This is the loss on the assumption that the eddy currents are constrained to flow in lines parallel with the bounding surface of the lamina. Any artificial constraint of this kind must tend to diminish the calculated loss, so that the true loss will be slightly greater than that found from (2). To get a rough idea of the difference take the loss in a *square* wire. Calculated on the same supposition as to direction of currents that is involved in (2) it is $\frac{\dot{B}^2 l r^2}{8\rho}$ × (area of section), where $r$ is the radius of *a circle of the same area* as the square wire. It is clear that the true loss must be slightly *less* than in a round wire of the same area; that is to say, it must be less than $\frac{4\dot{B}^2\, l r^2}{\pi\, 8\, \rho}$ × (area of section), which is the calculated loss in a round wire of radius $r$. Now this last expression is got by assuming the current flow to be everywhere parallel to the boundary of the circular section, an assumption which is obviously correct, and therefore the actual loss in the square wire cannot be more than $\frac{4}{\pi}$ times the loss when the currents are constrained. In a thin lamina the "constrained" and the true loss must be very much nearer equality, for in a large proportion of the area of section the currents are constrained by the bounding surface. In short, the result given in (2) *must* be correct for infinitely thin laminæ, and is sufficiently accurate for all practical purposes. In order to err on the right side we shall make an allowance for the eddy currents in the solid bolts used for clamping the core plates together; an addition of 5 per cent. will cover this.

(9) When we come to put the values given in Table I. into equation (2) the inquiry naturally arises—is $\dot{B}$ constant throughout the section of a lamina? It is clear that $\dot{B}$ itself is not uniform, being least at the centre of the lamina, where the eddy currents have the greatest demagnetising effect, and before drawing a transformer diagram we must ascertain what extra $H$ is required to neutralise the negative $H$ due to eddy currents; in the meantime we cannot make an appreciable error in reckoning $\dot{B}$, that is $\frac{dB}{dt}$, from the secondary E.M.F. Thus, $\dot{B}$ = effective $\frac{dB}{dt} = \frac{100}{34 \times 95}$ = E.M.F. in volts per square centimetre of core, or $\dot{B}^2 = 9{\cdot}55 \times 10^{-4}$; $t^2 = 25 \times 10^{-4}$; $\rho = 10 \times 10^{-6}$, and the eddy current loss is $\frac{9{\cdot}55 \times 25 \times 1{\cdot}05}{16 \times 10 \times 10^2} = {\cdot}0156$ watts per c.c. This multiplied by 13,700 (the volume of iron in the core) is the total eddy current loss,

$$W_e = 214 \text{ watts.}$$

(10) *Eddy Currents in the Coils.*—One feels inclined to say there are none in a reasonably well-designed transformer. Such as there are, however, are due to the stray induction through the coils outside the core, including the induction in each wire due to its own current; the latter being the more important. This effect has been investigated by Sir William Thomson, who has calculated the loss of power expressed as increased resistance consequent on the varying current density in the wire, but we need not consider the loss of power from this cause in such wires as are used for transformer coils. No doubt, if a large solid wire were used for the secondary the loss might be appreciable, but the secondary of a transformer for 200 amperes would always consist of several small insulated wires wound side by side and coupled in parallel.

(11) *$C^2R$ Loss in the Coils* depends on the load; taking the transformer at full load the secondary current is 224 amperes, primary current 11·2 amperes for the load plus ·5 ampere for excitement, or say, roughly, 12 amperes. We have

$$C_s^2 R_s = 224^2 \times {\cdot}003 = 150 \text{ watts}$$
$$C_p^2 R_p = \ 12^2 \times {\cdot}98 \ = 142$$

The total drop in volts due to resistance of primary, plus that in secondary, amounts to about 1·25 per cent. at full load.

We can now write down all the losses and find the full load efficiency:—

**Table II.**—*Thirty Horse-Power Transformer.*

| —— | Watts. | Percentage of total power. |
|---|---|---|
| Full load output | 22,400 | 95·0 |
| Core, hysteresis | 625 | 2·7 |
| Core, eddy currents | 214 | ·9 |
| $C_p^2 R_p$ | 141 | ·6 |
| $C_s^2 R_s$ | 150 | ·8 |
| Total | 23,530 | 100·0 |

$$\text{Efficiency} = \frac{22{\cdot}4}{23{\cdot}5} = 95 \text{ per cent.}$$

(12) A large transformer like this would only be used in a sub-station, or on a tolerably constant load of not less than 10,000 watts, so that the designer did not consider its all-day efficiency on one or two hours only at full load. When efficiency at or near full load is the only condition to be observed, it is perfectly justifiable to use a large core and very little copper in order to secure cheapness, and accordingly we find in the case we have taken that of the total loss nearly four-fifths is in the core. Altogether this transformer is a good representative of its class—viz., closed type for full load; and it has served to illustrate the way in which the efficiency can be calculated.

(13) Perhaps the clearest way of indicating the differences between closed and open transformers will be to choose one of the closed type of medium size and investigate its efficiency on an average all-day load. Then in imagination pull it to pieces and reconstruct it with a view to getting a higher efficiency, next convert it without any change in its coils into an open circuit transformer, and finally turn it into a rough imitation of Mr. Swinburne's "Hedgehog."

**Table III.**—*Ten Horse-Power Closed Transformer.*

| | | | |
|---|---|---|---|
| Full-load output | = | 7,500 | watts. |
| Frequency = F | = | 70 | per sec. |
| Total volume of iron in core | = | 6,600 | c.c. |
| Sectional area of iron in core | = | 58·5 | cms. |
| Mean length of magnetic circuit | = | 112 | " |
| Width of plates = $b$ | = | 10·2 | " |
| Thickness = $t$ | = | ·05 | " |

| —— | Primary. | Secondary. |
|---|---|---|
| Volts | 2,000 | 100 |
| Turns on coils | 1,120 | 56 |
| Resistance | 3·8 | ·0094 |

In Table III. are given the dimensions, &c., of a Goolden-Ravenshaw 10 horse-power transformer, which shall serve

Digitized by Google

as the victim of this destructive kind of criticism. The core plates being the same thickness as those used for the 30 horse-power size, the hysteresis and eddy current losses will be simply proportional to the volume of iron used, provided the induction is the same. As a matter of fact the maximum **B** is 9,800 gausses; 2 per cent. less than in the 30 horse-power. This is too small a difference to be worth notice in finding the hysteresis loss, but 4 per cent. may be deducted from the eddy current loss since it varies as $\mathbf{B}^2$. The output and losses may now be easily reckoned by comparison with Table II. They are inserted here for future reference.

**Table IV.**—*Ten Horse-Power Transformer.*

| — | Watts. | Percentage of total power. |
|---|---|---|
| Full load out-put | 7,500 | 94·0 |
| Core, hysteresis | 302 | 3·8 |
| Core, eddy currents | 99 | 1·2 |
| $C_p{}^2 R_p$ | 58 | ·7 |
| $C_s{}^2 R_s$ | 53 | ·6 |
| Total | 8,012 | 100·3 |

$$\text{Efficiency} = \frac{75}{80} = 94 \text{ per cent. at full load.}$$

Drop in E.M.F. at full load = 1·4 per cent.

The efficiency at different loads is shown as a curve in Fig. 3. Note that at about $\frac{1}{3}$ full load it is still 80 per cent., so that

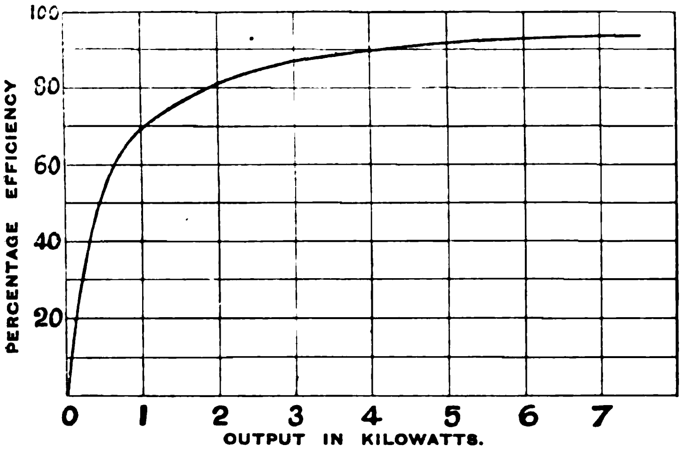



Fig. 3.—Efficiency-Output Curve of 10 H.-P. Ravenshaw Transformer.

where so large a constant load could be relied upon the transformer would be reasonably economical.

(*To be continued.*)

## PROBLEMS CONNECTED WITH INDOOR ILLUMINATION.

Physiological questions do not often come into the work of an electrical engineer, but the whole object of electric lighting, except from the photographer's point of view, is to stimulate the optic nerves of those who make use of it. Optic nerves have, indeed, been stimulated not wisely but too well, by naked arcs and badly arranged glow-lamps; and electric light has been condemned freely, and not unreasonably, as being injurious to eyesight, and, what is far worse, "unbecoming" to dresses and complexions. If electrical engineers could take up the position assumed by the electric supply companies, and restrict themselves to providing and distributing electrical energy, they would not be called upon to step out of their legitimate work. But those who are engaged in electric lighting have to supply lamps, and if these be glow-lamps, they can, at present neither get nor give any guarantee of their quality, efficiency, or life; and if arc lamps, they take refuge behind a "nominal candle-power," the ambiguity of which is largely due to the disparity between the illuminating power of the arc and of the standard candle in terms of which it is expressed. And with these lamps they have to provide the best illumination that they can. This optic nerve is, however, difficult to please, and it is not clear whether it alone is the arbiter, or whether the eye of which it is the essential part is to be satisfied, or whether, after all, the decision as to the quality and degree of illumination is to be referred to the judgment of the owner of the said eye. At any rate, the estimation of illumination comes to be a mere matter of opinion, and this, for several reasons, is much to be regretted. There will probably be a real objective standard of light before long; whether this will be supplied by a radiometer, a photo-electric cell, a photo-chemical eudiometer, or otherwise, we cannot yet predict. But of the illumination of a dining-room, a street, or a stage, we can never hope to have an accurate measurement in C.G.S. or any other units. We have a unit of illumination, and the result of a number of measurements were given in articles in *The Electrician* of August 15, 1890; but illumination measured quantitatively is not everything.

In electric lighting for domestic purposes, there is an æsthetic side of the question which must be considered. Difficult as it at first appears, it need not be approached by the engineer with so much caution as the wider æsthetic considerations of the design and treatment of fittings. Glow-lamps may be arranged for domestic use according to three different systems, and these are, of course, applicable to all other kinds of lighting, although the requirements are elsewhere not so exacting. The most luxurious and expensive method is that in which the lamps are screened from the eye, while they cast their light upon the walls or ceiling, and are thence reflected generally over the room. The ceilings being rarely, and the walls never of a pure white, and the reflecting power of their surface being small, a large amount of light must necessarily be wasted, and the effect is not good unless a considerable number of lamps are used, and are carefully arranged so that the illuminated surface is lighted with uniformity. This kind of illumination can without much difficulty be realised in a dining-room by throwing the light upon the table, while the lamps are carefully screened by a suitable shade, and we understand that if the screening is so well carried out that the guests do not realise that electric light is being used, this lighting is sometimes admitted to be "becoming." Where the illumination is not general, but special, as for lighting a particular picture, all that need be done is to place the lamp or lamps so that a tolerably uniform illumination is obtained without reflections from its surface, and with the lamps hid by reflectors. When the lamps are themselves visible, the question arises, shall they be subdued by more or less translucent shades, or shall they be allowed to shed their light direct?

The prejudice against arc lighting as a pleasant kind of illumination is too deeply rooted in this country to make it worth while discussing. True, we do not see so much of those pyrotechnic corruscations, those gleams of violet and flashes of blue, the fitful blink followed by a hiss and yellow flame that runs round the carbon; true, that we have arcs which are "absolutely steady" as compared with other arcs, and more steady than many gas burners; but great improvements must be made in both lamps and carbons before they can be admitted for interior use. But even with an "absolutely steady" arc, it is obvious that it would have to be screened by an opal globe to diminish the shadows and to prevent discomfort to the eye. For the same purposes, though to a much smaller degree, some such precautions must be taken with any light if it be more powerful than a candle, and it is strange that while a gas or oil burner is rarely seen in any situation where comfort and appearances are studied without some shade to soften the light, electric lights are too frequently used without any attempt whatever to diffuse the rays emitted by them.

General Webber recently extolled the advantages of 8-candle lamps over 16-candle, and condemned the use of "sunbeam" lamps for shop windows. He denounced "the other and

Digitized by Google

equally unreasoning extreme of procedure by which light is wasted foolishly in frosting bulbs, or enclosing them in obscured or coloured globes." Prof. Forbes, in the discussion made the extraordinary assertion that frosted, *i.e.*, ground glass globes, absorbed little if any light, and attributed the observed loss to dirt upon the surface. To discuss these statements in full would require several columns, and we will only allude to the chief points. The dazzling, which is so intense in an arc, is far less, but not absent from a 16-candle lamp, and whatever may be its value, it is only one half as great in an 8-candle lamp. Two 8-candle lamps, then, give the same light as one 16-candle, but with less dazzling, and if they can be placed at some distance apart, they will give a better distribution of illumination. But the first cost of wiring, and the cost of lamp renewals and risk of breakage are doubled. There are many cases where these considerations altogether outweigh any questions of comfort, and for many purposes the economy of a few powerful lamps is so great that it is worth while studying means for securing a certain degree of comfort without incurring needless expense. The use of powerful argand gas burners enclosed in brilliant reflectors is familiar to everybody. They are most inconvenient excrescences for the passer-by, and when electric light is used, there is less occasion for putting them out of doors. To induce shopkeepers to use glow-lamps, we should certainly recommend the use of lamps not less than 32 candle, screened from direct view, either by metallic or thick opal reflectors. So far do considerations of comfort weigh with some persons, that it has even been urged that a given number of 16-candle lamps may be replaced by 8 candle without affecting the illumination. We will readily admit that a better distribution might be obtained by the use of 30 8-candle lamps, instead of 20 16-candle lamps, although the aggregate light would be less; but to assert that the illumination, say at the Society of Arts (where the lamps are so high up that dazzling need not be considered), would be the same if the candle-power of each lamp were reduced to one-half, is too absurd a statement to require refutation. But apart from the facilities for better distribution of light, the demand for frosted bulbs arises from the same causes as the preference for 8-candle-power lamps, viz., there is less dazzling. If the reduction of size were carried far enough, there would be no need for frosting, and the ideal lighting of a well-decorated room, by wax candles, might be closely imitated by employing an immense number of small lamps.

But leaving the question of illumination, and coming to matters of comfort, we are on the verge of, if not beyond, the limits of the business of an engineer, and we will only briefly allude to the means, and say nothing of the ends attained. Prof. Forbes must have been deeply plunged in purely scientific speculation when he said that ground glass practically did not obstruct light. He described ground glass as consisting of a mass of prisms and reflecting surfaces, and suggested that since the glass was really clear, the light really got through after all, though it suffered somewhat from internal reflection. This is plausible enough in an *a priori* way, but the simple fact remains that a sheet of ground glass, or a frosted bulb, is found on the photometer to show an absorption of about 20 per cent. We have indeed found in one sample an absorption of only 16 or 17 per cent., but it frequently reaches 25 per cent. Now the interesting and scientific part of the question would be to discover where the light *does* go. A plain sheet of glass obstructs nine or ten per cent. of the light, and the loss takes place in three different ways: firstly, and most important, the reflection at the first surface; secondly, the absorption in the glass through imperfect transparency; and lastly, internal reflection at the second surface. The first two are unaltered with glass ground on the second surface, but here the loss by internal reflection is much greater, for the angles of incidence are greater. Probably only one-half of the light passes directly through, losing nothing by mere refraction, but the other half gets tossed backwards and forwards by internal reflections, and not much more than a half of it gets through at all. To make a measurement, the lamp must be wholly surrounded by ground glass. A flat screen will appear to absorb 30 per cent., because it diffuses the light in directions other than towards the photometer. Every photographer knows that there are very different qualities of ground glass, and that a very coarse or very fine grain each approximate to clear glass. A cut glass shade spun rapidly in front of a photometer will absorb about the same proportion as ground glass; no useful measurement can be made when it is stationary, as a plane facet may happen to let light pass direct, or a prism may increase or reduce the illumination on the photometer screen. A very beautiful lamp was invented by Mr. L. J. Crossley, in which half the bulb was opal, and though the naked filament was visible, it largely reduced dazzling, since it was seen against a bright, not a dark background; but, for reasons connected with the lamp monopoly, it has not been placed on the market. Silk shades get dusty and fancy glass looks tawdry by daylight, but anything is better than a naked 16-candle lamp, backed, perhaps, by some glaring copper or ormolu fitting.

The whole subject is one which we think might well be taken up by some architect. Members of this kindred profession have done great service by the design of original and convenient fittings, and useful mouldings and casings. Engineers will do all they can to make electric light safe and cheap; let some artistic genius make it comfortable and beautiful. Few statements are so detrimental to the progress of the industry as the half-truth—electric light is bad for the eyes.

## MEETINGS OF SCIENTIFIC SOCIETIES, &c.

**FRIDAY, February 20th.**

INSTITUTION OF CIVIL ENGINEERS.

*2 p.m.* Students' Visit to the Tower Bridge Works.

SOCIETY OF ARTS.

*4.30 p.m.* Popular Afternoon Lecture: "The Science of Colour," by Capt. ABNEY, F.R.S.

ROYAL INSTITUTION.

*9 p.m.* Evening Discourse: "Infectious Diseases, their Nature, Cause and Mode of Spread," by Dr. ED. E. KLEIN, F.R.S.

**SATURDAY, February, 21st.**

ROYAL INSTITUTION.

*3 p.m.* Afternoon Lecture: "The Forces of Cohesion," by Lord RAYLEIGH, F.R.S.

**MONDAY, February 23rd.**

SOCIETY OF ARTS.

*8 p.m.* Cantor Lecture III. 2. "The Electric Transmission of Power," by GISBERT KAPP.

**TUESDAY, February 24th.**

ROYAL INSTITUTION.

*3 p.m.* Afternoon Lecture: "The Structure and Functions of the Nervous System," by Prof. VICTOR HORSLEY, F.R.C.S.

INSTITUTION OF CIVIL ENGINEERS.

*8 p.m.* Ordinary Meeting. Paper to be further discussed: "Electric Mining-Machinery," by LLEWELYN B., and CLAUDE W. ATKINSON, A.M.I.C.E. Paper to be read, time permitting: "On the Subterranean Water in the Chalk Formation of the Upper Thames, and its Relation to the Supply of London," by JOHN THORNHILL HARRISON, M.I.C.E.

**WEDNESDAY, February 25th.**

SOCIETY OF ARTS.

*8 p.m.* Ordinary Meeting. Paper to be read: "Colonisation and its Limitations," by E. J. RAVENSTEIN.

**THURSDAY, February 26th.**

INSTITUTION OF ELECTRICAL ENGINEERS.

*8. p.m.* Ordinary General Meeting.

**FRIDAY, February 27th.**

SOCIETY OF ARTS.

*4.30 p.m.* Popular Afternoon Lecture: "The Science of Colour," by Captain ABNEY, C.B., F.R.S.

PHYSICAL SOCIETY.

*5.30 p.m.* Ordinary Meeting. Papers to be read: "Proof of the Generality of certain formulæ published for a special case by Mr. Blakesley." "Tests of a Transformer," by Prof. W. E. AYRTON and J. F. TAYLOR. "Further Contributions to Dynamometry," by T. H. BLAKESLEY. "Note on Electrostatic Wattmeters," by J. SWINBURNE. "Interference with Alternating Currents," by Prof. W. E. AYRTON and Dr. W. E. SUMPNER.

INSTITUTION OF CIVIL ENGINEERS.

*7.30 p.m.* Students' Meeting. Paper to be read: "Disintegrators," by BERTRAM CHATTERTON, S.I.C.E.

ELECTRO-HARMONIC SOCIETY.

*8 p.m.* Ladies' Night. Concert in St. James' Hall Restaurant.

ROYAL INSTITUTION.

*9 p.m.* Evening Discourse: "The Art of Acting," by PERCY FITZGERALD, M.A.

Digitized by Google

# The Electrician.

**Published every Friday, Price Fourpence; Post Free, Fourpence Halfpenny**
**Editorial, Publishing, and Printing Offices:**
**SALISBURY COURT, FLEET ST., LONDON, E.C.**
*Telephone No.* 2714. *Telegrams:* "ELECTRICIAN NEWSPAPER, LONDON."


*All Letters relating to Subscriptions, Advertisements and other business matters should be addressed to the Publisher,* "THE ELECTRICIAN," *Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to* "THE ELECTRICIAN" *Printing and Publishing Company, Limited, and be crossed* "*Coutts and Co.*" *All other letters to be addressed to the Editor.*

*All letters intended for insertion in* "THE ELECTRICIAN," *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

THE ELECTRICIAN" *is published every Friday morning, in time for the morning mails. Subscribers should receive their copies by the first post on Friday morning.*

"THE ELECTRICIAN" *is on sale at the railway bookstalls throughout the Kingdom on Friday morning, and can be obtained of all Booksellers and Newsvendors; or direct from the Publishing Offices as above.*

*New Volumes of* "THE ELECTRICIAN" *commence in May and November.*

## SUBSCRIPTION RATES.

**The rates for Subscriptions to "THE ELECTRICIAN" are as follows:—**

| | 3 months. s. d. | 6 months. s. d. | 12 months. s. d. |
|---|---|---|---|
| For the United Kingdom | 5 0 | 10 0 | 19 6 |
| For Foreign Parts and Colonies:— Within Postal Union | 6 6 | 12 6 | 24 0 |
| For Aden, Borneo, Ceylon, China, India, Japan, Java, Labuan, Mozambique, New Caledonia, Persia, Philippine Islands, Siam, Transvaal, and Zanzibar | 7 6 | 14 6 | 28 0 |

## TO ADVERTISERS.

"THE ELECTRICIAN" *offers exceptional advantages to Advertisers.* **It has by far the largest circulation of any English Electrical paper, and circulates all over the World.**

*Particulars relating to Advertisements will be promptly forwarded on application to the Offices as above.*

TRADE ADVERTISEMENTS *intended for the current issue must reach the Offices not later than First Post on Thursday morning. Renewals of expiring advertisement orders and alterations to standing advertisements should be in the Publisher's hands by Wednesday at latest. No alteration can be made in Wrapper advertisements after Wednesday evening.*

SMALL PREPAID ADVERTISEMENTS *(for Rates see page xvii.) are accepted up to 4 p.m. on Thursday.*

## TECHNICAL PRINTING.

"THE ELECTRICIAN" PRINTING AND PUBLISHING COMPANY (LIMITED) *inform Electricians, Electric Light Engineers, &c., that they make a specialty of Technical Printing, and have a large Staff thoroughly acquainted with Electro-Technology. They can, therefore, promise Accuracy and Despatch in the Printing of Electro-Technical Literature, &c.*

## "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. (Royal 8vo.)

*Early in each year is issued* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. *The* DIRECTORY *was established in 1883, and the 1891 Edition, published on the 23rd February, consists of 900 pages of printed matter. The names and addresses of all persons engaged in the Electrical Industries at home and abroad may be relied upon as accurate. Useful Tables and Electrical Formulæ, and information specially compiled for this work are given, together with popularly-written Biographical Notices of the leading Electricians, Electrical Engineers, &c., accompanied in many cases by Portraits.*

*Order at once. Price 5s., post free 5s. 9d. Abroad postage extra. Full particulars on application.*

## ELECTRICAL BOOKS AND PUBLICATIONS.

*All Books, Newspapers, and other publications, dealing with Electrical and kindred subjects, can be ordered direct of* "THE ELECTRICIAN" *Printing and Publishing Company, who are proprietors of the well-known* "ELECTRICIAN" *Series of Standard Electrical Works, and are agents for all the leading publishing houses at home and abroad.*

## CONTENTS OF THE CURRENT NUMBER.


NOTES ... 471
The Magnetic Circuits of Transformers: Closed versus Open. By S. Evershed. Illustrated 477
Problems connected with Indoor Illumination ... 480
Meetings of Scientific Societies 481
THE LONDON COUNTY COUNCIL AND TECHNICAL EDUCATION.. 482
Standards of Light ... 483
The Atlas Accumulator. Illustrated ... 484
The Thunderstorms of Sixty-six Summers. Illustrated... 485
The Telephonic Reproduction of Speech. By E. Mercadier ... 485
On the Influence of the Strength of the Magnet in a Magneto Telephone Receiver. By C. R. Cross and H. E. Hayes. Illustrated ... 486
On the Physical Properties of Hard Rubber or Vulcanite. By Alfred M. Mayer ... 487
New Tesla Alternating Motor. Illustrated ... 487
Electricity and its Tactical Value for Military Operations. By Major R. L. Hippisley, R.E. ... 489
Electric Cranes. By R. Bolton 490
The Distribution of Electricity, with Special Reference to the Chelsea System. By Major-General C. E. Webber. *Discussion* ... 491
Physical Society ... 492
Alloys for Resistance Coils. By Dr. K. Feussner and Dr. St. Lindeck ... 493
Parliamentary Intelligence ... 494
American Notes ... 495
Australian Notes ... 495
CORRESPONDENCE—
Electric Theories—Ether—John Sprague ... 495
Chelmsford Lighting-Crompton & Co. (Limited) ... 496
"More Board of Trade Rules"—"In Statu Pupillari" ... 496
Trade Notes and Notices ... 496
The Patin Alternate-Current Arc Lamp. Illustrated ... 496
PATENT RECORD ... 497
COMPANIES' MEETINGS, &c.—
The India-Rubber, Gutta-Percha and Telegraph Works Company (Limited) 498
Westminster Electric Supply Corporation (Limited) ... 498
New Companies Registered ... 499
City Notes, &c. ... 499


## STEEL-PLATE PORTRAITS

*Of W. H. Preece, F.R.S.; Michael Faraday; Sir John Pender, K.C.M.G.; Sir William Thomson, F.R.S. (Past-President of the Institution of Electrical Engineers); C. H. B. Patey, C.B. (Late Secretary of Telegraphs, G.P.O.); Dr. John Hopkinson, F.R.S. (Past-President of the Institution of Electrical Engineers); Dr. Oliver J. Lodge, F.R.S., and Prof. William Crookes, F.R.S. (President of the Institution of Electrical Engineers), have been issued as Supplements to* "THE ELECTRICIAN." *A few Copies of these admirably-executed Steel Engravings can be supplied, price 1s. each, post free on roller, 1s. 2d. Or framed in neat Black Pillar or Brown Ornamental Frames, price, post free, 4s. 6d.*

## THE LONDON COUNTY COUNCIL AND TECHNICAL EDUCATION.

The debate on Technical Education which took place at a meeting of the London County Council last week afforded one of those rare occasions on which an important public question can be discussed in that assembly without political bias or party animosity. On the whole the meeting contrived to rise to the level of the subject; and with the exception of an acrimonious fling at the City Companies the discussion was pursued with fairness and an evident desire to arrive at a wise decision. The matter is not yet finally disposed of; and the narrow majority by which Mr. BENN's amendment was carried may probably give rise to the whole subject being reconsidered. But the general line of difference which separated the supporters and opponents of the Committee's Report on Technical Education is sufficiently clear to enable us to appreciate their positions, in spite of a disturbing element to which reference will be made presently. It will be remembered that a windfall in the shape of the new Beer and Spirit taxes dropped from the hands of Mr. GOSCHEN last year into the lap of the County Council, who appointed a special committee to report as to the disposal of the gift, which amounted to £23,000, and which will be continued year by year without abatement, and probably with increment. The Committee have made their report, in which they recommend

Digitized by Google

the application of the fund to the purposes of technical education in London, apportioned among ten institutions in sums varying from £4,000 to £500—the existing Polytechnics of the Borough-road, of Battersea, and of Regent-street receiving each the larger of the sums just named. It was further proposed that a Standing Committee on Technical Education be created to report upon the application of these subventions, and generally to determine their amounts from time to time. It is this report that the London County Council has had under consideration; and although they may be disappointed with the immediate result of its vote, the friends of technical education, we cannot help thinking, in the long run will be satisfied with what has occurred.

It may be said, in the first place, that the question was not discussed solely on its own merits. We have alluded to the introduction of a disturbing element; and this took the shape of a counter proposal to devote the unexpected subsidy to furthering the schemes which the County Council has in hand for the housing of the working classes, the purchase of open spaces, and similar efforts to ameliorate the condition of the London poor. This, it must be admitted, was a highly-flavoured red-herring to trail across the path of the technical educationists; and it does not surprise us that in an assembly of barely one hundred representatives of metropolitan populations, fifty darted hotly on the opposite scent. The more influential, and certainly the ablest of the members present, voted in the minority of 45, and they may hope to muster a majority on their side very soon if they are really in earnest. So far as the two proposals are concerned, there is a good deal to be said for both, and for one perhaps as much as for the other. Both objects are most desirable in themselves; both are attainable by the expenditure of money, and from both may beneficial results be confidently predicted. But, whereas the prospective results of technical education have to be argued, and to some extent conjectured, those from the improved habitations and general condition of the poor are demonstrable certainties which nobody ventures to dispute. This fact was betrayed in the conduct of last week's discussion at the London County Council, where not a word was spoken either in support or in opposition to the amendment, its merits being accepted as beyond cavil, the only question open being whether its claims to attention were superior to or more urgent than those of the technical education of our artisans. The minority thought, perhaps, that as the poor are always with us, there is no fear of them slipping out of the sphere of benevolent activity; whilst in respect to the technics of manufacture and commerce, the object to be attained by their cultivation may slip from our reach beyond recall if not seized betimes and securely held. Perhaps, too, the urgency for technical education is not so deeply felt in the metropolis as it is in the great industrial centres of the provinces, where local prosperity depends upon the pre-eminence of the English operative, and where the opposing claims of industrial dwellings, if quite as deserving, are not so attractive as in London. Be this as it may, however, the friends of the London working classes have scored a point against the friends of national industry, without any argument at all.

But having thus satisfied their consciences, it is not improbable that when the question of disposing of the money has to be seriously considered, the problem of investing it to secure the best results will prove as hard of solution and as uncertain in its operations as any investment in technical education would have been. From the general tone of the debate, indeed, we may augur that money will be forthcoming in due course for both these commendable objects. For although, as we have observed, nothing was said against ameliorating the condition of the working classes, neither was anything said against technical instruction. The Vice-Chairman, Sir T. FARRER, did indeed minimise the value of polytechnics by describing them as mere experiments which were on their trial, and of by no means paramount importance; but the judgement of the Vice-chairman is somewhat discounted by his further argument for diverting the money to other purposes than those recommended in the Report, because, if it were adopted, the drinking interests would be henceforward bound up with the cause of education. In this line of reasoning he had been preceded by other speakers of the temperance persuasion, who seemed to think that somehow or other people would be induced to drink more beer and spirits in order to encourage technology. It is difficult to treat such scruples seriously, especially as they were not followed up by a blunt refusal of the unholy thing. Mr. CHARRINGTON and his followers voted no doubt with Mr. BENN, with the result, if the decision stands good, that the working classes, who are the chief consumers of beer and spirits, will drink more of these beverages in order to swell the fund for improving their dwelling houses. We know perfectly well they will do no such thing; and we know, too, that the drink bill rises invariably with increased prosperity. That it has risen quite remarkably of late may perhaps be accepted as evidence that the money already expended on the extension and improvement of our technical training, amounting to a vast sum, is beginning to bear good fruit. This reflection may at all events console us for a temporary defeat of the cause in the London County Council.

## STANDARDS OF LIGHT.

For all who have to do with electric lighting, the ultimate standard with which incandescent lamps are to be compared is of direct and considerable interest. It is, therefore, with some regret that we chronicle the general tendency of a recent Paper read by Mr. W. C. Young before the London Section of the Society of Chemical Industry on "Standard Sperm Candles." Naturally, the first and ostensible object of the communication was the discussion of the question as to the reliability of the sperm candle for determining the candle-power of the gas supplied to London and other large towns by the stereotyped system commonly in use, but as any decision come to with regard to the most extensive and uniform series of tests carried out anywhere on the photometric value of an illuminant cannot but influence photometry generally, it is in our opinion expedient to discount the conclusions arrived at by Mr. Young lest their application to the measurement of the candle-power of incandescent lamps lead to undesirable results. Mr. Young is a staunch upholder of the standard sperm candle for the gas photometrist's purpose, and with that belief we are not disposed to quarrel, the matter not concerning us. But he appears scarcely sufficiently alive to the urgent necessity of sweeping away the anomalous archaic and inaccurate "standard" afforded by the sperm candle and replacing it by one or other of the several very practicable devices (which it would be invidious to particularise) in which a substance of known composition is consumed under constant conditions. When once a reasonably accurate standard had been thus secured it would be extremely simple to make a candle which should be as approximately equal to it, or a multiple or sub-multiple of it, as its uncertain nature will allow. This would satisfy the contention of those who declaim against anything more accurate than the standard candle on the ground that the former is cheap, simple, and portable, forgetting that more important qualities may be sacrificed to gain cheapness, simplicity, and portability. As a matter of fact this is practically what has been done for standards of light; standards other than the candle are based not on the real but on the ideal sperm candle, its illuminating power being arrived at from the average of numerous observations of that of candles possessed of an objec-

Digitized by Google

tive existence. But the retention of a standard incapable of reproduction at any time with reasonable accuracy is indefensible, and any decision in favour of the sperm candle for special purposes might be mischievous if unaccompanied by a rider exposing its inefficiency on general and broader grounds.

## THE ATLAS ACCUMULATOR.

At a recent meeting of the Société Internationale des Electriciens, M. R. V. Picou read a Paper on the "Atlas" accumulator, the outcome of the joint labours of Mr. Carl Hering and MM. Abdank-Abakanowicz, d'Arsonval and Picou. Each element, as shown in Fig. 1, consists of a pile of positive and negative plates separated by thin sheets of perforated indiarubber, thin sheets of lead being "sandwiched" in at intervals. The positives are of peroxide of lead, and the negatives of spongy lead, both being pierced with numerous holes. The pile of plates is kept in position, and electric connection is effected, by means of nuts and bolts of an alloy of lead, as shown, which are arranged to permit of expansion in every direction.

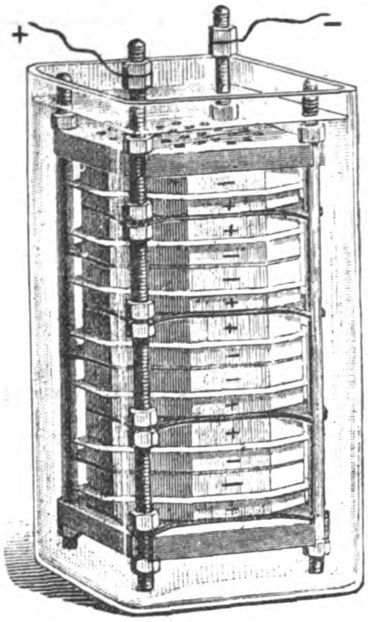


Fig. 1.—Atlas Accumulator.

The following are some of the data given by M. Picou :—

| | | |
|---|---|---|
| Porosity of Plates ... ... | = | 50 per cent. |
| Density of Plates ... ... | = | 4 |
| Capacity per lb. of plate ... | = | 9 amp. hours. |
| Discharging current ... ... | = | ·7 to 9 ·amp. per lb. of plate. |
| Dimensions of a 150-ampere hour cell ... ... ... | = | $6\frac{1}{2} \times 7\frac{1}{3} \times 13$ inches |

In the course of his remarks M. Picou stated that he had found out experimentally that accumulators ought preferably to be charged at a constant E.M.F. of about 2·3 volts per cell. M. Hospitalier then showed some curves illustrating this point. A Gadot accumulator (type 2ter.), with plates weighing 9·35 kilogramme (20·61b.), was charged with a constant current of about 1 ampere per kilogramme of plate (·45 ampere per lb.) and discharged through a constant resistance at the rate of 1·5 ampere per kilogramme of plate (·67 ampere per lb.). The charges and discharges were repeated a number of times until concordant results were obtained. A quantity efficiency of 80 per cent., and an energy efficiency of 70 per cent., was attained. (See curves, Fig. 2.) This same accumulator was then charged at a constant E.M.F. of 2·3 volts and discharged as before until the E.M.F. fell to 1·7 volts. The efficiencies were about the same as before. It is, however, to be observed that the strength of the current was at first very great, being nearly 50 amperes, or more than five times the normal. In spite of this current the accumulator did not gas. The curves (Fig. 3) give the data connected with this experiment. From the diagram we can see that at the end of the first hour the charge had nearly attained 50 per cent. of its maximum value, 75 per cent. being reached after two hours, and 83 per cent. after three hours, the maximum being reached after six hours' charging. From a practical point of view this is of some importance, since it means that we may charge a cell in this way to within 17 per cent. of maximum in three hours without injury, while to reach

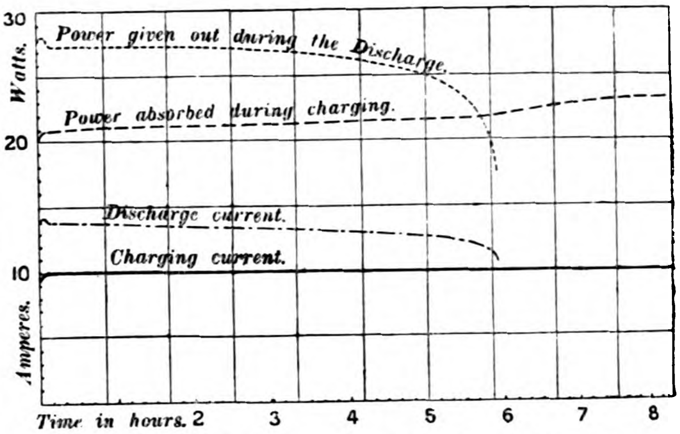



Fig. 2.—Gadot Accumulator (11 plates of 850 grms.)

Ampere hours supplied 83 } Efficiency 83·2.
" " given out 69 }
Watt hours supplied 180·2 } Efficiency 70·1.
" " given out 136·5 }

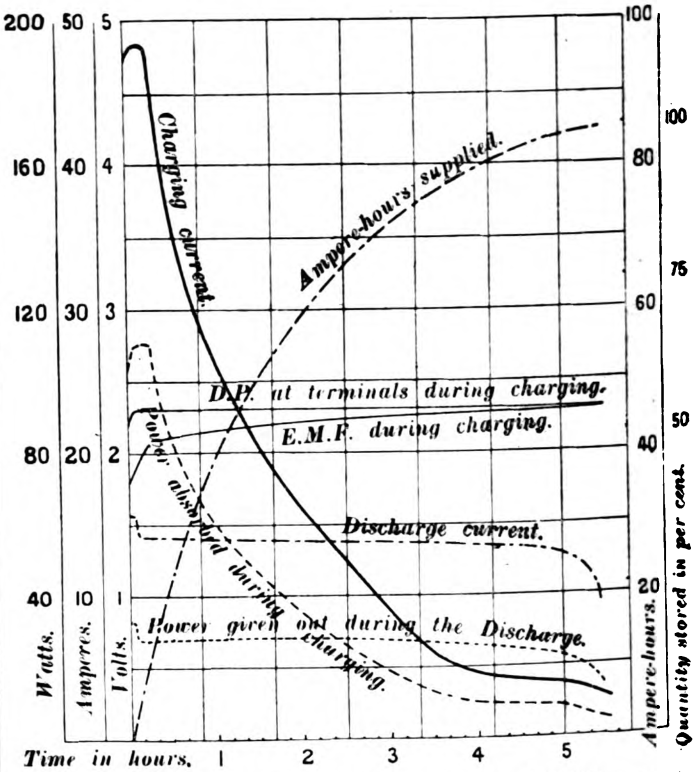



Fig. 3.—Gadot Accumulator. (Weight of Plates, 9·35 kilogrammes), charged at a constant difference of potential of 2·28 volts.; discharged on a constant resistance.

Ampere hours supplied 85·6 } Efficiency, 86·2
" " given out 73·8 }
Watt hours supplied 192·6 } Efficiency, 73
" " given out 140·7 }

this state with a constant current would have taken $6\frac{1}{2}$ hours. Moreover, the E.M.F. required to charge a 52 cell battery is only 120 volts with the constant-potential method but 135 volts when a constant current is employed.

These experiments were carried out in M. Hospitalier's laboratory at the Ecole de Physique et de Chimie, by MM. Chevalot and Delarivière, under the direction of M. Gaston Roux.

Digitized by Google

## THE THUNDERSTORMS OF SIXTY-SIX SUMMERS.

Not a little obscurity still hangs about the nature of thunderstorms, and the subject has of late engaged the thoughts of many scientific men, in this country, and on the Continent, and elsewhere. A thunderstorm committee was appointed by the Royal Meteorological Society a short time ago, and is now at work. In its second report (*Quart. Jour.*, January, 1890) are given two diagrams, showing, by means of curves, for eleven different districts of England, the monthly averages of days of thunderstorm and lightning, also the yearly values in the years 1871-87. While these are no doubt instructive, it has been thought a drawback that cases of sheet lightning were included in the comparison. For sheet lightning is often the indication of a thunderstorm a long way off. One case is recorded—*e.g.*, in which the reflected lightning of a thunderstorm near the Northern French coast was seen as far as our northern midland counties.

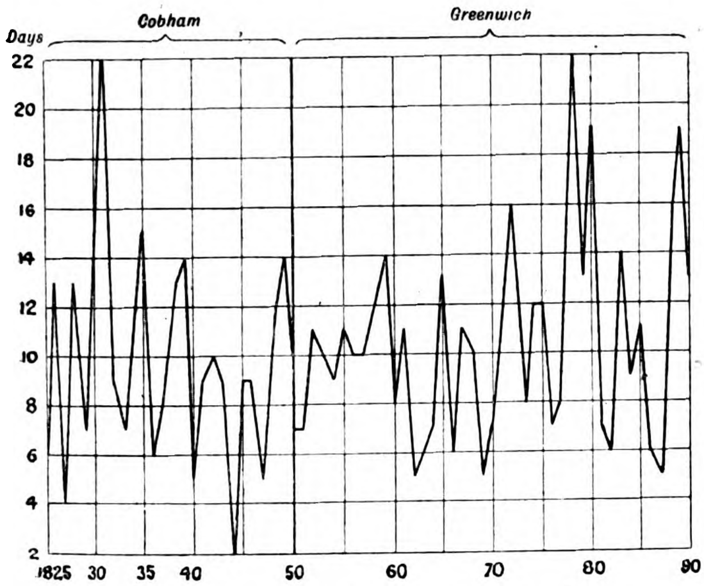



Fig. 1.—Days on which Thunder was heard.

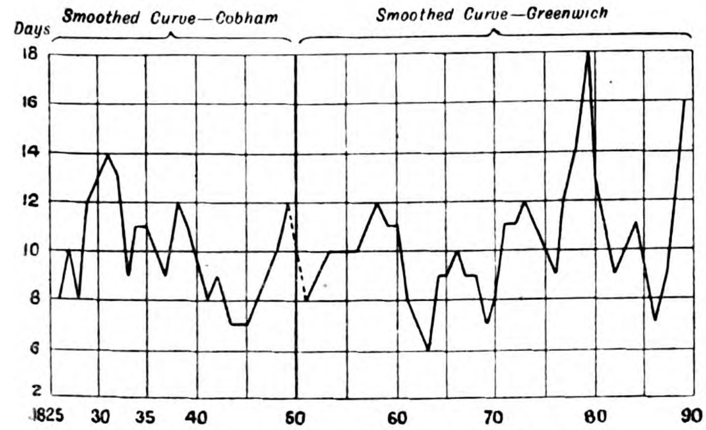



Fig. 2.—Days on which Thunder was heard.

At present, putting sheet lightning aside, the number of days, in May to September of each year since 1825, on which thunder was heard at Cobham (to 1850) and Greenwich (1850 to 1890) are shown in the diagrams. The Cobham is shown as far as it goes; and the Greenwich one as given in the *Weekly Return*. (It will be seen that in 1850 the Cobham observer records 10 days, and the Greenwich seven. The two records do not fully agree. But the data are probably sufficient for the purpose).

Looking at the curve (Fig. 1), then, one sees, first of all, that its highest points are in 1831 and 1878. In each year there were 22 days, in May to September, on which thunder was heard. The range extends down to 2 in 1844. A singular feature of the Greenwich curve at once strikes the eye. It is the succession of similar double-crested waves (five of them completed since the first decade), the second crest always lower than the first. What is the cause of this phenomenon? It seems difficult to suppose it purely accidental. We appear to be now in the hollow of a crest, and should almost expect to have rather more thunderstorms this year than we had in 1890, but not so many as in 1889.

The curve (Fig. 2) has been smoothed somewhat by the well-known method of making three years' averages, and the result appears in the upper part of the diagram, which perhaps gives a clearer idea of how thunderstorms have been distributed in this period of sixty-six years. It may be noted that, taking the intervals between the tops of the waves here given, from 1838, the numbers run as follows:—11, 9, 8, 7, 6, 5, 5 years. Also the gradual rise of the curve from 1863 to 1879 may be remarked.

No very obvious relation subsists between the numbers of days of thunder and the mean temperature of the summer and autumn months; though, doubtless, a detailed study of temperature would show variations in that to be related to the numbers of days of thunder, as here indicated. As regards rainfall, some of the highest years in this curve (*e.g.*, 1887 to 1889) are years of excessive rainfall; but it is not always so.

## THE TELEPHONIC REPRODUCTION OF SPEECH.*

BY E. MERCARDIER.

The principal object of the telephone is the reproduction of speech at a distance with all its component elements; the articulations with their inflections, the vowels and diphthongs with their characteristic accents, timbre with all its delicacy, and the whole reproduction with sufficient intensity. But the transformations of energy, which go to make up telephonic effects, tend to injuriously affect the human voice.

*Alteration of Timbre.*—This consists in the production of a disagreeable snuffling, which often distorts words. I pointed out in a previous communication† that this impairing of the timbre was due to the fact that frequently the movements due to the production of the fundamental note, and the harmonics of the telephone diaphragm were superimposed on those due to the voice, without, however, becoming confounded with them. Hence a more or less great disturbance of the electric waves, which reach the telephone receiver, of the movements of the molecules of the diaphragm, and finally of the sound waves which result from these movements, and which reach the ear of the listener. If my theory be correct, it was not necessary in order to correct this alteration of timbre to take a diaphragm the fundamental note of which is superior to the limit of the sounds emitted in articulate speech, that is to say, one whose fundamental note is somewhere about $ut_4$ for men and $ut_5$ for women. Then the human voice would not tend to produce the fundamental note and harmonics of the diaphragm, which would no longer coincide with the tones of the human voice. Moreover, in order to produce them it would be necessary (owing to the stiffness of the diaphragm) to employ a mechanical force greater than that which the human voice is capable of exerting when speaking. This has been verified by experiment. I will only cite two extreme cases. A diaphragm of 100mm. diameter and 1mm. thick, or one 30mm. diameter and ·1mm. thick. Both satisfy the condition mentioned above, and fixed to appropriate telephones neither of them produces a sensible alteration in the timbre of the voice.

*Alteration of Articulations and Vowels.*—This consists on the one hand of the exaggerated predominance of certain consonants, vowels and syllables, *p*, *b*, *r*, *k*, *a*, *o*, *an*, *on*, *ent*, and in the marked weakening of *l*, *s*, *c*, *z*, *i*, *e*, and *u*. The consequence is, that it is frequently very difficult to understand the meaning of a sentence and to decipher the words distorted in this way. Hence a constant source of error. The alteration is due in large measure to the shape and aperture of the buccal cavity, which are different in the pronunciation of the various articulations and vowels mentioned above, and to the resulting energy of the sound waves being much weaker in the second case than in the first. From this point of view this distortion would seem inevitable, but it is also due in some degree to the correlative production of the harmonics of the diaphragm. In fact, while seeking to remedy this defect, I found that it was markedly diminished by precisely the same method as indicated above, employed to suppress the alteration of timbre,

* *Comptes Rendus*, Vol. CXII., No. 3.
† *Comptes Rendus* November, 1885.

Digitized by Google

that is to say by suitably proportioning the thickness and diameter of the diaphragm so that its fundamental note shall be very sharp. The line joining the transmitter to the receiver also plays a certain part in this connection, which I hope to examine later on.

*Various Effects.*—The third difficulty which is present in a large number of telephones is the production of two parasitic resonances. One of these is not very inconvenient, since it is weak, and only noticeable by trained ears. It consists in metallic crackling, which seems to me to be due to a kind of friction along the radii of the diaphragms, caused by a change in the direction of the lines of force. This effect disappears in a diaphragm with a high fundamental note, either because it is then too shrill to affect the ear, or because it is not produced at all, owing to the mechanical force necessary for its production being greater than that which the human voice can exert. The other effect is more intense and of greater tonality: it is the resonance due to the mass of air enclosed in the telephone box itself. To cause this vague effect (composed to some extent of the various inflections of the timbre of the voice) to disappear, it is only necessary to take the precaution to leave a very small air space underneath the diaphragm, which can be attained by filling the interior of the boxes with felt. We thus see that apart from this last effect, which is easily eliminated, the distortions suffered by articulate speech when reproduced telephonically can be considerably diminished, if not entirely obviated, and this by a simple means, the same for all, consisting merely in the employment of diaphragms having a high fundamental note, whether they have considerable thickness and considerable diameter, or are thin and are of small diameter. At the same time that we obtain clearness in the reproduction of speech, we satisfy the conditions necessary to obtain sufficient loudness,* a very fortunate circumstance since the two desiderata of clearness and loudness are equally indispensable. This fact thus permits us to approximate perfection in an instrument as delicate as it is marvellous.

## ON THE INFLUENCE OF THE STRENGTH OF THE MAGNET IN A MAGNETO TELEPHONE RECEIVER.†

BY C. R. CROSS AND H. E. HAYES.

The following investigations of Messrs. C. R. Cross and H. E. Hayes, carried out in October last in the Physical Laboratory of the Massachusetts Institute of Technology, are of interest in view of their connection with recent work by M. Mercadier (*The Electrician*, January 23rd, p. 368, and present issue):—

The present investigation is a continuation of the research described in a previously-published Paper by Messrs. Cross and Williams. With a magneto telephone transmitter it was found that, as the strength of the magnet was increased, the induced current produced by a definite motion of the diaphragm increased quite rapidly to a maximum, and then gradually decreased. With diaphragms of different thickness it was found that, as the field necessary to saturate the diaphragm increased in strength, the maximum value of the induced current occurred with a greater strength of field, and also that the value of this maximum current increased with the thickness of the diaphragm, other things remaining the same.

The diaphragms used were of iron, and of the same thickness as in the previous experiments, viz., Nos. 21, 22, and 23 B.W.G., corresponding to a thickness of 0·032in., 0·023in., and 0·024in., respectively.

A series of observations gave the results shown in the curves shown in Fig. 1. The induced currents are represented by abscissæ, the strengths of the field by ordinates. The numbers 21, 22, and 23, affixed to the curves, indicate the thickness of the corresponding diaphragms by their gauge number. The curves show that with the diaphragms numbers 21, 22, 23, the maximum induced currents were 124, 93, 91, respectively, corresponding to relative strength of field 61, 56, 49. The results prove that, within the limits of the experiments, the maximum current is greater, and is reached with a stronger field, as the diaphragm is thicker. An examination of the curves (Fig. 1) shows that the point of maximum current is less distinctly marked with the thinner diaphragms than with the thickest. We are inclined to believe this to be an accidental peculiarity, due to a slight yielding of the diaphragm, which was fastened at its edges and which when thin would tend to bulge towards the magnet, thus causing its whole motion to be performed in a stronger field, and so giving rise to a stronger induced current than would otherwise be the case. An extremely slight displacement of this kind will produce a noticeable difference in the resulting induced current. This effect may also have acted to diminish somewhat the difference between the maximum current obtained with the two thinnest diaphrams, which difference is much less than the difference between the maximum current with the two thickest ones. Care was taken in all the experiments that the magnet of the apparatus should be far below saturation, even with the strongest magnetising currents which were used.

Our experiments were next directed to a study of the conditions operative in the magneto receiver, and particularly to ascertain the effect of a varying degree of magnetisation in the magnet of the receiver upon the change in its strength when subjected to the action of a slight current of the same order of magnitude as that used in telephony. The apparatus employed consisted of a core of soft Norway iron, 6in. long and a quarter of an inch in diameter, and provided with a suitable magnetising coil. A diaphragm was placed opposite one end of the core, as in the usual magneto receiver. This end of the core also carried two coils of fine wire, like the ordinary telephone magnet coil, one having a resistance of about 130 ohms, the other of about 190 ohms. The former of these coils was connected with a storage cell, a fixed resistance, and a key. By means of this apparatus a current of suitable magnitude could be caused to traverse the coil, which evidently corresponds to the coil of the ordinary receiver, and which we have called the "line coil." The effect of this current will be slightly to increase or decrease the magnetisation of the bar magnet, as in the receiver itself. The second fine wire coil is a "measuring coil," and is connected in

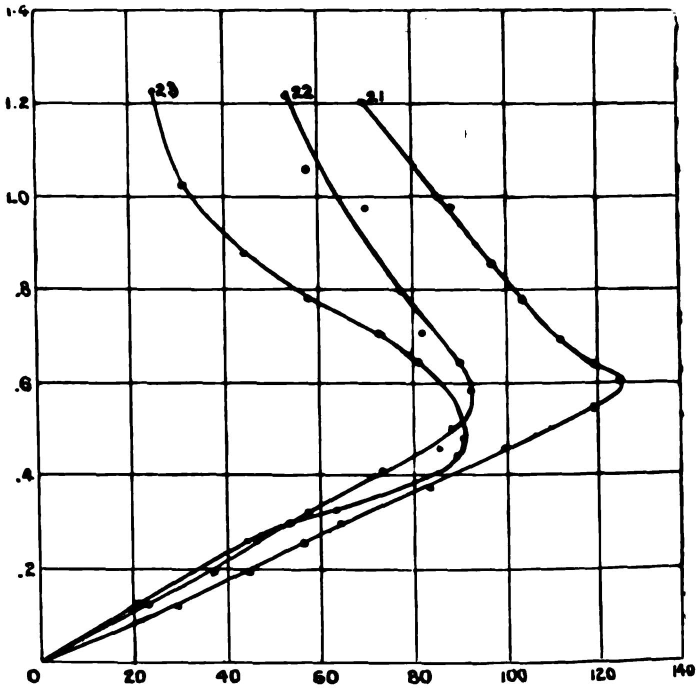



Fig. 1.—Curves showing the relation between the induced currents and the Strength of the Magnetic Field.
Induced Currents, Ordinates, ·2, ·4, ·6, &c.
Strength of Field, Abscissæ, 20, 40, 60, &c.

circuit with a ballistic galvanometer, from whose deflection when a current was sent through the first fine-wire coil the effect of this current on the magnet of the receiver could be determined. A magnetometer arranged in the usual manner showed the relative strength of the field of the receiver magnet under differing conditions of magnetisation. The observations consisted in adjusting the magnitude of the current through the magnetising coil so as to give a certain deflection of the magnetometer needle. The magnetising circuit included a suitable resistance coil, by the use of which any desired current could readily be secured. The key was then pressed, so that a certain current flowed through the line coil. The proper value was given to this current by means of a rheostat. The induction occurring in the measuring coil gave rise to a transient current through this circuit, the value of which was known from the deflection of the needle of the ballistic galvanometer included in it. Of course the key had to be kept down until the observation was completed, and it was also necessary, on account of the self-induction of the measuring circuit, always to read either on opening or on closing the key. In our experiments the latter alternative was chosen.

The results were plotted as previously by using the relative strength of the field as expressed by tangents of the magnetometer deflections as ordinates, and the induced currents in terms of an arbitrary unit as abscissæ. The deflection of the ballistic galvanometer used was proportional to the strength of the transient current passing through its coils.

* *Comptes Rendus*, Vol. CXII., p. 97; *Electrician*, January 23, 1891, p. 368.

† From the proceedings of the American Academy of Arts and Sciences.

Digitized by Google

A series of observations was first made with the diaphragm removed, in order to study the deportment of the core alone under varying degrees of magnetisation. The results are shown graphically in Curve 1, Fig. 2. It appears from these, that with increasing magnetisation of the core the induced current remains nearly constant for a time, and then diminishes rapidly and at an increasing rate, which afterwards becomes nearly constant, a result which would be anticipated from the corresponding diminution in the magnetic change which a small current in the line coil would produce. The current which traversed the line coil was six milliamperes, a value which was used in most of the measurements, it having been found by trial that the general character of the results was the same as when a smaller line current was used, while the greater magnitude of the deflection of the current induced in the secondary measuring circuit allowed more satisfactory readings to be made than if the line current were smaller. A corresponding series of measurements with a diaphragm of ferrotype iron, No. 31 B.W.G., 0·010in. in thickness, gave the results shown in Curve 31, Fig. 2. Curve 2, Fig, 2, is constructed with abscissæ equal to the difference of the corresponding abscissæ of curves 31 and 1, and shows for various strengths of field the increase of the induced current due to the presence of the diaphragm, an interesting illustration of the action to which Du Moncel ascribed the chief efficacy of the diaphragm.

In order to study the effect of the thickness of the diaphragm further measurements were made, using sheet-iron diaphragms, Nos. 21, 22, 23, 26 B.W.G., whose thickness was 0·032in., 0·027in., 0·24in., and 0·018in. respectively.

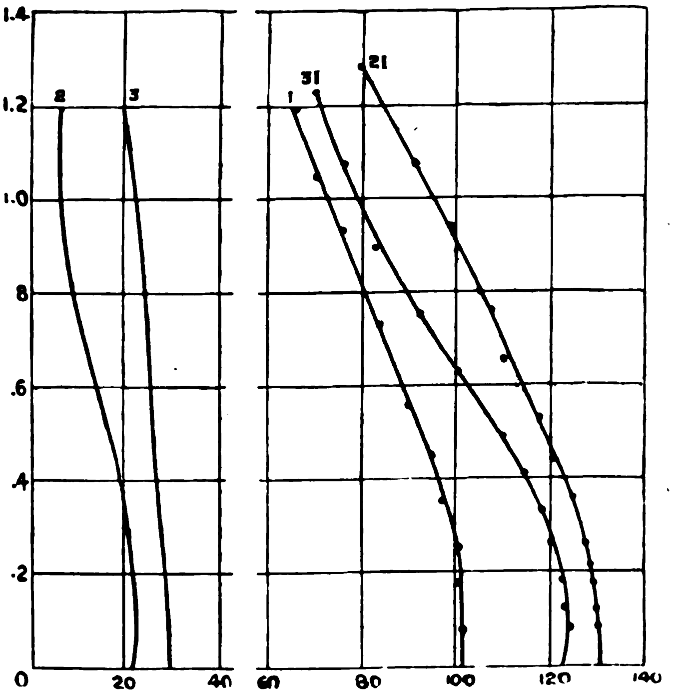



Fig. 2.—Curves showing Relation between Induced Currents and Strength of Field.
Induced Current, ordinates.
Strength of Field abscissæ.

Several series of measurements were made with currents of widely different strengths, and with the thinnest and the thickest of the diaphragms used in these experiments, in order to ascertain whether the induced current in the measuring coil was proportional to the inducing line current, and since this was found to be sensibly the case, the strength of six milliamperes was adopted, as already stated.

Considerable trouble was experienced in obtaining satisfactory consecutive readings of the deflections, on account of the close proximity of the laboratory to the streets, rendered especially disturbing by the presence of the electric railway. The difficulty was avoided as far as possible by working at night.

It will be seen from inspection of any one of the various curves last referred to, that as the strength of the field increases, the induced current increases, and then gradually diminishes. This would of course be anticipated, as the increased magnetisation of both the core and the diaphragm increases the strength of field in which the latter moves, and at the same time diminishes the susceptibility of both masses of metal to magnetisation. The effect of the former predominates slightly at first, but is overpowered by the latter cause when the magnetisation is increased. It would seem that above No. 22 an increased thickness of diaphragm causes little effect. A comparison of the curves will show that, with the exception of Curve 31, for which the diaphragm was of ferrotype iron, the value of the maximum induced current is greater according as the diaphragm is thinner; and also that the strength of field corresponding to this maximum current is likewise greater the thinner the diaphragm. The following approximate values were found from constructions of the curves on a large scale.

| | | | | |
|---|---|---|---|---|
| For No. 26, | Maximum Current = | 142, | Field = | ·18 |
| " " 23, | " " | 137 | " | ·13 |
| " " 22, | " " | 132 | " | ·10 |
| " " 21, | " " | 131 | " | ·06 |

It also appears that with the thinner diaphragms the decrease of the induced current with increase of field, after the maximum value of the current is reached, is more rapid than with the thicker ones. Moreover, the deviation of the latter portion of the curve from a straight line is greater in the case of the thinner diaphragms. The great value of the maximum induced current with the thin than with the thick diaphragm would naturally be ascribed to the less stiffness of the former, and its consequent greater motion when a current passes through the line, although its smaller mass and greater ease of saturation must in a measure counterbalance this effect. The quicker approach of the thin diaphragm towards saturation will explain the more rapid falling of the current with it, and also the ess uniform rate of this change as the field increases. Curve 3, showing the effect of the diaphragm, still further illustrates this.

It should be observed that the results which we have described do not necessarily show the varying accoustic effect of the receiver, since the amplitude of the motion of the diaphragm rather than the simple amount of the change of strength of the magnet determines the magnitude of the resulting air-waves—at least, according to the view commonly held. We hope to return to the study of this part of the problem, which is rendered somewhat difficult on account of the very small motion of the diaphragm.

## ON THE PHYSICAL PROPERTIES OF HARD-RUBBER, OR VULCANITE.*

BY ALFRED M. MAYER.

The discovery of the large coefficient of expansion of hard-rubber by Kohlrausch,† in 1873, and of its remarkable diathermancy by Bell,‡ in 1880, attracted the attention of physicists to this substance. In this paper I give additional and more minute experiments on the above-mentioned and other properties of this substance.

Hard-rubber, vulcanite, or ebonite, as it is variously called, is formed of rubber and sulphur. These are combined in proportions of about two parts of rubber to one of sulphur. These ingredients, intimately mixed, are by the action of a temperature of 300° F., lasting three hours, converted into a black compound. The sun, viewed through thin plates of this substance, appears of a deep red colour. The hard-rubber used in our experiments was formed of 64 parts of rubber of Para and 34 parts of sulphur.

*The coefficient of linear expansion* was obtained with the apparatus devised by me for this purpose and shown in the accompanying figure. A plate of steel one metre long and 6cm. broad had a lug of steel 15mm. broad screwed on to its end to act as an abutting piece against which the end of the bar of vulcanite, 96cm. long, 6cm. broad, and 1·3cm. thick was pressed by means of springs. A block of steel, carrying a tracer, while bearing against the end of the bar of vulcanite was slid along the end of the bar and traced on the surface of the steel bar a very fine line. The bars are in a closed case in which they have remained for 24 hours. The temperature is taken from thermometers lying on the vulcanite bar. After having traced the line the apparatus is placed in a metal case surrounded by ice, and after the temperature has become stationary another line is cut by the tracer. The bar in falling through the observed temperature has shortened by the distance between the lines less the shrinkage of the steel bar. The distance between the lines is measured by a micrometer microscope. As the tracer is of steel its contraction is the same as that of the steel bar on which it rests, so that we have only to consider the length of the steel plate equal to that of the vulcanite bar in computing the coefficient of expansion of the vulcanite. Calling this length $l$, the distance between the lines $d$, the coefficient of expansion of the steel $k$, and the coefficient of expansion of the vulcanite $e$, we have in the range of temperature $t$,

$$e = \frac{d \div l}{t} + k$$

The mean of twelve determinations thus made between 0°C. and 18°C. gave ·0000636 as the mean coefficient in the above range of temperature.

*The formula of the cubical expansion of ebonite* was determined by a mercurial thermometer made of a bulb of ebonite to which was

* From the *American Journal of Science.*
† Pogg. Ann., cxlix, 577, 1873.
‡ This Journal, Oct., 1880.

Digitized by Google

attached a glass capillary tube of cylindrical bore, the tube of vulcanite was placed in a metal shield to protect it from moisture, and it and the glass tube surrounded with ice. The distance of the mercury from a fine line engraved on the glass tube was read with a cathetometer when the level of the mercury had become stationary, and the lengths between the line and the level of the mercury at different temperatures, obtained by heating the apparatus in a hot air chamber furnished with a thermostat, was measured. Knowing the capacity of the ebonite bulb and of a millimetre in length of the glass tube we obtained the rate of the apparent expansion, or rather, contraction of the mercury, from which, after having allowed for the expansion of the glass tube and the mercury in it, we deduced the absolute expansion of the vulcanite. The results of these experiments may be closely expressed in the following formula.

$$V_t = V_0 + \cdot000182t + \cdot00000025t^2.$$

The formula of the cubical expansion of mercury as given by Mendeleeff* is

$$V = V_0 + \cdot0001801t + \cdot00000002t^2$$

It is thus seen that the cubical expansion of vulcanite exceeds that of mercury so that the apparatus we have described may be used as a thermometer in which, as Kohlrausch observed, the scale will be inverted; when the temperature *rises*, the mercury in the stem *falls*.

The following table gives the volumes of vulcanite and of mercury at temperatures from 0 deg. to 100 deg., as computed from the above formulæ. The difference (in the fourth column) which are all negative, show the increasing rate of expansion of the vulcanite over the mercury.

| Temp. | Vol. of Mercury. | Vol. of Vulcanite. | Differences. |
|---|---|---|---|
| 0° | 1·000000 | 1·000000 | ·000000 |
| 10 | 1·001803 | 1·001845 | ·000042 |
| 20 | 1·003610 | 1·003740 | ·000130 |
| 30 | 1·005421 | 1·005685 | ·000264 |
| 40 | 1·007236 | 1·007680 | ·000444 |
| 50 | 1·009055 | 1·009725 | ·000670 |
| 60 | 1·010878 | 1·011820 | ·000942 |
| 70 | 1·012705 | 1·013965 | ·001260 |
| 80 | 1·014536 | 1·016160 | ·001624 |
| 90 | 1·016371 | 1·018405 | ·002034 |
| 100 | 1·018210 | 1·020700 | ·002490 |

As the apparent expansion of mercury in glass of a Fahr. thermometer is ·0000869 of its volume for 1deg., and as the apparent contraction of mercury in a vulcanite thermometer is ·00249 from 32deg. to 212deg., it follows that the length of scale from 32deg. to 212deg. on a vulcanite thermometer $= \frac{\cdot00249}{\cdot0000869} =$ 28deg. ·6 of length of scale on a similar mercurial thermometer of glass.

Kohlrausch states in his Paper, cited above, that "the increase of the coefficient of expansion of ebonite with the temperature is very considerable. The linear expansion for the temperature $t$ can be put

$$\cdot000061 + \cdot0000076\,t."$$

This formula agrees well with that which we determined for the cubical expansion. Further on he says:—"The solid expansion of ebonite is, from the above numbers, at 0deg. equal to that of mercury; at higher temperatures it is still greater. It is possible that other kinds expand still more, so that as a curiosity a mercurial thermometer might be constructed whose readings sink on being heated. The great expansion may possibly be connected with the proportion of sulphur which ebonite contains: Kopp (Pogg. Ann., vol. lxxxvi, p. 156) found for the coefficient of sulphur ·000061 at 30deg. On the other hand, the contrast to soft caoutchouc is very remarkable. I will mention one fact which was observed in the observation of expansion. The bar of ebonite, which was about one centimeter in thickness, after being heated, required a considerable time before it assumed a constant length. Although the bad conductivity is doubtless the principal cause of this, I imagine that another phenomenon is also at work. Like the elastic change of form, the expansion by heat may also not take place instantaneously, but continue itself after the change of temperature, gradually becoming weaker. A few observations of Matthiessen's with glass (Pogg. Ann., cxxviii, p. 521), seem to point in this direction; probably this thermal after action, like the elastic, occurs in an eminent degree in organic substances."

*The specific heat of vulcanite* was determined by the method of mixtures. Small fragments of vulcanite were heated to near the temperature of boiling water in Regnault's apparatus and dropped into a water calorimeter. After corrections for equivalents in water of calorimeter and thermometer and for radiation and evaporation, three experiments gave these results:—

1) ·33124  2) ·33077  3) ·33225  Mean = ·33125

*On the diathermancy of vulcanite* and similar substances, numerous careful experiments were made by observing with a thermopile the percentages of heat rays transmitted by plates of different thicknesses.

The result of these measurements is to show that the rays transmitted by vulcanite and obsidian are of long wave-length; these are in greater percentage in the rays from the Locatelli lamp than in those from the sun. A plate of vulcanite one-half millimeter in thickness transmits 32 per cent. of these rays, while of the sun's rays 24 per cent. are transmitted. A plate of obsidian of 8mm. thickness acts in like manner, but it screens even a greater proportion of the sun's rays than it does those from the Locatelli lamp, for it transmits 16·5 per cent. of the former rays, and 32 per cent. of the latter.

In making the experiments on the transmission of the sun's rays I used a revolving diaphragm pierced with holes of various diameters. The face of this diaphragm was exposed to the solar beam, sections of which, equal to the area of the different holes, were transmitted to the thermopile, which was placed at such distances from the diaphragm that the whole of the rays transmitted were included in the area of the face of the pile. The deflections of galvanometer produced by beams going through holes of different diameters are given below:—

| Diameter of hole. | Deflection. | Diameter of hole. | Deflection. |
|---|---|---|---|
| 1) 1·25mm. | 8·5 | 3) 4·9mm. | 131·5 |
| 2) 3.4 | 63·0 | 4) 6·1 | 204·0 |

If the heat given to pile is as the area of the aperture, then the squares of the diameter of aperture divided by the deflections should equal a constant, as follows:—

$$1)\ \frac{1\cdot5625}{8\cdot5} = \cdot1838 \qquad 3)\ \frac{24\cdot01}{131\cdot5} = \cdot1826$$

$$2)\ \frac{11\cdot56}{63} = \cdot1835 \qquad 4)\ \frac{37\cdot21}{20\cdot4} = \cdot1824$$

Mean = ·18305.

I mention these experiments, because they show that such a diaphragm may be of service to those who wish to obtain in succession definite amounts of heat from a solar beam.

*The index of refraction of vulcanite* was measured by ascertaining, in a spectrometer, the angle of maximum polarisation of a polished surface of vulcanite. The mean of fourteen measures gave for this angle 57° 29′, and the tan. 57° 29′ = 1·568 for the index of refraction; a number nearly as great as the index of refraction of flint glass.

Thin lenses of vulcanite and of obsidian were made for me by Mr. John A. Brashear, and with them I concentrated the rays of long wave-length to invisible foci on the face of the thermopile.

* *Jour. de Physique*, v., p. 259.

## NEW TESLA ALTERNATING MOTOR.

We have already, says the *Electrical Engineer* of New York, described a number of different forms of alternating current motors designed by Mr. Nikola Tesla, depending upon a variety of phenomena met with in the employment of alternating currents. One general type of these consists of a machine with, say, four poles, between which is mounted an armature, generally wound with closed coils. On two opposite poles of the field are primary coils connected up in the main circuit. On the same cores are also wound secondary coils on the other pair of poles. When an alternating current is caused to pass through the primary coils, it energises directly one set of poles, and induces currents in the secondary coils, which in turn energise the poles; but the phases of the current in the secondary coils may differ in time from those of the primary current, and hence a shifting of the poles is effected that imparts a rotation to the motor.

In the new motor designed by Mr. Tesla, however, two energising circuits are brought into inductive relation in the motor itself, and the employment of an external induction device is thus avoided. The operation is dependent upon the existence of a certain difference of phase between the currents of the primary and secondary coils, and will be readily understood by reference to the accompanying diagram. Here A represents the field magnet of a motor, which is built up of sections or plates. B and C are polar projections upon which the coils are wound. Upon one pair of these poles, as C, are wound the primary coils D, which are directly connected to the circuit of an alternating-current generator G. The secondary coils, F, are wound on the same

Digitized by Google

poles with the primary, and connected with other coils, E, which surround the poles B. The current in both the primary and secondary coils will lag behind the impressed electromotive force, but to secure the proper difference in phase between the primary and secondary currents themselves, the resistance of the circuit of the secondary is increased, so as to reduce as much as possible its self induction. This is accomplished by makiog the coils E of comparatively small wire, having but few turns around the cores, or by inserting in the secondary circuit an artifical resistance, R. In practice, it has been found desirable to wind the armature with closed coils, in which currents are induced by the action of the primaries.

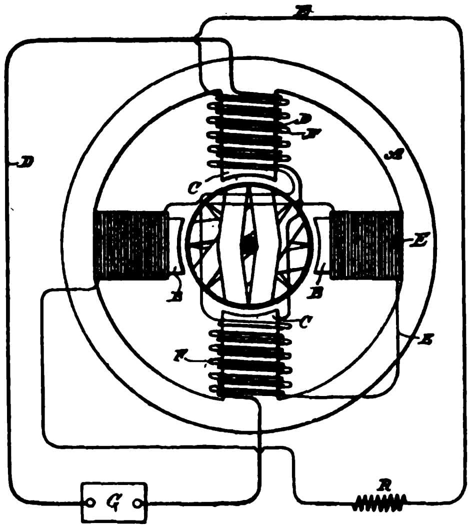


Diagram of Tesla Alternating Motor.

## ELECTRICITY AND ITS TACTICAL VALUE FOR MILITARY OPERATIONS.*

BY MAJOR R. L. HIPPISLEY, R.E.

I propose to confine myself in this lecture to the consideration of only one of the uses to which the electric light can be put for war purposes, namely, portable lights for field operations. A highly specialised equipment is necessary for this purpose—one which cannot be satisfactorily extemporised on the eve of war, and several units of which ought to be kept in store ready for an emergency. But it will be labour wasted and money ill-spent if this equipment is designed and brought out, and if no one will use it. Now, an electric light apparatus, portable enough to follow an army in the field, could be made use of for a variety of purposes.

Taking first its most obvious use—viz., in sieges—we may take for granted that every first-class fortress will soon have its first-class search-lights. In England preparations are being made on a large scale for the introduction of the most brilliant search-lights for our southern defences, both sea and land, to be at the disposal of the artillery for defensive purposes. We may, therefore, take for granted that a besieging army will find any permanent fortress, against which it may be engaged, in possession of electric lights with which to search out the night operations conducted against it. The siege of a fortified place would, therefore, no longer be the comparatively simple operation of constructing works at night and firing from them during the day. The construction of the ordinary siege works in the method hitherto adopted would not be possible except at an enormous sacrifice of life. But this advantage on the part of the attack can be greatly obviated by the employment by them of electric search-lights; for it has been shown from the Milford Haven experiments in 1886 that, when the atmosphere is at all heavily laden with smoke or with mist, the penetrating power of the lights from a fortress can be diminished to a large extent by the employment on the part of the attack of another beam, crossing the former at an angle. At Milford Haven it was found that the penetrative effect of the electric lights of the defence was very feeble when the beams were crossed by those of the attack, as the illuminated spaces at their intersection presented a screen, more or less opaque, according to the amount of smoke or mist with which the atmosphere was charged. An electric beam can therefore be used as a screen, behind which operations can be conducted in secret. The applicability of this use of the light in the attack of a fortress is obvious. In order to produce this screening effect, it is only necessary that a powerful search light should be placed in front of the flank of the ground to be hidden, so that its beam may be projected in front of it. It is better to throw the beam diagonally across the front, rather than to make it traverse straight across, because its obscuring power is much greater when so disposed, and also because it contributes to disconcert the enemy's fire by its dazzling effect upon those having to aim the guns. The projector used should be capable of throwing a very condensed beam, and care should be taken to avoid any stray rays illum'nating the ground which is intended to be hidden.

Not only will the electric light produce cover behind which parallels or siege batteries can be commenced, if the nature of the ground and the shape of the fortress admit of it, but it can also be used with great effect for the direction of the guns subsequently placed in such works. The firing can then be carried on at night with almost as great accuracy as during the day. Guns were laid by night at Lydd in 1886, on a work illuminated by a beam from a flanking position 1,200 yards distant from it. The outline of the work was shown up very distinctly, and the gun laid with perfect accuracy. The apparatus for use in sieges must be as powerful as it is possible to get. This applies, of course, to all the purposes to which the light can be put. The only limit is arrived at when the apparatus becomes so ponderous as to be unmovable. But as an army cannot set down in front of a fortress without bringing up its armament of heavy guns, one can afford to construct the apparatus for this purpose more heavily, and, therefore, more powerfully than for other things.

*Attack and Reconnoitring.*—A recent writer, who has collected into one book all the possible uses to which electric lights can be put for war purposes, has, it seems to me, been injudicious in puffing it beyond its merits. He has stated that it can be used in the attack of a position as distinguished from that of a fortress, and also in a reconnaissance in force by night. The employment of search-lights for such purposes will, no doubt, be considered a somewhat hazardous proceeding. Indeed, I should not have mentioned the employment of electric lights for such purposes as reconnoitring and attacking if it had not been that the writer just mentioned had enumerated such employments amongst its possible uses. Many great and radical improvements and changes would have to be introduced into the apparatus before any attempt could be made to carry out such undertakings, even if they could be defended on tactical grounds.

*Defence.*—It is quite another matter when we come to speak of the use of the electric light in the defence of a position against an expected night attack. Here we are on certain ground again. There is nothing to lose by the search-light and everything to gain. For it has been conclusively shown that the light can be placed so as not only to reveal nothing of the defenders' position and movements, but so that it actually affords additional security to them by the depth of the obscurity which it casts over objects in its immediate vicinity, which are out of the reach of the beam. It has been already mentioned that the apparatus is extremely difficult to hit. This is on account of, firstly, the difficulty of estimating the range, even with tolerable accuracy; and secondly, because without special appliances it is almost impossible to aim at the light. As an instance of the deceptive effects of distance, it may be remarked that if the beam be directed on to the ground so as to illuminate a patch of ground between the defenders and the enemy, but sufficiently far from the latter, it appears to anyone looking at the projector from a distance as if the light were situated immediately over the patch of illuminated ground; and if the projector be elevated or depressed slightly, so as to cause the illuminated patch to advance or retire, it seems as if the projector itself were advancing or retiring. Owing to this illusion it is almost an impossibility, without cross bearings, to determine the range of the light if it is kept constantly on the move, as it would have to be when searching for an enemy in front; and even if kept steadily fixed his difficulty in estimating the range is very great.

At Okehampton, in 1888, 32 rounds of shrapnel shell were fired from an unknown range, which was estimated at 1,680 yards by officers with range-finders and pickets with lanterns attached to them. In the morning they found the estimated range was 100 yards too great. Seven bullets passed through the mirror without doing any damage to the light. With regard to the difficulty of aiming, it is of course impossible to look at the direct light on account of its blinding effect, and, therefore, it is impossible to aim at in the ordinary way. Extraordinary methods of aiming, such as that by the shadows of the sights, or by using oiled black paper, are hardly likely to be resorted to by the troops engaged in the attack, even if the men could be taught how to do so. The experiments at Shoeburyness in 1883, at Lydd in 1887, and at Okehampton in 1888, have given remarkable evidence upon this point. At Shoeburyness 124 rounds were fired in one night from Martini-Henry rifles at the electric light apparatus, at ranges varying from 950 yards to 400 yards, and only one hit was made. On the following night 120 more rounds were fired, and five hits scored;

* From a Lecture delivered before the Aldershot Military Society.

Digitized by Google

and at the same time 75 rounds were fired rom a Gardner gun, and only one hit scored. Later on in the same year 400 rounds were fired from a Gatling gun, with the result that 19 bullets hit the apparatus, but this was largely due to the fact that the telephone was used to inform the officer at the firing-point of the results of his firing. It should also be remembered that the ranges were accurately known to a yard. At Lydd similar experiments were made. Ten marksmen fired 200 rounds at ranges of from 1,000 to 600 yards, without effecting any hits; 500 rounds were then fired from a Gardner gun at 1,000 yards, with the result of one hit; and 250 rounds at 600 yards from the Gardner gun, with three hits. The guns were aimed by the shadows of the sights on a piece of white paper held behind the backsight. In these experiments the light from the projector was thrown upon a plane mirror mounted on a pole The mirror could be traversed or elevated from a safe position behind a parapet where the projector was placed. The mirror was a thin sheet of silvered copper stretched on a frame, and though pierced occasionally with bullets, the reflected light from it was as strong as ever.

If opportunity offers in the defence of a position, the arrangements for displaying the light should be the same as those at Shoeburyness, Lydd, and Okehampton, the invulnerability of which has been so conclusively proved. It will be very seldom that an extemporised shelter cannot be made for the projector. The light is thus worked under cover, all that is exposed being the thin stretched metal mirror mounted on a pole, duplicates of which could be easily and cheaply provided in case of accidents, and could be substituted for the broken one in about a minute.

Perhaps you will permit me to make a few remarks upon the necessity for caution in drawing conclusions with reference to points which present themselves as unfavourable to the employment of the light in defence operations. When a demonstration has to be made, and experiments are being tried with the search-light apparatus, under novel circumstances, and in the presence of critical witnesses, it is almost impossible to get people to appreciate the difference between defects which are inherent and defects which are due to remedial causes. For instance, if anybody feels inclined to combat my assertion that the electric light can be so placed as to reveal nothing of the defenders' position, and yet afford him a clear view of the enemy, and if he has before his mind the results of the trials made at the North Camp Redoubt during the manœuvres of the Second Field Column last July, and to prove his point intends to call witnesses to say that the light did on the contrary reveal the outlines of the redoubt at certain times, I can reply that if properly manœuvred it would not have done so, and that all that occasion proves is the necessity for more care on the part of those who were directing the light. On the occasion referred to, the light was traversed through too wide an angle, and, before the advance on the redoubt had been begun, it was actually at one time pointing with its back to the enemy, and, therefore possibly, did reveal the some portions of the redoubt; while, however, the advance was being made, I think everybody agreed that the redoubt was quite invisible.

With respect to the limit of visibility of objects illuminated by the electric search-light, different observers have maintained discordant opinions. So much depends upon the state of the atmosphere, as regards clearness and dryness, that it is almost impossible to secure the same limits on any two separate occasions. The background and colour of the object also makes a great difference. Moonlight assists the light very materially. Under favourable conditions I think small bodies of infantry may be detected with ease at 2,000 yards, but more generally the useful limit is reached at 1,500 yards. In a climate like that of England we have the worst possible conditions of visibility, not only on account of the fog, which is almost invariably present to a greater or less degree, but also on account of the variability of the amount of invisible moisture in the atmosphere at different parts of the range. Where this invisible moisture in the air varies at different spots, as it would do if a stream traversed the path of the beam, the light is more intercepted than it would be if the air throughout were homogeneous. On the Continent and in dry climates the nights are generally much clearer, and the usefulness of the search-light correspondingly greater.

As regards our own preparations in this respect, I do not think we are yet fully alive to the advantages and importance of possessing portable search lights for field operations; and it has been my principal object on this occasion to try and show, not only that it is important that we should be so equipped, but also to show that, in some respects, foreign countries are ahead of us. Many experiments have been tried in England with search-lights of various degrees of portability, but as yet there has been only a part of one equipment recognised for field operations, and that is the steam traction-engine and dynamo exhibited at the manœuvres last year. There is yet no special vehicle for carrying the projector. I maintain that, valuable as the traction-engine is, it is not enough, and that we must also have a lighter apparatus for horse transport. We cannot do better than adopt one of the two Continental types, at any rate till a better one is produced, because they have thrashed out the subject in a most thorough manner, and their productions are the result of years of trial and error, and are likely to be the best and most complete that can be obtained.

DISCUSSION.

Lieut.-General Sir EVELYN WOOD said he had found the electric light of inestimable value in Egypt, and never went to sleep at night without throwing the light in the direction of the enemy to see if he was moving. But had there been a battle since 1859 in which the electric light could have been used by the aggressors? The noise of a traction engine alone would be heard long before you reached the enemy. And then there was the unavoidable noise that would be caused by the pulling of horses. What was the weight of our engine? Ours was seven and a-half tons, the engine of continental pattern was four tons. A team pulls one and three-quarter ton on the level road. Even if the weight got down two and a-half tons it could not be taken in and out of camp unless you had a line of macadam. He failed to see its use in attack.

Colonel LONSDALE HALE asked whether the electric beam would penetrate Colonel Crease's smoke. Some people seemed to think Colonel Crease's smoke a fad. In the course of some experiments at Portsmouth, a body of men advanced within 200 yards of a position unseen under cover of the smoke. He brought this forward in connection with the electric light, because it was important to consider. He thought, with this smoke-cloud, which can be made very portable, the electric light would be comparatively useless in the field for search purposes. With regard to pushing forward the specialities of Engineers, he thought there would be little success in this direction until the departments at Chatham were removed to Aldershot - among the rough-and-tumble of Aldershot, in contact with other troops.

Field-Marshal Sir J. LINTORN SIMMONS said it was very difficult to bring up three tons. As for four tons being drawn by four horses, they may as well try to move the hall with four horses. They need not be afraid of a locomotive. Several years ago he saw eight or ten different kinds of locomotives tried at Birmingham. The course marked out was over a mile, over hedges and ditches, and across ploughed fields. In the hedges an opening was made a little wider than the engine, and earth was thrown into the ditches. The locomotives were started, and they went over the fields and ditches. Some of them stuck fast, and were never got out; but the majority of them got to the end of their journey, and did remarkably well.

## ELECTRIC CRANES.*

BY REGINALD BOLTON.

The use of hoisting machinery forms a subject of interest to many engineers, while the question of its economies is of even deeper interest to all those engaged in the transport or movement of materials. The application of electricity to this particular purpose is one that at first sight may not present great apparent advantage, but a consideration of the conditions to be fulfilled will, on the contrary, show that there is no more suitable conjunction of force and duty, and even at the present stage, no purchaser of hoisting machinery can afford to disregard the claims of the conveyance of power by electricity, for reasons which the author hopes, succinctly, to show.

There are three considerations which present themselves, and which, if answered affirmatively, cover the whole subject.

Naturally, the primary one is,

1. Its comparative economy.

The second in order is,

2. Its superior merits.

The only remaining consideration being,

3. Its practicability.

Under the first we have to look into a few of the figures of electric and steam motors on cranes.

Now, an electric motor is in itself a most economical transmitter of power, its efficiency running as high as 90 per cent. in regular work, and if worked under proper conditions, its life may be as long as that of any ordinary steam engine, while under the special safeguards designed by the author its durability would be far more prolonged. But the power must necessarily be generated and conveyed to this motor, and so the question of the economy of the generating dynamo and the power that drives it comes into question. Such directly-connected engines and dynamos as are used on board ship, and in numerous central-station installations on land, have repeatedly given a united efficiency of over 80 per cent. of the horse-power of the steam in the cylinder.

There are a far greater number of cases, however, where such a dynamo would receive its motion direct from a shaft driven by a larger engine, and in such a case an even superior result might be relied upon. It would, in fact, be safe to assume an output of 85 per cent. of the actual power put on to the dynamo

* Abstract of a Paper read before the Civil and Mechanical Engineers' Society, February 18, 1891.

Digitized by Google

pulley, in the shape of electrical force, and as, in the case of shop cranes, or wharf cranes, they would not be remotely situated from the generating dynamo, the loss in transmission would be small and can be stated at 1 per cent. to 2 per cent. only.

In the case of a large dock, with cranes situated at all parts, there would be greater distances to be dealt with, but even these would not exceed the limits of ordinary low-tension circuits, and the system would show a very favourable comparison in losses by transmission, as against the distribution of hydraulic power.

For all ordinary conditions, then, we may deal with the following figures :—

| | | |
|---|---|---|
| One h.p. put into dynamo results in ............... | ·85 | of 1 h.p. |
| Less by loss in transmission two per cent......... | ·0085 of | ,, |
| Leaving the force put into motor as.................. | ·8415 | of a h.p. |
| Output of motor 90 per cent. ........................ = | ·7573 | of 1 h.p. |

Or a total loss of less than 25 per cent.

Now take the comparative case of a steam driven crane, say of two tons power, having two cylinders each 5½in. diameter by 8in. stroke, running at 150 revolutions per minute. Such engines are on full work linked up to cut off steam as late as ⅝ to ¾ of the stroke, and thus exhaust their steam at a considerable pressure. The usual boiler pressure is 70lb. maintained at an average of about 65lb., and wire-drawn by pipes and connections to, say, 60lb. initial pressure. Under above conditions they indicate about 14½ horse-power, but their consumption of steam is very considerable, and cannot be assumed at less than 35lbs. per horse-power per hour. An excellent authority gave, recently, instances of such small high-speed engines absorbing over 40 lbs. per horse-power per hour. The net efficiency is still further reduced by the internal friction of the machines, which even in good engines would average 15 per cent., so that we arrive at a final efficiency of these engines used as motors on cranes of not more than 60 per cent.

On all small steam cranes, however, there is a further waste in the boilers, which, being small and of the vertical type, are far from economical in raising steam, and habitually consume 5 to 7lbs. of fuel per horse-power per hour. In practice no crane is ever continually at work, and during the periods of lowering, changing gear and stops, &c., the fuel continues to burn, and there is also the cost in fuel and labour of raising steam in the morning for the day's work.

It is customary among crane builders to construct the boilers of steam cranes a good deal smaller than would be necessary if the engines were in constant running ; the gain in pressure during the stops and changes mentioned compensating the loss of pressure during working, and the steam gauge is consequently constantly on the move. Now, against these figures we should have, in the case of a direct-driven dynamo, a better engine running with an earlier cut off, and also necessary steam more economically raised. The motor when the crane is standing wastes no power, and the dynamo may be shut down or started at short notice. The crane driver need pay no attention to the crane when standing idle, and he starts without delay in the morning, the power being derived from the shop boilers. There would thus appear to be a very decided economy in favour of the electric cranes, as against steam-driven machines. In the case of overhead travellers, there is the saving due to the absence of long square shafts running in movable bearings, and which, together with the cotton or wire ropes in rope-driven cranes, are kept constantly running even when the crane is out of use.

## THE DISTRIBUTION OF ELECTRICITY, WITH SPECIAL REFERENCE TO THE CHELSEA SYSTEM.*

BY MAJOR-GENERAL C. E. WEBBER.

Before the opening of the discussion, General Webber directed attention to several alterations which had been made in the Paper since it was read.

DISCUSSION (Authorised Abstract).

Mr. KAPP read a communication from Prof. S. P. Thompson, who said one of the most interesting parts of the Paper was that relating to continuous-current transformers. He had often urged the importance of this particular mode of transformation, and in a Paper read before the Physical Society three years ago had pointed out the properties of such machines. According to the theory there given the "coefficient of transformation" was the ratio of the number of windings, and was independent of the speed or the magnetism of the magnets. The effect of the resistance of the primary circuit on the potential difference at the terminals of the secondary was to virtually increase the resistance of the secondary, and if equal weight of copper be used in the two circuits the latter resistance is virtually doubled. Hence constant pressure at the terminals of the secondary can be obtained by supplying the primary from a suitable over-compounded dynamo. In the same Paper he showed that the mutual induction between the two windings reduced sparking to a minimum. He now inquired whether the results arrived at theoretically were confirmed in practice.

Prof. FORBES said most people who had only seen the diagram of the automatic arrangements considered them very complicated. Such had been his own impression, but on seeing the apparatus itself and watching its action, the impression faded away. The amount of attention required by the apparatus is immensely less than in any non-automatic system, and for this reason Mr. King deserved great praise. The installation of continuous-current transformers he considered very interesting, In the data given of the Wolverhampton machine, it stated that the efficiency was 92 per cent. at a load of 40,000 watts. It was not quite clear what was meant by this efficiency, whether it referred to the complete machine or only to the dynamo part of it, Prof. S. P. Thompson had said the E.M.F.s should be in the ratio of the windings, but this did not seem to hold in this machine for the turns were as 200 to 80, whereas the E.M.F.s were as 5 to 1. On these points he asked for explanations. General Webber, he said, had stated that it was not necessary to comply with two of the rules he (Prof. Forbes) had laid down in his Cantor Lectures of 1885. The first of these, viz., that each distributing box should be nearer the station than any lamp fed from it, was still debatable, for it is chiefly a question of copper, and where the distribution is purely at low pressure the rule is still an important one. In high-pressure systems, however, it is not essential, although, as a general rule, the principle is a right one. The second rule, that small groups of lamps should be fed by separate wires, he agreed was not necessary. On the question of frosted bulbs he entirely disagreed with General. Webber's statements, for they are essential to artistic lighting. In no case was it desirable that the naked filament should be seen by the eye Further, he considered that a room illuminated by frosted lamps appeared lighter than one fitted with clear ones, for the illumination is mainly estimated by contrast with the brightest thing present. The intense brightness of a naked filament thus causes other things to appear dark. Little, if any, light was necessarily lost by the use of frosted bulbs, and what was absorbed was due to the dirt which the frosting collects. General Webber's conclusion as to the use of 8 or 16 candle-lamps was one in which he could not concur. Much depended on the size and character of the room illuminated. No general impression was of any use in comparing illuminating power, and to make any satisfactory comparison, some definite test, such as the ease with which small type can be deciphered, must be made. Referring to the Board of Trade regulation respecting declaration of varying pressures at different parts of a system, he said this was not originated by the Board, but was granted on the application of the St. James' and Pall Company. If care be taken in designing the mains the actual pressure need never be less than the declared pressure. Difficulties, however, had occurred in America, owing to the mains not being laid along the shortest routes. Speaking of underground mains he said some method of drawing in the cables was very desirable, especially in a growing system, and thought the chief objection to the "layer and faggot" plan so largely used in New York was its great expense. Bitumen concrete was open to several objections, for it could not be considered an insulator, was not waterproof, and was rather liable to fracture ; the casing might thus fail to provide that protection which it is so desirable should be given to the cable. The Callender "solid system" of embedding cables in bitumen was not to be recommended, for after they are once laid the cables are practically inaccesible. Two such mains which he had recently tested at Bath gave insulation resistances of 30 and 40 ohms respectively. The apparatus in use at Bath for localising faults was, he said, very effective. It consists of a trolley carrying iron plates on which coils of wires connected with a telephone are wound. A varying current, such as produced by a Thomson-Houston Arc Lighting Dynamo, or by an alternator, is sent into the faulty line, and the trolley wheeled along the route. When a fault is passed, a distinct change occurs in the character of the sound emitted by the telephone. In conclusion, he regretted that the cost of the Chelsea system had not been given, for this would have added enormously to the interest of the Paper.

Mr. CROMPTON said the Paper should be one of extreme interest, for it described a system of distribution which is hitherto unique. It was the only complete system of storage on a large scale in which the cells were charged at high pressure and discharged at low presure. Three years ago, in a Paper read before the Institution, he he himself compared the merits of secondary battery transformers with the alternate-current system, and these pointed out the value of batteries. He then proposed to use accumulators in a modified way, viz., utilising them at the times of largest and of least demand. This proposal, he thought, showed considerable foresight, for almost all continental specifications now involve the same idea. Since that time he had prepared tables, showing what proportion of the demand could be economically supplied by batteries under various conditions, and in all cases this proportion is small. The Chelsea system, involving, as it does, a great number of cells, was necessarily very costly, and in his opinion the automatic apparatus was too complicated, and therefore liable to failure. He was disappointed at not finding a statement as to the cost of the system, for the time had now arrived when a comparison of statistics would benefit the whole industry. Part costs, and those of isolated tests, were of no use, and might be misleading ; the monthly bills were necessary to a correct understanding. The St. James' Company and his own had published their figures, and he hoped other companies would do the same. It was important to know both the cost of generating a unit at the terminals of the dynamo, and also what is lost in distribution. On the latter point General Webber says his loss is 28 per cent. Mr. Crompton thought this rather low, for if the accumulators were in perfect order he would expect a loss of 25 per cent. If, therefore, all the losses in switchboards, feeders,

* Paper read before the Institution of Electrical Engineers, January 22, 1891.

distributing mains, service lines, and meters only brought the loss to 28 per cent, General Webber's experience must be felicitous. On the question of underground mains Mr. Crompton said it was a marvel to him how General Webber had arrived at the cost of his (Mr. Crompton's) system, for if he had referred to the 1888 Paper he would have found figures differing widely from those given. In order that a comparison of actual costs might be made the following table was prepared. The bitumen casing he considered an excellent device, and was not at all sure that it was not the best where it can be got in. Probably it would outlast wrought iron pipes. Pipes, however, could be preserved by serving them with jute or yarn and soaking in bitumen. Whilst acknowledging the value of the casing he must qualify it by saying that Callender cable was not the best to use with the casing. Good india-rubber cable gave excellent results. The table shows the culvert system is the cheaper for ordinary sized mains wherever it can be put in; the cost there given cannot be reduced. Referring to the circular issued by the London Chamber of Commerce, which General Webber had criticised, Mr. Crompton said it was circulated with the object of obtaining other peoples' opinions on the subjects dealt with. Considering the imperishable nature of the materials used in constructing culverts, and of the bare conductors themselves, 1 per cent. of the total cost would provide a respectable sum to cover depreciation and the repairs necessitated by wear and tear in withdrawing and inserting conductors. In fact, experienced persons whom he had consulted on the subject considered ½ per cent. sufficient. With covered cables, the depreciation and risk of injury were much greater, cases having occurred where, in attempting to withdraw a cable, the copper had been drawn out of the insulation. Taking all into consideration, he thought 5 per cent. was not too high, and on the whole he was inclined to believe that the covered, rather than the uncovered, system had heen favoured.

**TABLE** *showing the Cost per Yard of Underground Mains.*

| — | Extract from Tables I. and II. of Mr. Crompton's Paper of 1888. | | | | Webber, 1891. | | Crompton, 1891. | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | I. Callender. | | II. Culvert. | | | | Pipes. | | Culverts. | |
| Area of conductors | ½″ | ¼″ | ½″ | ¼″ | ½″ | ¼″ | ½″ | ¼″ | ½″ | ¼″ |
| Cost of callender casing, wrought iron pipes, or culverts ......... | 11/4 | 11/4 | 11/8 | 11/8 | 6/6 | 6/6 | 6/6 | 6/6 | 11/9 | 11/9 |
| Cost of surface boxes, 12 yards apart ......... ... | 2/3 | 2/3 | ... | | 2/3 | 2/3 | 1/11½ | 1/11½ | 1/11½ | 1/11½ |
| Cost of insulators and straining gear............... | ... | | 3/ | 3/ | ... | | ... | | /7½ | /7½ |
| Cost of cables ... | 31/7 | 15/9 | ... | | 31/ | 18/ | 31/ | 18/ | ... | |
| Cost of copper (bare)............ | ... | | 12/2 | 6/3 | ... | | ... | | 12/2 | 6/3 |
| Totals.............. | 45/2 | 29/4 | 26/10 | 20/11 | 29/9 | 26/9 | 29/5½ | 26/5½ | 26/6 | 20/7 |
| If high-class rubber cable be used (extra) ... | ... | | ... | | ... | | 10/4 | 2/8 | ... | |
| Totals.............. | ... | | ... | | ... | | 49/9½ | 29/1½ | ... | |

Mr. F. KING said he would have been pleased to hear more comments, adverse or otherwise, on the system of distribution described in General Webber's Paper. The probable life of secondary batteries was an important factor in the cost of such a system. In the Paper the positives were estimated to last three years, and the cells had now been in use about 18 months. During this period only 30 single plates out of 57,970 in use, had been supplied to Chelsea, and these had been required through accidents. On the subject of ultimate maintenance rate, he pointed out that in 1888 the E. P. S. Company guaranteed to maintain batteries for 12½ per cent. on the cost price and, judging from the experience gained at Chelsea, he looked forward to a fair margin of profit. If the positives only lasted three years this would mean 7·3 per cent., and if the negatives had a six years' life their cost will be 3·9 per cent., thus making a total of 11·2 per cent. He had reason to hope that both kinds of plates would last considerably longer than the times mentioned above. He was sorry that no remarks had been made on the regulation of pressure, for he believed the system described to be one of the most perfect ever used. The curves traced by the recording voltmeters, and shown in Figs. 13 and 13A, illustrate how good the regulation is. Continuous-current transformers could, he believed, be used as additional sub-stations, and if care be taken to connect the machine to separate feeders the pressure in the distributors could be kept within ½ or ⅜ of a volt. A considerable saving of copper in the mains can also be effected by arranging the transformer so that it supplies current at about one volt greater pressure during the period of greatest demand. In answer to Prof. Forbes' question about the transformation coefficient of the Wolverhampton transformer, he said the 200 turns on the primary was probably a misprint for 400.

Mr. W. HOWARD TASKER agreed with Prof. Forbes that the Callender cables he had recently tested at Bath were defective. In Chelsea, they had got much better insulation, one circuit carrying 3,000 lights showing a resistance of 20,000 ohms, and up to the present time there had been no occasion to withdraw any cable, excepting to put in larger ones. As regards meters, he said the Aron meters, of which 250 were in use at Chelsea, were very satisfactory. Referring to Fig. 10, he pointed out the remarkable increases of load during the last quarters of 1889 and 1890, whereas in the first quarter of 1890 the demand was fairly constant.

Mr. MORDEY, speaking of the fault finder described by Prof. Forbes, said Mr. Henry Sayers had successfully used the same arrangement at Oporto for two years, and he believed Mr. Spagnoletti had also employed a similar device. He was much interested in Mr. King's remarks about continuous-current transformers, and thought they might be of considerable use where long distances were involved. For short distances, however, the triple loss in the generating dynamo and in the primary and secondary of the continuous-current transformer would be serious, and in this connection he inquired the relative cost of working direct and by transformation. He was glad to see that converters had been employed, and he thought the Company would regret that they did not put stationary transformers in. Speaking of the life accumulators, he said the 12½ per cent. guarantee mentioned by Mr. King would be very nice, provided they could get it in a practical shape. When the Company were pressed on the point they rather hesitated, and would only undertake the maintenance under certain conditions, which were difficult for ordinary engineers to fulfil. Unfortunately, there were no men outside the Company's works skilful enough to look after the batteries in the way required.

GENERAL WEBBER, in his reply, said he could not answer Prof. Thompson's questions, for the transformers had only been worked at their full output. The perfect balance of the armatures is, however, an important feature in the machines. To Prof. Forbes' inquiry about the efficiency of the Wolverhampton transformer, he said he understood it to mean that of the whole machine. He said he could not agree with Prof. Forbes on the subject of frosted bulbs, for he was of opinion that the light should pass direct to the thing to be illuminated. On the other hand, the filament should not meet the eye, and the bulbs might be frosted on the portions seen. Such lamps had recently been made. As pointed out by Prof. Forbes, the Board of Trade regulation on the declaration of varying pressures is useful under certain conditions, but in a growing system it gives little or no relief. Its only use seems to be at the boundary of a district. On the subject of underground mains, he said that bitumen casing, although not an insulator, gives assistance to the insulation on the cables. The embedded cable at Bath he had only spoken of in connection with a high tension system, and in such cases their use was justifiable, for the amount of copper was so small that ample allowance could be made for increased demand. The figures he had given respecting the cost of Mr. Crompton's mains had been arrived at by careful estimates prepared by a surveyor and himself, which gave £130 as the cost of 100 yards. In the table given by Mr. Crompton it was hardly fair to put a pipe with a hole 1½in. diameter on the same footing as a 2in. or 2½in. way in a Callender-Webber casing, and if this were taken into account the difference in cost would be rather the other way. This difference would not be large for ordinary sized mains, and as he had pointed out on page 19, bare copper conductors were cheaper when the section exceeded 1½in. Speaking of the cost of the Chelsea system, he said it would be unfair to give figures relating to the initiation of a new system for difficulties and expenses; such as those connected with experimental foundations for machinery, &c., would give a false impression as to the real working cost. He had, however, given figures for the boiler efficiency, and the losses in generation, conversion, and distribution, together with the cost of coal per unit sold, and these, he thought, were the important things. In reply to Mr. Mordey's remarks, he said the system of conversion was not nearly identical with the system with which Mr. Mordey is connected. The real point which determines the system it is best to adopt is the density of supply, but the conditions are so variable that it is difficult to lay down any rules. The question as to how far apart the distributing stations for a given district should be placed, and in what way this depends on the size of copper to be laid down, still awaits an answer, and when this is forthcoming some useful data will have been arrived at.

## PHYSICAL SOCIETY.

The annual general meeting was held on February 13, 1891, Prof. A. W. Reinold, F.R.S, Past President, in the chair.

The reports of the Council and treasurer were read and approved. From the former it appears that there has been a satisfactory increase in the number of members, and in the average attendance at the meetings. During the year a translation of Prof. Van der Waal's memoir on "The Continuity of the Liquid and Gaseous States of Matter" has been issued to members, and it is hoped that the translation of Volte's works now in hand will be published before the next general meeting. The Council regret the loss by death of Mr. W. H. Snell and Mr. W. Lant-Carpenter, and obituary notices of these late members accompany the report. The treasurer's statement shows that the financial condition of the Society is very satisfactory, and that the sales of the Society's publications have increased considerably.

After the usual votes of thanks the following gentlemen were declared duly elected to form the new Council: President, Prof. W. E. Ayrton, F.R.S.; Vice-Presidents, Dr. E. Atkinson, Walter Baily, M.A., Prof. O. T. Lodge, D.Sc., F.R.S., Prof. S. P. Thompson, D.Sc.; secretaries, Prof. J. Perry, F.R.S., T. H. Blakesley, M.A., M.Inst.C.E.; treasurer, Prof. A. W. Rücker, M.A., F.R.S.; demonstrator, C. V. Boys, F.R.S.; other members of Council, Shelford Bidwell, M.A., LL.B., F.R.S., W. H. Coffin, Major-

Digitized by Google

General E. R. Festing, R.E., F.R.S., Prof. G. F. Fitzgerald, M A., F.R.S., Prof. J. V. Jones, M.A., Rev. F. J. Smith, M.A., Prof. W. Stroud, D.Sc., H. Tomlinson, B.A., F.R.S., G. M. Whipple, D.Sc , James Wimshurst.

The meeting was resolved into an ordinary science meeting, and Messrs. W. Thorp, B.Sc., G. W. Yule, and S. Joyce were elected members of the Society.

A Paper on the "Change in the Absorption Spectrum of Cobalt Glass produced by Heat," by Sir John Conroy, Bart., M.A., was read by Mr. Blakesley.

Prof. Minchin showed some experiments in illustration of his Paper on "Photo-Electricity," read at the previous meeting. In one of these, a seleno-aluminium battery, illuminated by the light of a taper, deflected an electrometer needle, thereby actuating a relay and ringing a bell. He afterwards exhibited one of his "impulsion cells" in action, and showed the change from the insensitive to the sensitive state produced by a Hertz oscillator at a distance.

DISCUSSION.

In the discussion, Mr. TUNZELMANN said Kalischer and Von Uljanin had worked at the same subject, the former being the first to make experiments on a photo-E.M.F. in selenium. His cells were made by winding brass wires on glass tubes and coating them with selenium, which was subsequently annealed. These cells lost their power after some time, and could not respond to feeble lights. By using two wires of different metals we obtained better results. Fritts, in 1883, used brass and gold plates coated with selenium, and Uljanin employed platinum plates deposited so thin as to be transparent. The latter experimenter found that the E.M.F. was proportional to the square root of the intensity of the light. He also observed that the orange-yellow of the prismatic spectrum produced the greater effect, whereas the yellow-green and the green rays of the diffraction spectrum gave the maximum E.M.F. Comparing these results with Langley's observations on the energy of the spectrum, it would appear that the E.M.F. bears no relation to the maximum energy falling on the surfaces. Speaking of the cause of the phenomena, he said the electrolytic dea of Von Uljanin seemed inapplicable to Prof. Minchin's results, and he inquired whether a mixture of selenium and aluminium would undergo a gradual change by exposure to light.

Dr. GLADSTONE said such a change, if it occurred, would be very slow, for nearly all difficult chemical reactions take time to complete. The fading of colours was adduced as an instance of slow chemical change produced by light.

Dr. WALLER thought the subject might throw light on the changes occurring in the retina, and asked if it was possible to separate thermo-electric and photo-chemical effects?

Dr. BURTON said he had suggested that the action of light on the retina was a photo-chemical one, some time ago. But hitherto it had been difficult to obtain substances sensitive to any but the blue and violet rays, whereas the eye was most sensitive to green and yellow light. In the photo-electric batteries, however, the E.M.F. may generate a current, and therefore energy, and the important question seemed to be, where does this energy come from? Is it a chemical change, precipitated by the action of light, or does a direct conversion of light into electric energy occur?

Prof. MINCHIN, in his reply, said he thought his cells really transformed the incident energy. They were usually kept on open circuit, and there appeared to be no deterioration with time, the only change being a sluggishness in developing their maximum E.M.F.

## ALLOYS FOR RESISTANCE COILS.

BY DR. K. FEUSSNER AND DR. ST. LINDECK.

As is well known for the purpose of electrical resistance coils for exact measurements, it is best to use alloys and not pure metals, owing to the large increase of resistance that takes place in the latter when their temperature is raised. For pure metals this increase generally amounts to ·004 for each degree Cent., whilst for most alloys it is considerably less; in German silver, for instance, an alloy of 4 of copper, 2 of zinc, and 1 of nickel, it is only about one-tenth as large.

A series of tests have been conduced by the authors on various materials with the view of determining their applicability for this object. Some of the results for eight different wires are given in the annexed table. As will be seen, this contains first a statement of the constitution of the various wires (in the cases of the first six as determined from analysis at the Government laboratory, for the other two from the manufacturers' certificates), the specific resistance in microhms per cubic centimetre, and the temperature coefficient.

Column I. gives figures for the German silver, ordinarily used for resistance coils by Messrs. Siemens & Halske. Under various conditions this wire shows remarkable changes in its resistance, and such changes tend almost always towards an increase. When the wire is coiled its resistance increases, and the smaller the coil, the greater the increase. Where the diameter of the coil is ten times the diameter of the wire, the increase amounts to ·01 of the original value. After coiling, and when the layers are undisturbed, the resistance still goes on increasing, but at a continually diminishing rate. During the first eight days after winding, the increase amounted to ·0003. Warming the wire for the first time to a temperature of 40deg. Cent. generally increases its resistance by ·0004 of its value. After a long continued heating to a high temperature the effect of a subsequent heating became less noticeable, but never entirely disappeared. Generally the resistance of such wires never becomes quite constant, the variation sometimes amounting to ·0001 in a few days.

| — | I. German silver. | II. Obermaier's Nickelin A diar. 1 0 mm. | III. Obermaier's Nickelin B diar. 0·1 mm. | IV. Rheotan | V. Patent Nickel A diar. 0·6 mm. | VI. Patent Nickel B diar. 1·0 mm. | VII. Manganese Copper | VIII. Nickel Manganese Copper |
|---|---|---|---|---|---|---|---|---|
| Copper ...... | 60·10 | 61·63 | 54·57 | 53·38 | 74·41 | 74·71 | 70 | 73 |
| Zinc .......... | 25·37 | 19 67 | 20·44 | 16·89 | 0·23 | 0·52 | — | — |
| Tin .......... | — | — | — | — | — | Trace. | — | — |
| Nickel ........ | 14·03 | 18·46 | 24·48 | 25·31 | 25·10 | 25·14 | — | 3 |
| Iron ........ | 0·30 | 0·24 | 0·64 | 4·46 | 0·42 | 0·70 | — | — |
| Cobalt ........ | Trace. | 0·19 | — | — | Trace. | Trace. | — | — |
| Manganese.... | Trace. | 0 18 | 0·27 | 0·37 | 0·13 | 0·17 | 30 | 24 |
| | 99·86 | 100·37 | 100·40 | 100 31 | 100·29 | 100·24 | | |
| Spec. resistance | 30·0 | 33·2 | 44·8 | 52 5 | 34·2 | 32·8 | 100·6 | 47·7 |
| Temp. co-effic't | 0·00036 | 0·00030 | 0·00033 | 0·00041 | 0·00019 | 0·00021 | 0·00004 | -0·00003 |

For exact measurements a wire of such properties is very unsuitable. What is wanted is an alloy, as far as possible, free from this variability, and also possessed of a low temperature coefficient. First nickelin, which has lately often been used, was tested. The results obtained from two varieties of this wire, as made by Herr Obermaier of Nuremburg, are given in columns II. and III. Chemical analysis shows that they are virtually German silver with somewhat increased proportions of nickel, and that they can therefore hardly justify their claim to a special name. Their resistance is, however, higher, and their temperature coefficient lower than that of ordinary German silver. Tested for constancy of resistance they showed an improvement on German silver, though the above-mentioned faults still existed.

In the fourth column are given the results obtained with Dr. Geitner's "rheotan," a wire lately brought out specially for resistance coils. Chemically it differs from the nickelin of column III. only in the replacement of 4 per cent. of zinc with iron. Its high temperature coefficient makes it less suitable for resistance coils than nickelin. At the same time, from its chemical composition, it can hardly be expected to give much better results with regard to constancy, but owing to our not having any wire of convenient thickness at hand we cannot give the results of experiments on this point.

To explain the continuous alteration in resistance of the above wires, it must be pointed out that the operations of casting, drawing, &c., always produce a tendency towards a crystalline structure. We conjectured, therefore, that the variability of the resistance depended upon the presence of zinc, which is easily crystallisable, and we accordingly looked for an alloy of nickel and copper or nickel and silver only. Whilst still thus engaged, we obtained from Messrs. Siemens and Halske a resistance-coil with the extremely low temperature coefficient of ·00017. By the courtesy of these gentlemen we learnt that the wire of which it was made was obtained from Messrs. Basse and Selve, of Altena, and we received samples thereof for testing bearing the label "patent nickel." Columns V. and VI. give the results obtained for wires of two different thicknesses, the analysis showing that no metals other than copper and nickel were present to any appreciable extent. Tests were carried out as to the constancy of their resistance, exactly as was done with the German silver and nickelin wires. On being wound, the resistance rose as in the former case, though to only half the extent, and on being left to itself for a few days, the resistance of the coil returned to its orignal value, which never happened with the others. On being heated the resistance fell, but a coil which had once been heated for some hours to 150 degrees showed no permanent alterations after subsequent heatings to 100 degrees, and is at present perfectly constant.

On the general behaviour of wires with regard to changes in their resistance we have arrived at the following conclusion. By all mechanical operations, including the winding of coils, the substance of wire is subjected to stresses which harden it and raise its electrical resistance. By a subsequent heating the former condition may be gradually restored, as in the case of annealing. Moreover, in the case of German silver and nickelin wires a gradual change towards the crystalline state or a crystallising out of certain constituents is always going on, and through this the

From the *Zeitschrift für Instrument-Runde*.

Digitized by Google

electrical resistance slowly increases. Under the influence of heat this change goes on more rapidly. In alloys of nickel and copper, which are free from zinc, this tendency to change to the crystalline state does not exist, and, consequently, wires of this sort, after being heated to a certain temperature, possess a definite fixed resistance for any temperature below this.

So far as our observations therefore go, patent nickel is exceedingly well adapted for the construction of exact resistance coils. Its extremely low temperature coefficient is an additional advantage.

We also devoted attention to the manganese alloys lately brought out by the Isabellen factory near Dillenburg, particularly to those varieties which, according to Weston, possess a negative temperature coefficient. For the purposes of our examination we obtained pigs of alloy from the factory, and by means of a saw cut them into strips, which were then drawn into wire. The metal is very tough, and draws well, but sawing it is very difficult. Manganese copper (column VII. in the table) is steel-grey in colour, nickel manganese copper (column VIII.) being pale rose. Our chemical analysis of the two are not yet completed, and we, therefore, give the manufacturers' figures for their constitution. The specific resistances and temperature coefficients given can also only be regarded as preliminary. It, however, appears that the temperature coefficients are in both cases very small, whilst that of the second (column VIII.) is undoubtedly negative. Moreover, the extraordinarily high specific resistance of manganese copper is worthy of notice.

We have, therefore, to distinctly assert that alloys are to be found whose resistance decreases with an increase of temperature. It is obvious that these materials are of great importance in the manufacture of resistance coils, especially if by a combination of such materials a wire can be produced with a zero temperature coefficient. This and other interesting points we hope to be able to clear up on a future occasion.

## PARLIAMENTARY INTELLIGENCE.

### HOUSE OF COMMONS, Thursday, February 12th.

### Electric Railway Bills.

In the House of Commons on Thursday night, last week, on the order for the second reading of the Central London Railway Bill, Mr. T. H. BOLTON, who had a motion on the paper embodying an instruction to the Committee, stated that, as he had given notice of a similar instruction in the case of the South Kensington and Paddington Subway Bill, he would take the discussion upon the latter measure. The Central London Railway Bill, accordingly, was read a second time, and was remitted to a Special Committee.

On the motion for the second reading of the South Kensington and Paddington Subway Bill,

Mr. BAUMANN said before the Bill was read a second time, and before the House proceeded to discuss the proposed instruction, he desired to enter his protest against the promoters of this Bill in regard to the second reading. This Bill proposed to make a subterranean railway from Bishop's-road, Paddington, underneath Kensington-gardens, to a point behind the Albert Hall in the Exhibition-road, a part of London which was commonly known as South Kensington, although, as a matter of fact, the station was, he believed, in the parish of St. John, Westminster. This scheme raised a very important metropolitan question. Obviously this was a Bill which ought not to be sent to a Committee in haste. He thought without demur he should have been allowed to ascertain the feelings of the 60 metropolitan members, and to give London an opportunity of expressing its opinion upon this proposed invasion of Kensington-gardens. But not a day was conceded to him by the promoters. He had never previously experienced any difficulty in meeting with the promoters of private Bills and arranging for the date of the second reading. The London County Council and the Corporation of London were always most obliging in fixing a day which would suit the convenience of hon. gentlemen. The result of the tactics of the promoters of this Bill was that he had not had time to consult with the other metropolitan members, or to ascertain the feeling of London. He should like to know why the promoters of this Bill were so nervously anxious to force the Bill through the House in such a desperate hurry. Promoters of a genuine and popular scheme for the benefit of London, as a rule, invited discussion, and he was afraid the promoters of this Bill thought that the more it was looked at, the less it would be liked. He did not feel justified in attacking the Bill on its merits, but he made this protest in the hope of drawing attention to the fact that Kensington Gardens were to be tunnelled under and a station erected in the heart of the gardens for no other purpose than to put money into the coffers of the Albert Hall. He hoped before the third reading a sufficiently strong public feeling would be aroused to save Kensington Gardens from this fate, and prevent this iniquitous measure becoming law.

Mr. WHITMORE, as one of the promoters of the Bill, regretted that the hon. member had not had the opportunity of ascertaining the feeling of hon. members on this subject. He hoped the House would not interpose any obstacle to the further progress of the Bill as he believed the subway would not interfere in any way with Kensington Gardens. If should appear that any injury, real or sentimental, would accrue, he would join his hon. friend in opposing the Bill on the third reading.

Mr. COURTNEY said that, so far as he knew, the promoters of the Bill had done nothing unusual, and there was no justification for the attitude of Mr. Baumann.

After some further discussion, the Bill was read a second time.

Mr. T. H. BOLTON then moved: "That it be an instruction to the Committee to whom the South Kensington and Paddington Subway Bill is committed, that they consider the propriety of inserting clauses in the Bill requiring payment to the local authority of a royalty, or a share of the earnings of the subway, after fair interest on capital and working expenses have been provided for, as compensation for the right to tunnel under the public streets." He explained that while, as a matter of convenience, he raised this question on the present Bill, it applied equally to the London Central Railway Bill and other schemes involving the construction of tunnels which were likely to come before Parliament. The experiment of the first tunnel railway—that from London Bridge to Stockwell—had proved both an engineering and a financial success. The fact that it is was a success would lead the investing public to have confidence in schemes of this character and ample capital would be forthcoming to carry them out. In view of the many tunnel railways that were likely to spring up all over London the question raised in his amendment became one of very great importance in the interests of the public. The promoters of the Bill under consideration—the South Kensington and Paddington Subway Bill—proposed to make a tunnel under the public streets without the payment of compensation to anyone, and the proposition he was putting forward was that the public had a right to require some compensation for the user of the subsoil under the public street. He knew it would be suggested that the absolute freehold of the soil was not invested in any public body; but that was very much more a purely legal assertion than a statement of any practical value. The shadowy right of the landowner in the public road was hardly worth consideration alongside the right of the public. The public were for all practical purposes the owners of the roads. For the purpose of saving expense, a private company of capitalists came to Parliament and asked Parliament to give them legislative powers to use the subsoil of the road without paying anybody anything for it, and he affirmed that the public had not only a moral, but, to a very large extent, a legal, claim to consideration in connection with the making of these tunnels below the public streets. To require the company to make an actual money payment to the public would, of course, be to place a very heavy burden upon the promoters; but he suggested that it would be reasonable and fair to ask them to pay a royalty, or give to the public a share of the earnings after interest had been paid upon capital and the working expenses were defrayed. He did not believe that a provision of this kind would in any way seriously embarrass the company. He did not propose to order the Committee to put a clause of the kind he suggested into the Bill, but he wished the House to direct the Committee to consider the propriety of inserting such a clause.

Colonel MAKINS said the hon. member had enunciated an entirely new principle in dealing with companies, and he thought it rather hard that this particular company should be selected for the experiment. Powers were never granted by Parliament to any private company unless it was for the public benefit, and Parliament would take care that the public obtained benefit in one way or another. This Subway Company would be in the same position as gas, water, and tramway companies, and yet it had never been sought to make the public partners with these companies in their undertakings. All such companies were rated for the poor, and paid a very large sum into the coffers of the local authorities in the way of rating.

Mr. ESSLEMONT said no Committee would sanction this subway scheme, or any other scheme, unless they considered the project itself to be in the interest of the public, His friend proposed to give the public a share in the profits of a private company if that company was a success. If the company was not a success, however, the public would contribute nothing to the cost of the failure.

Mr. H. LAWSON trusted the promoters would see their way to accept the instruction in the interest of the public.

Mr. ISAACS objected to the proposed instruction, first on legal grounds; and, secondly, on the ground of equity. The subsoil of the roads was vested, not in the public authority, but in the owners of houses on either side. Omnibuses which actually used the surface of the roads were absolutely exempt from taxation, although omnibus companies, as a rule, paid large dividends. These omnibus companies did not even contribute to local taxation for the running of their omnibuses.

Mr. JAMES ROWLANDS pointed out that there was a difference between railway and omnibus companies. The former were granted a monopoly by Parliament, while it was open to any person to start a service of omnibuses upon the public roads. He did not think any reason had been given why the House should not pass this instruction. It was time to decide whether some lien ought not to be put upon these companies for the benefit of the community.

Mr. COURTNEY said Mr. Bolton had undoubtedly brought a very grave question under the notice of the House. There were many different forms in which the interests of the public might be protected in connection with schemes of this character. He would suggest that one form might be to give the public as cheap a service as possible by the new line. Parliament might insert a provision to the effect that when the project made profits to a certain extent the public should get the benefit in reduced fares.

Mr. WALTER JAMES thought the common-sense view was to look upon the promoters of such a scheme as this as the very best friends of the local authority, because unless new methods of locomotion, either underground or overhead, were carried out, the growing wants of the ever-

Digitized by Google

increasing population of the metropolis would compel the local authorities to make more streets.

Mr. BOLTON said that after the representations which had been made to him, and relying upon the Committee giving full consideration to the matter, he would not press his instruction.

The proposed instruction was accordingly withdrawn.

## AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *February* 7, 1891.

**Electrical Statistics.**—A very elaborate series of maps has just been issued by the Thomson-Houston Electric Company showing the location of all the electric light and electric railway plants in the United States, together with the system or systems in use in each place. These maps have been prepared from data collected from original sources by disinterested persons, and has been admirably done, involving, as it does, an enormous amount of work. The statistics of the different systems as gathered from these maps show that the Thomson-Houston system of electric lighting is in use in a very much larger number of plants than any other system in the United States. The following are the exact figures of the different systems as shown by the schedule :—

| | | | |
|---|---|---|---|
| Thomson-Houston | 666 | Excelsior | 25 |
| Westinghouse | 323 | Sperry | 24 |
| Edison | 202 | National | 16 |
| Brush | 199 | Remington | 4 |
| Fort Wayne | 144 | Eickemeyer | 2 |
| American | 67 | Hawkeye | 2 |
| Western Electric | 53 | Standard | 1 |
| United States | 51 | Hochhausen | 1 |
| Schuyler | 49 | Beard | 1 |
| Heisler | 49 | Knowles | 1 |
| Waterhouse | 41 | Mayo | 1 |
| Ball | 31 | Keith | 1 |
| Van Depoele | 31 | | |

Of electric railway plants there are ten distinct systems in use, having a total of 241 installations. The actual number as shown for each system is as follows :—

| | | | |
|---|---|---|---|
| Thomson-Houston | 103 | Short | 8 |
| Edison | 83 | Storage | 4 |
| United Electric Traction | 21 | Westinghouse | 3 |
| Van Depoele | 8 | Bentley-Knight | 1 |
| Rae | 8 | Underground Storage | 1 |

Considering the fact that the first Thomson-Houston electric road was put in operation about July 1st, 1888, its present showing is a remarkable one.

**The Westinghouse Company.**—The Westinghouse Company is very rapidly recovering from its financial difficulties, and this is a matter of congratulation for all who are in any way interested in the electrical business. The prospects are that in a short time the Company will be upon a sound financial basis. It continues to do an enormous business in electric lighting and electric railway installations. Although only three of its roads are yet in operation, a large number are under contract and in process of construction.

**Electric Welding in Canada.**—It is reported from Canada that the Canadian Edison Company, whose factory is now at Sherbrooke, Quebec, but which will soon be transferred to Peterborough, Ontario, has made a contract with the Thomson Electric Welding Company, by which the Edison Company agrees to build all the welding machinery for the Canadian trade.

## AUSTRALIAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

SYDNEY, *January* 4, 1891.

An event of great interest to the electrical world took place on January 1st, viz., the switching on of the electric light in the City of Newcastle, the second largest city in New South Wales. The Sydney Electric Light Company, who are the contractors for the plant, had until January 7th to complete their contract, but the local gas company's contract with the City Council expired on the 1st, and the gas company demanded £50 per week and a month's notice, or, in other words, asked £200 for lighting the streets for the seven days between the termination of their contract and the commencement of the new one with the Electric Company. This price the Council considered simply absurd for 400 lamps, and refused it. By working pretty well night and day the electric lighting contractors' representatives succeeded in lighting the major portion of the lights on New Year's night, the plant running smoothly from the first, and the light apparently giving great satisfaction. The main street is lighted by 22 arc lamps of the Brockie-Pell type slung from wire rope in the centre of the street, the effect being very good. These lamps are supplied with current from a Brush dynamo, driven by a Westinghouse engine. In the smaller streets are placed about 400 incandescent lamps of 25 candle-power run in series of 20, and the effect from these lamps is also good, and is a marked improvement on any incandescent street lighting yet seen here. The incandescent plant is on the Westinghouse alternating current-system, this being its first introduction into the Colonies, and consists of two 750 light alternators. The engines employed are of the Westinghouse compound type, and are supplied with steam from a battery of Babcock and Wilcox boilers. The whole plant is very complete, and reflects great credit on all concerned ; and it is to be hoped that the Sydney Electric Light Company will reap the benefit of having carried out such a first class piece of work.

## CORRESPONDENCE.

### ELECTRIC THEORIES—ETHER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR : I must say a few words in reply to the excellent letter of Prof. Silvanus P. Thompson, p. 464. The point about Ohm's law is not so "transcendental" as he thinks. Debates about mere words are idle, but what seems a mere verbal distinction may prove to involve important principles; just as a slight change of angle on a railway switch may involve an entirely different line of travel. I will show in due course what I mean in this instance, and it will be seen then that my meaning clears off a "time factor," which is involved in that of Prof. Thompson.

I see no objection to his definitions ; the words "in some way or other," are just the point at issue. I am rather doubtful, as to No. 4, whether the words "from the magnet" are permissible. The magnet may be a permanent one, which certainly transfers no energy from itself, and I imagine the same holds for an electro-magnet. I should be more disposed to say "by the agency of the magnet." The energy comes from elsewhere. As to No. 5 I quite accept the definition because it really involves my own contention, that the "primary circuit" is the true carrier of the energy.

I should greatly regret that anyone should imagine that my words implied that Prof. Thompson "shifted his ground" in any invidious sense. I am quite sure that he is, as I know I am myself, sincerely desirous to ascertain "what is truth ;" and would, as surely as I should, scorn any mere dialectic trap, or apparent victory. I merely meant that in the question he put me, p. 375, "with respect to the transfer of energy laterally through the medium, into or out of a conductor," he introduced a matter entirely different from that contained in his words quoted p. 406. I may add that my own words, p. 406, need modification by an added word "that they in no degree transmit the energy *directly* from the source ;" because they do so in the process called induction, as defined in proposition 5, p. 464.

As to the ether, we may ignore it in the discussion ; but none the less it is the real thing which always underlies the word "medium," as Sir W. Thomson says, when treating of Clark-Maxwell's doctrines as to the function of the medium, "it must be ether." However, I shall have nothing to say about it myself, unless as an element of the views I may have to define and oppose.

But I must remark that Mr. Burn's summary of my argument is not complete. I said it had no friction internal or external, and no retarding effect on ordinary matter traversing it. Certainly I do hold that "what has no gravitation can have no inertia," if after gravitation is introduced "or influence upon the motion of matter." I think my meaning is

Digitized by Google

much the same as Sir W. Thomson's when speaking of "a massless fluid; by massless I mean devoid of inertia." Nor am I alone in seeing these consequences and difficulties. Your own editorial article, Vol. XXII., p. 309, indicates the very same doubts.

The question you put, p. 444, "What kind of proof can Mr. Sprague give of the longitudinal theory which he upholds?" I will do my best to answer. It may be that neither theory is capable of experimental proof, though I doubt that; but there is the Euclidean mode of investigation open to us, ending in the phrase, "which is absurd."—Yours, &c.,

JOHN T. SPRAGUE.

## CHELMSFORD LIGHTING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Our attention has been called to a paragraph in your issue of the 13th inst., *re* Chelmsford lighting. As your paragraph, without further explanation, might lead your readers to suppose that the lighting by the arc lamps has been irregular and unsteady, we beg most emphatically to contradict this statement, and to inform you that the actual question which has been put to us by the Town Council has been the advisability of substituting incandescent lamps for certain arc lamps which are placed in narrow and winding streets, with a view to improving the distribution of the lighting in these streets.

The question is an interesting one in connection with the problem of town lighting, and is receiving our careful attention, but nothing has as yet been decided upon.—Yours, &c.,

February 17, 1891. CROMPTON AND CO. (LIMITED).

## MORE BOARD OF TRADE RULES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I notice that you state as comment on my letter of last week that the salary of the Electric Inspector of Liverpool is £150 per annum, may I be permitted to correct this figure, as the actual sum paid by the Corporation of this city in accordance with the advertisement in July, 1889, is £160 per annum I do not think it was ever proposed that the Liverpool Electric Supply Company (Limited) should pay the inspector's salary, though, it will be remembered, that in the draft order of 1889 the clause existed stipulating a payment of some £200 per annum to the local authority, which was afterwards eliminated from the Act of Parliament containing the said order.

You will, I think, consider this rather different from the suggestion made in your issue of the 13th inst.—Yours, &c.,

IN STATU PUPILLARI.

# TRADE NOTES AND NOTICES.

"THE ELECTRICIAN"
**ELECTRICAL TRADES' DIRECTORY & HANDBOOK for 1891**

The new edition of our well-known Directory and Handbook will be ready on Monday. The book consists of over 900 pages, and has entailed this year an exceptionally heavy amount of work. The HANDBOOK DIVISION contains a mass of most useful information. The DIRECTORY DIVISION consists of 430 pages, and contains a very carefully compiled Alphabetical and Classified List of Firms and Persons engaged in the Electrical and Allied Trades in all parts of the world. This Division has been corrected up to date, and the book is thoroughly reliable, the very numerous changes which take place at the beginning of the year being incorporated. By the aid of this Directory, makers of Electrical Machinery, Apparatus, Instruments, Fittings, Sundries, Novelties, and other goods, may safely communicate direct with probable customers without the annoyance and great expense consequent upon using books which are mere lists of Members of Scientific Societies repeated again and again. A large number of copies have been already subscribed for from the Colonies, the Continent, the United States, and other Foreign Countries, whilst at Home orders have been received from Local Authorities, Railway, Tramway, Mining, and other large Industrial Corporations, as well as from those for whom the Directory and Handbook is primarily compiled. The Colonial and Foreign Division will be found extensive and reliable. *Orders should be forwarded at once.*

TENDERS WANTED.—The Corporation of Bedford, having obtained a Provisional Order for supplying electricity in the borough, invite tenders for the public lighting, at a price per lamp. Tenders are to be sent to Mr. T. S. Porter, clerk to the urban sanitary authority, Bedford, by the 31st March. Further particulars will be found in our advertising columns.

—— We would remind our readers that tenders for the Glasgow Corporation electric lighting contract have to be in by Saturday, the 28th inst.

DISSOLUTION OF PARTNERSHIP.—Messrs. Wild and Lucraft, trading as the Torbay Cycle Company, 3, Victoria-street, Paignton, Devon, as cycle manufacturers and electrical engineers, have dissolved partnership.

REMOVAL NOTICE.—Messrs. Montagu J. Scott and Co. have removed from Jermyn-street to 134, Regent-street, London, W.

THE "NEW ERA" PENDULUM MOVEMENT.—This rather high-flown name has been given to a very simple pendulum indicator for electric bells. The pendulum principle, borrowed from the old mechanical bell, is worthy of more attention than is commonly paid to it, as such an indicator is much less likely to stick or get out of order than the drop or throw-back patterns. In the movement, of which a sample has been sent to us by the makers' (Messrs. Mix and Genest) representatives, the International Electric Company, a single magnet is riveted to a sheet-iron stamping, which forms a support for a light and freely-swinging pendulum.

## THE PATIN ALTERNATE-CURRENT ARC LAMP.

In June last the Paris municipal authorities had a series of tests carried out on various alternate-current arc lamps, and amongst the competing lamps was that of M. Patin, which excited considerable interest at the time owing to its simplicity and excellent performance.

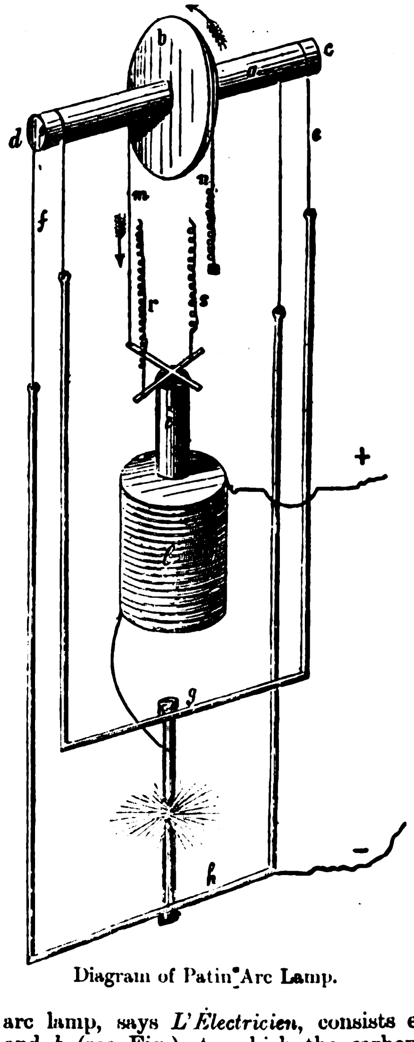



Diagram of Patin Arc Lamp.

The Patin arc lamp, says *L'Électricien*, consists essentially of two frames, *g* and *h* (see Fig.), to which the carbon-holders are attached, and which are joined together by the cords *e* and *f*. These cords are carried round the spindle *a* at the points *c* and *d*, the spindle having at its centre the pulley *b*. Round the groove of the pulley *b* runs the cord *m*, one end of which is attached to the core *i* of the solenoid 1 in the manner shown. The core *i* is also suspended by means of the springs *r* and *s*. The upper frame is sen-

Digitized by Google

sibly heavier than the lower, so that when left to themselves the carbons are in contact. The solenoid 1 is in series with the carbons, and when the current is switched on the core *i* is sucked down, striking the arc. As the arc lengthens and the current diminishes the core is released, and the force of gravity brings the carbons into proximity. These lamps can be made to run without much difficulty with a terminal pressure of only 40 volts. When running several lamps in parallel it is, however, advisable to introduce special regulating coils into each lamp circuit.

## PATENT RECORD.

### APPLICATIONS FOR PATENTS.

**Note.**—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

January 17, 1891.

1,672. W. T. Lord, London. Improvements in laying or running wires for electric lighting.

1,680. A. E. Tavernier, London. A new or improved process for the manufacture of wire for transmitting electric currents.

January 30, 1891.

1,741. H. Howard, London. Improvements in electric welding and in apparatus therefor.

January 31, 1891.

1,779. W. Hartnell, Leeds. Improvements in motors and dynamos for use in mines and other places.

1,788. M. Bailey, London. Improvements in the construction of battery elements.

1,804. G. F. Redfern, London. An improved arrangement of shunt for electric motors. (Wirth and Co., agents for W. Lahmeyer and Co., Germany.)

1,818. J. B. Winder, London. A new or improved preparation of soluble bichromates and sulphuric acid for use in charging voltaic batteries, and for other purposes.

February 2, 1891.

1,844. J. S. Lewis, Yardley. Arm or elbow rests for telephonic purposes.

1,905. L. B. Atkinson, London. An improved method of and means for distributing electric currents.

February 3, 1891.

1,908. D. Maxwell, London. Improvements in electric switches.

1,912. J. S. Lewis, Yardley. An improved galvanometer or instrument employed for measuring, indicating, or detecting electric currents.

1,913. J. S. Lewis, Yardley. An improved electric bell.

1,923. G. Binswanger, London. Improvements in electrical switches.

1,928. C. H. Demuth, Manchester. Improvements in the method of and means for increasing the strength, volume, or intensity of sound during transmission, applicable to telephones, microphones, phonographs, and other sound transmitting and emitting instruments and apparatus.

1,963. M. W. Dewey, London. Improvements in methods of and apparatus for electrically soldering cans and other sheet metal ware.

1,968. H. H. Lake, London. Improvements in and relating to electric lamps or lighting apparatus. (F. V. Macquaire, France.)

1,969. H. H. Lake, London. Improvements in electrical signalling apparatus. (S. J. Burrell, United States.)

1,987. A. M. Clark, London. Improvements in electric lamps. (J. W. Easton, United States.)

February 4, 1891.

1,994. G. Belt, Wolverhampton. An electric light lamp shade.

2,009. E. Berg, Berlin. Electrical thief and fire alarm.

2,010. E. Berg, Berlin. Improvements in signalizing telegraphs.

2,033. W. Lowrie and R. Hammond, London. Improvements in dynamo electric machines.

2,040. H. Müller, London. Improvements in switches for secondary batteries or accumulators.

2,045. R. R. Hutchinson, London. Electrical ore stamping and pulverizing apparatus.

2,046. R. R. Hutchinson, London. Improvements in and relating to electrically propelled vehicles, especially adapted for high rates of speed.

2,061. W. P. Thomson, Liverpool. Improvements in electric lamp holders. (J. B. Moore, United States.)

2,067. C. Baur and W. Dieselhorst, London. Improvements in electrical transformers.

2,081. C. A. Gisborne, London. Improvements in or relating to multiple circuit telegraphy. (D. H. Keeley, Canada.)

February 5, 1891.

2,115. J. Dean and C. Jubb, Halifax. Improvements in or connected with metallic gauze brushes employed in dynamo electric machine

2,152. J. C. Woodburn, Glasgow. Improvements in electric switches.

2,155. J. Nebel, London. Improvements in armatures for dynamo electric machines.

February 6, 1891.

2,180. G. T. Mackley, London. Improved means or appliance for fixing or driving staples or like devices, especially applicable to electrical fittings. (C. Mackley, Germany.)

2,199. G. W. Cox, F. Robinson, and W. H. Gritton, Liverpool. Improvements in automatic electric switches.

2,200. E. Attenborough, London. Improvements in or relating to electro-motors.

2,201. J. E. Spagnoletti, London. Improvements in laying and insulating underground mains for carrying electricity.

2,219. E. E. Lever, London. Improvements in electric arc lamps.

2,221. G. Edward and T. Edward, Glasgow. Improvements in and relating to machinery for covering telegraph and telephone cables and wires with lead or other metallic compounds, also applicable for the manufacture of metal pipes and the like.

February 7, 1891.

2,289. Siemens Bros. & Co., Limited, London. Electrical block signalling apparatus for single line railways. (Siemens & Halske, Germany.)

2,297. C. W. Hazeltine, London. A method of and apparatus for prolonging the life of the carbons in electric arc lamps. [Date applied for under Patents Act, 1883, Sec. 103, July 9th, 1890, being date of application in United States.]

February 9, 1891.

2,334. J. W. Eyre and C. Graham, London. Improvements in and relating to electrical communicators for use on public vehicles and the like.

February 10, 1891.

2,368. G. L. Anders and J. R. Shearer, London. An antiseptic mouthpiece for telephones, speaking tubes, and like purposes.

2,418. J. Matthews and G. B. Cruickshank, London. Improvements in electric accumulators or storage batteries.

2,431. J. A. Colquhoun, Liverpool. Improvements in safety appliances applicable with switches, fusible cut-outs, or other electrical circuit breakers, for the prevention of flashing or sparking across from one conducting part to another.

2,433. J. Perry, London. A continuous current transformer.

2,446. J. Y. Johnson, London. Improvements in or connected with means or apparatus employed in electrolysis. (G. D. Davis, United States).

February 11, 1891.

2,471. T. W. Bush and M. Doubleday, Bridgford. The manufacture of hydrolised lead cells for electrical or storage purposes.

### SPECIFICATIONS PUBLISHED.

1889.

20,486. Pritchett and Low. Distributing electricity. (Price 6d.)

1890.

911. Pitt (Atherton). Electrical conductors. (Price 8d.)

993. Edmundson and Clarke. Incandescence electric lamps. (Price 8d.)

1,031. Von Peichl. Electric compass, &c. (Price 8d.)

1,072. Binswanger. Electrical switches. (Price 6d.)

2,153. Dewar. Telephone switch boards. (Price 8d.)

2,491. Gritten and Parmley. Containing covering, &c., electric wires. (Price 8d.)

2,654. Kingsbury (Western Electric Company). Electric cables. (Price 8d.)

2,655. Kingsbury (Western Electric Company). Insulating electric wires. (Price 8d.)

2,659. Parsons. Electric arc lamps. (Price 8d.)

2,845. Mackerill. Secondary batteries. (Price 4d.)

3,028. Reignier. Dynamo electric, &c., machines. (Price 8d.)

3,660. McClellan. Connecting, &c., electric circuits. (Price 6d.)

3,913. Kapp and others. Alternate current transformers. (Price 8d.)

3,969. Siemens Bros. & Co. (Limited). Electric switch-boards. (Price 6d.)

4,053. Drake and Gorham. Safety devices for electrical currents. (Price 6d.)

4,275. Kingdon. Electrical switches.

7,670. Abel. (Société anonyme Continentale pour la fabrication des Compteurs à Gaz et autres appareils.) Electric meter. (Price 11d.)

13,557. Dixon. Secondary batteries. (Price 8d.)

13,904. Dewey. Electric railways. (Price 8d.)

16,570. Groswith. Electric motors. (Price 6d.)

18,470. Purdy. Telegraph keys. (Price 6d.)

18,638. Hartmann and Braun. Electricity meters. (Price 8d.)

18,699. Thomson and Von Kohler. Electric circuit closers. (Price 6d.)

19,155. Lake (Hatch). Electrical storage batteries. (Price 6d.)

19,744. Harness. Electric belts. (Price 6d.)

19,806. Marshall. Incandescent electric lamps. (Price 6d.)

20,019. Sabold. Electric railway circuits. (Price 6d.)

20,612 White. Incandescent electric lamps. (Price 6d.)

21,026. Berne and Fish. Electrical railway switches.

Digitized by Google

## BOOKS, &c., RECEIVED.

"Proceedings of the Royal Society," Vol. XLIX., No. 296. (London: Harrison and Sons.)

"A Dictionary of Metric and other useful Measures." By Latimer Clark. (London: E. and F. N. Spon.)

"Laxton's Price Book, 1891." (London: Kelly and Co.)

"A Treatise on the Law and Practice relating to Letters Patent for Inventions." By Robert Frost, B.Sc. (London: Stevens and Haynes.)

## COMPANIES' MEETINGS & REPORTS.

### India Rubber, Gutta Percha, and Telegraph Works Company (Limited).

The twenty-seventh ordinary general meeting of the Company was held yesterday at the Cannon-street Hotel, under the presidency of Mr. S. William Silver.

The SECRETARY (Mr. William J. Tyler) read the notice convening the meeting, and the report of the Directors and statement of accounts were taken as read.

The CHAIRMAN: In rising to move that the report be received and adopted, I would remark that since we last had the pleasure of meeting you the works have been well employed, and we have found ample requirements for our capital. The report in your hands shows the result to be very satisfactory, notwithstanding the keen competition met with in obtaining orders, and the prices of the raw materials having considerably advanced, which, as a matter of course, have affected the rate of profit. In the submarine telegraph cable branch we have manufactured during the year upwards of 2,000 miles, and I may remark that the item referred to under the head of "Cable on account of contracts," has just been successfully laid by our staff on board the "Silvertown," off the West Coast of S.A. The general trade has exceeded in amount any previous year, being over half a million. I am glad to say the prospects for this year are as satisfactory, and that we have several contracts in view. These remarks apply equally to "Persan" as to "Silvertown." I have, therefore, great pleasure in asking you to adopt the report, which recommends an addition being made to the reserve fund, as this supplies us with the sinews of war, in the absence of a considerable increase in the capital of the Company, the result of which would seriously affect the dividend, as it would increase the number of those who would share it with us. The freehold buildings and machinery have been maintained, and are in the highest state of efficiency. We have in our operations at Silvertown evidence that capital and labour when combined with judgment, and well-directed energy, can be made to render a fair return to the investor for his money, and a just remuneration to the employed. I have to move:—

*"That the report and accounts now presented be received and adopted, and that a dividend of 5 per cent. or 10s. per share free of income-tax, payable on and after the 20th inst. be now declared."*

Mr. NEIL BANNATYNE seconded the motion.

Mr. J. CARTER thought that the Directors ought to have paid a larger dividend, seeing that a similar company to their own—the Telegraph Construction and Maintenance Company— paid last year to its shareholders a dividend of 20 per cent., its £12 shares standing in the market at £46 to £48.

Mr. WEBBER said he entirely disapproved of the balance-sheet on similar grounds. The Company seemed to treat the shareholders in a most arbitrary sort of way in the matter of dividends. They carried forward a balance of £41,236, out of which they could have easily paid another 5 per cent. and have still carried forward a balance of £20,500. This year he found that £25,000 was carried to the reserve fund, bringing it up to £300,000, and he maintained that this amount, instead of being added to that fund, should have gone into the pockets of the shareholders.

Mr. TOINTON also supported this view.

The CHAIRMAN, in reply, said that it was a question for the shareholders themselves to decide, whether they would prefer to have the capital increased, and let their partners divide the profit with them, or to let the reserve fund stand as it did. It was as broad as it was long. He thought they could not have heard his remark about the general day-by-day trade which amounted to half a million.

Mr. WEBBER asked what had been laid out on the buildings account at Silvertown.

The CHAIRMAN replied that during last year about £14,000 or £15,000 had been spent on buildings and necessary extensions.

The motion was then put to the meeting and carried with five dissentients.

On the motion of the CHAIRMAN, seconded by Mr. A. W. JARVIS, the retiring Directors, Mr. Bannatyne and Mr. Henderson were re-elected to their seats at the Board.

Mr. BANNATYNE, in acknowledging his reappointment, said he had been for many years a large shareholder of the Company, besides being on the Directorate, and had studied its proceedings and history during that time, and he would just say, without going into a discussion of details which had been referred to by one or two speakers, who were opposed to the recommendation of the report, that one evidence of the increasing prosperity of the Company, and of the estimation in which it was held by the investing public, was its position on the Share List, which showed that the public appreciated its shares as an investment; and one of the elements in having obtained that position was no doubt the larger reserve fund, which was employed partly in keeping the business going and made the dividend so reliable. If they were to pay away any large portion of that fund, did anyone who knew anything about such companies suppose that the shares would occupy the same position on the market? He did not think so. He had great reason to be satisfied with the progress of the Company for many years and its present position and prospects.

Mr. HENDERSON having also acknowledged his re-election,

General TREVOR proposed and Mr. COCHRANE seconded the re-election of the auditor, Mr. J. Weise, which was agreed to.

A vote of thanks to the Chairman and Directors terminated the proceedings.

### Westminster Electric Supply Corporation, Limited.

The following is the report of the Board of Directors, to be presented to the shareholders at the fourth Ordinary General Meeting to be held at the offices of the Corporation, 32, Victoria-street, S.W., on Wednesday, the 25th inst., at 11 o'clock.

In submitting their report to the shareholders, the Board are pleased to be able to state that the business of the corporation is proceeding in a satisfactory manner. At the present time current is being supplied to the equivalent of about 12,000 lamps of eight candle-power, formal applications have been signed for about 17,000 more, and numerous inquiries continue to be made for the supply of current.

The central station in Millbank-street is now finished, and has been running continuously day and night since November 13, 1890. Current is being supplied from this station throughout the whole length of Victoria-street, in various parts of Pimlico, and also to the Houses of Parliament. The temporary station in Dacre-street is still supplying current to the western portion of the district as far as Belgrave-square and its neighbourhood.

PATENT
SILICIUM BRONZE AND SILICIUM COPPER WIRE.
The best for overhead Telephone and Telegraph Lines,
AND ALL ELECTRICAL PURPOSES.
Hard Drawn High Conductivity Copper Wire.
ROLLED AND DRAWN PHOSPHOR BRONZE.
PHOSPHOR BRONZE VULCAN PHOSPHOR DURO METAL
PHOSPHOR BRONZE BEARINGS, BUSHES, AND OTHER PARTS OF ELECTRICAL MACHINERY
*SOLE PROPRIETORS of the British, Indian and Colonial Patents,*
THE PHOSPHOR BRONZE COMPANY (Limited),
*87, Sumner Street, Southwark, London, S.E.*
WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

Digitized by Google

The two other permanent central stations of the Corporation, namely, those in Eccleston place, S.W., and in Davies street, W., have been greatly delayed by the severe frost, which practically rendered building operations impossible for two months. Great progress has however been made, and in both cases temporary buildings have been put up, covering a part of the engine and boiler room space, sufficient to allow of current being supplied while the building operations are being completed. Engines, dynamos, and boilers are now in place at each station, and Prof. Kennedy reports that these will be at work in the course of next month.

The work of laying the mains, like that of building, was seriously hampered by the severe weather. Notwithstanding this, since the work was started in February, 1890, mains have been laid along about 16 miles of roadway and these include a total length of about 75 miles of " ways " into which about 40 miles of copper have been drawn.

In consequence of the great and pressing demand for the supply of electric current, it has been necessary to proceed with greater rapidity than at first arranged with the laying of mains throughout the district. This has led to the calling up of the capital sooner than was anticipated, but will result in an earlier division of profit.

The Board have applied to Parliament for powers to supply electricity in the northern part of the parish of St. Margaret, Westminster, which was not included in the original Provisional Order. Many petitions for the admission of the low-tension system have been signed by residents in that district, and the decision of the Board of Trade is shortly expected. This area, comprising among others, Bridge-street, Parliament-street, Great George-street, Queen Anne's Gate, and part of Whitehall, can be supplied from the existing station in Millbank-street, and consequently if obtained will prove a valuable source of revenue.

To complete the works now in hand, and to provide for such new works as the Directors may consider desirable, they propose to obtain the consent of the shareholders to the issue of the balance of the authorised share capital, £85,235 in 17,C47 shares of £5 each.

## NEW COMPANIES REGISTERED.

**THE CITY OF LONDON ELECTRIC LIGHTING (PIONEER) COMPANY (LIMITED).**—Registered by Ashurst, Morris, Crisp, and Co., 17, Throgmorton-avenue, E.C., with a capital of £100,000 in £50 shares. Object: To carry into effect two agreements made with the Brush Electrical Engineering Company (Limited), and the Laing, Wharton, and Down Construction Syndicate (Limited), respectively, and to carry on in the City of London the business of an electric light Company in all its branches, electricians, mechanical engineers, suppliers of electricity for the purposes of light, heat, motive power, &c. The first subscribers are:—The Right Hon. J. Savory, Lord Mayor, His Grace the Duke of Marlborough, Blenheim, Woodstock, The Right Hon. the Earl of Suffolk and Berkshire, Charlton, Malmesbury, The Hon. A. Chatteris, 23, St. James'-place, J. B. Braithwaite, jun., 27, Austinfriars, E.C., J. C. Bull, Wilcote, Long Ditton-hill, Surbiton, C. Braithwaite, 27, Austinfriars, E.C. There shall not be less than three nor more than five Directors; the first shall be appointed by the subscribers to the Memorandum of Association. Qualification, £250. Remuneration, £1,000, divisible.

**SOCIETE D'ECLAIRAGE ELECTRIQUE DE CANNES.**—This Company has been formed in Lyons with a capital of 1,100,000fr., divided into 2,200 shares of 500fr. each, the object of the Company being to supply electric light and power in Cannes and neighbourhood.

## CITY NOTES, &c.

**BRAZILIAN SUBMARINE TELEGRAPH COMPANY.**—The receipts of this Company for the week ended February 13th amounted to £5,538.

**CITY AND SOUTH LONDON RAILWAY COMPANY.**—The receipts of this Company for the week ended February 14th amounted to £728.

**COMPANY PROMOTING.**—Some severe strictures upon company promotion will be found in our contemporary *The Sunday Times* for the 15th inst.—many of the companies dealt with being Electrical.

**PORTRUSH ELECTRIC TRAMWAY COMPANY.**—At the annual meeting of this Company on the 2nd inst. at Portrush, the report of the Directors was submitted, in which they report another large increase in the passenger traffic in the past year, the first-class having increased from 7,847 last year to 8,943, and the third-class from 56,822 last year to 73,859; the total passengers carried for the year being 82,802, with receipts £2,573 19s. 5d., against £2,038. 11s.7d. in 1889. Goods and mineral traffic amounted to 316 tons, against 323 tons in 1889, and the receipts to £41. 8s. 11d. against £37. 9s. 9d. Receipts for parcels and miscellaneous traffic have increased from £43. 8s. to £77. 7s., making the total receipts £2,698 15s. 4d., against £2,114. 9s. 4d. in 1889. There has been a reduction in expenditure compared with 1889 of £153. 18s. 9d. This leaves a credit for 1890 of £1,011. 3s. 4d., against £381. 18s. 7d. for 1889. The ratio of expenses to receipts, which was 82 per cent. in 1889, has been reduced to 62 per cent. for 1890. The expenses of the electrical working amounted to £272 for 20,884 miles run, or 3¼d. per mile, while steam power cost £707 for £11,286 miles run, or 15d. per mile. The favourable state of the revenue account is, the Directors state, therefore, largely owing to the increased use of electricity as the motive power upon the line, and a corresponding reduction in the use of steam. The total mileage run shows an increase of 1,288 over the previous year, the respective numbers being 32,170 and 30,882. The Directors charge the balance of £1,011. 3s. 4d. with interest at 4 per cent. on £10,000 of £11,500 for the construction of the branch line to the Giant's Causeway, and the net revenue account has, therefore, been charged with £400 interest on the above £10,000, and with £400 interest on the advance of £10,000 by the Board of Works. Mr. James Stewart Moore, of Ballydivity, has been appointed a Director, in place of Mr. Atkinson, deceased At the meeting Sir William Thomson, F.R.S., and Dr. Traill were reelected as Directors, and the proposals of the Directors were carried.

**WOODHOUSE AND RAWSON UNITED (LIMITED).**—A prospectus has been issued this week, asking the public to subscribe for a further 20,000 ordinary shares of £5 each (upon which, the prospectus states, there is no present intention of calling up more than £?. 10s. per share); 10,000 Preference shares of £5 each, entitled to a preference as to capital and to 7 per cent. preferential cumulative dividend per annum, together with a further 1 per cent. in every year in which the ordinary shares have received a dividend of 10 per cent. or upwards, and £100,000 Five and a-Half per Cent. 1891 Debenture Stock (part of a total issue of £2?0 000). The Five and a-Half per Cent. Debenture Stock is created partly to pay off the existing Six per Cent. Debentures, and partly to pay off the balance of the sum deposited with the Company as a Guarantee Fund. The Debenture Stock will, upon the existing Debentures being paid off, become a first charge upon the entire undertaking. The Debenture Stock is redeemable in 10 years at £105, being 5 per cent. premium, or at an earlier date (but at the same premium) if with the consent of two-thirds of the holders of the stock. The prices of issue for the ordinary shares is 5s. per share premium, and for the Preference Shares and Debenture Stock, par. The prospectus further informs intending subscribers that the objects of the issue are to provide capital for the constantly increasing business of the Company, and to carry out various additional proposals, including a contract for the lighting of a portion of the city of Paris, and further to enable the Directors to pay off the balance of the £75,000 deposited with the Company, which they can now do on advantageous terms. After setting out the dividends which have been paid, &c., one of the concluding paragraphs of the prospectus reads a follows:—"*To give some idea of the extent, and at the same time variety of the operations of the Company, a résumé of last year's work is enclosed with the prospectus, by which it will be seen that almost every kind of article connected with electricity is manufactured at the works of the Company, and in addition to which, as will be seen, important financial operations connected with electrical industries have been completed.*"

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY.**—The traffic receipts of this Company for the week ending February 13, 1891, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £4,493.


# THE NON-CONDUCTOR OF ELECTRICITY.

WAREHOUSE.

**VULCANISED FIBRE,**

PATENTED.

This new material is supplied in two qualities, Flexible and Hard.

The FLEXIBLE is a substitute for Leather, Rubber, Gutta Percha, &c., and is extensively used by Brass Finishers, Axle Makers, Hydraulic, Sanitary, and other Engineers, Pump Makers, Carriage Builders, &c.

It makes the best Hot and Cold Water Packings, and for Axle Washers of all kinds it is unequalled.

The HARD is a substitute for Metals, Hard Wood, Ivory, Vulcanite, Ebonite, &c., and is a good Insulator.

Sold in sheets, 5ft. 6in. by 3ft. 6in., varying in thickness from 1-50in. to 1in.

FACTORY.

FLEXIBLE, 2/- per lb.; HARD, 2/8 per lb.

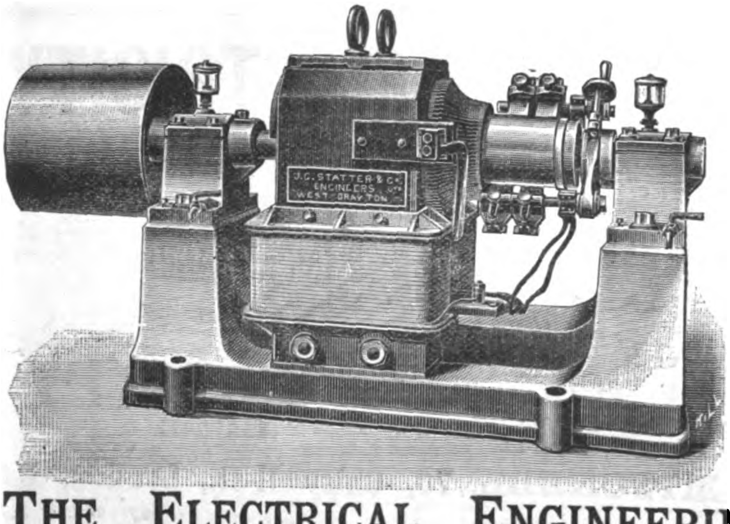
**MOSSES & MITCHELL, 70, Chiswell-st., London, E.C.**


Digitized by Google

## COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name. | Previous Week's Price, Feb. 11. | | Price Wednesday, Feb. 18. | | Rate per Cent. Yielded. £ s. d. | Dividend Due. | Business Done During Week Ending Feb. 18. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **TELEGRAPHS.** | | | | | | | | |
| £1,381,380 | Stock | 15/0 | Anglo-American ........................xd | 48½ | 49½ | 48 | 49 | 5 17 4 | Jan., Apr., July, Oct. | 48½ | 48 |
| £2,809,310 | Stock | 30/0 | Do. Preferred ........................xd | 86 | 87 | 84½ | 85½ | 6 14 6 | ,, ,, | 86 | 84½ |
| £2,809,310 | Stock | .. | Do. Deferred ........................ | 12¼ | 12¾ | 12 | 12½ | .. | .. | .. | .. |
| £250,000 | 100 | 4% | African Direct, Telegraph 4% Debentures ...... | 99 | 102 | 99 | 102 | 3 18 5 | January and July .. | 100 | .. |
| 130,000 | £10 | 3/0 | Brazilian Submarine ........................ | 11¾ | 12¼ | 11¾ | 12¼ | 6 2 5 | Mar., June, Oct., Dec. | 12 1/16 | 12 |
| £84,500 | £100 | 5% | Do. 5 per Cent. Bonds ........................ | 100 | 103 | 100 | 103 | 4 17 1 | January and July .. | .. | .. |
| £75,000 | £100 | 5% | Do. 5 per Cent. Bonds (2nd Series, 1906).... | 103 | 107 | 103 | 107 | 4 13 6 | June and December | .. | .. |
| $7,216,000 | $100 | 7% | Commercial Cable Capital Stock ................ | 104 | 106 | 107 | 109 | 5 19 3 | April and October .. | 108¼ | 106½ |
| 16,000 | 10 | 8/0 | Cuba Submarine ........................xd | 11 | 12 | 10½ | 11½ | 6 19 2 | February and August | .. | .. |
| 6,000 | 10 | 10% | Do. Preference 10% ........................ | 16½ | 17½ | 16 | 17 | 5 17 8 | ,, ,, | .. | .. |
| 12,931 | 5 | 2/4¾ | Direct Spanish (£4 paid) ........................ | 3¾ | 4¼ | 3¾ | 4¼ | .. | April and October.. | .. | .. |
| 6,000 | 5 | 10% | Do. Preference 10% ........................ | 9 | 10 | 9 | 10 | 5 0 0 | ,, ,, | .. | .. |
| 60,710 | 20 | 3/6 | Direct United States ........................ | 10⅛ | 10¾ | 10⅛ | 10⅜ | 6 15 0 | Jan., Apr., July, Oct. | 10⅜ | .. |
| 400,000 | 10 | 2/6 | Eastern ........................ | 14⅛ | 14⅜ | 14⅛ | 14⅜ | 4 10 5 | ,, ,, | 14⅜ | 14⅛ |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference ........................ | 15 | 15½ | 15 | 15½ | 3 17 5 | ,, ,, | 15⅛ | .. |
| £1,200,000 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock...... | 106 | 109 | 107 | 110 | 3 12 9 | May and November | 109 | 107½ |
| £200,000 | 100 | 5% | Do. 5 per Cent Debentures, 1899 .......... | 106 | 109 | 107 | 110 | 4 10 11 | February & August | 108½ | 108¼ |
| 250,000 | 10 | 2/6 | Eastern Extension ........................ | 14¾ | 15¼ | 14¾ | 15¼ | 4 11 10 | Jan., Apr., July, Oct. | 15⅛ | .. |
| £320,000 | 100 | 6% | Do. 6 per Cent. Debentures, 1891 .......... | .. | | .. | | .. | February & August | .. | .. |
| .. | £100 | .. | Do. 4 per Cent. Debentures Stock .......... | 105 | 107 | 105 | 107 | 3 14 9 | .. | .. | .. |
| £91,800 | 100 | 5% | Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900 .... | 102 | 105 | 103 | 106 | 4 14 4 | January and July .. | 105 | 104¾ |
| £145,300 | 100 | 5% | Eastern & S. African 5 per Cent. Mor. Deb., 1900.. | 102 | 105 | 103 | 106 | 4 14 4 | ,, ,, | .. | .. |
| 180,227 | 10 | 1/9 | Globe Telegraph and Trust ........................ | 9 | 9¼ | 9 | 9¼ | 5 5 6 | Jan., Apr., July, Oct. | 9¼ | 9 |
| 180,042 | 10 | 6% | Do. 6 per Cent. Preference ........................ | 14⅞ | 15⅛ | 14⅞ | 15⅛ | 3 19 4 | ,, ,, | 15⅛ | 14 15/16 |
| 150,000 | 10 | 5/0 | Great Northern ........................ | 16¾ | 17¼ | 16¾ | 17¼ | 4 6 11 | Jan., April, and July | 16⅞ | .. |
| £230,000 | 100 | 5% | Do. 5 per Cent. Debentures, 1883 .......... | 105 | 108 | 105 | 108 | 4 12 7 | March & September | 106¾ | .. |
| 17,000 | 25 | 12/6 | Indo-European ........................ | 36 | 38 | 36 | 38 | 6 11 7 | May and November | .. | .. |
| 38,348 | 10 | 4/0 | London Platino-Brazilian ........................ | 6½ | 7½ | 6½ | 7½ | 5 14 4 | ,, ,, | .. | .. |
| £100,000 | 100 | 6% | Do. 6 per Cent. Debentures ........................ | 108 | 111 | 108 | 111 | 5 8 1 | March & September | .. | .. |
| 9,000 | 8 | 4/0 | Reuter's ........................ | 8½ | 9 | 8½ | 9 | 5 11 1 | April and October.. | .. | .. |
| 3,381 | £100 Cert. | 6% | Submarine Cables Trust 6% ........................ | 112 | 115 | 113 | 117 | 5 2 7 | ,, ,, | .. | .. |
| 15,609 | 10 | 4/0 | West African Telegraph ........................ | 8 | 9 | 8 | 9 | 5 11 1 | January and July .. | .. | .. |
| £290,900 | 100 | 5% | Do. 5 per Cent. Debentures ........................ | 99 | 102 | 100 | 103 | 4 17 1 | March & September | 101½ | .. |
| 30,000 | 10 | 3/0 | West Coast of America ........................ | 2 | 4 | 2 | 4 | .. | January and July .. | 96 | .. |
| £150,000 | 100 | 8% | Do. Debentures 8% 1902 ........................ | 95 | 100 | 94 | 99 | .. | June and December | 95 | 94½ |
| 88,321 | 10 | .. | West India and Panama ........................ | 3⅛ | 3⅜ | 3⅛ | 3⅜ | .. | .. | 3⅜ | 3¼ |
| 34,563 | 10 | 6/0 | Do. 1st Preference 6% ........................ | 11¼ | 11¾ | 11¼ | 11¾ | 5 2 2 | May and November | 11⅝ | 11 3/16 |
| 4,669 | 10 | £3 | Do. 6 p. c. 2nd Pref. ........................ | 11 | 12 | 11 | 12 | 5 0 0 | ,, ,, | .. | .. |
| 64,174 | 15 | 6/0 | Western and Brazilian ........................ | 12¼ | 12¾ | 12¼ | 12¾ | 4 14 2 | ,, ,, | 12¾ | 12⅜ |
| 27,873 | 7½ | 6/0 | Do. 5 per Cent. Cumulative Preferred ...... | 6¾ | 7¼ | 6¾ | 7¼ | .. | — | 7 | 6⅞ |
| 27,873 | 7½ | 4/6 | Do. 5 per Cent. Deferred ........................ | 5½ | 6 | 5¼ | 5¾ | .. | .. | 5⅞ | 5 11/16 |
| £200,000 | 100 | 6% | Do. 6 per Cent. Debs., Series "A" 1910 .... | 103 | 106 | 103 | 106 | 5 13 2 | February & August | 103¾ | .. |
| £250,000 | 100 | 6% | Do. 6 per Cent. Mort. Debs., Series "B" 1910 | 103 | 106 | 103 | 106 | 5 13 2 | ,, ,, | 105 | 104 |
| $1,336,000 | $1,000 | 7% | Western Union 7 per Cent. 1st Mortgage ........ | 120 | 125 | 120 | 125 | 5 12 0 | May and November | .. | .. |
| £175,100 | £100 | 6% | Do, 6 per Cent. Sterling Bonds ............ | 99 | 103 | 99 | 103 | 5 16 0 | March & September | .. | .. |
| | | | **TELEPHONES.** | | | | | | | | |
| 224,850 | 14/0 | 0/4½ | Consolidated Telephone Const. & Maintenance. .. | 7/16 | 9/16 | 7/16 | 9/16 | .. | May and November | .. | .. |
| 220,000 | £1 | 3% | Oriental (11s. paid) ........................ | 3/16 | 5/16 | 3/16 | 7/16 | 5 5 9 | Yearly ............ | .. | .. |
| 438,984 | 5 | 2/6 | National ........................ | 4⅝ | 4⅞ | 4⅝ | 4⅞ | 5 12 10 | June and December | 4 13/16 | 4⅝ |
| 15,000 | 10 | 6/0 | Do. 6 per Cent. Cumulative 1st Pref. ...... | 12½ | 13 | 12½ | 13 | 4 12 4 | ,, ,, | 12¾ | .. |
| 15,000 | 10 | 4/9⅜ | Do. 6 per Cent. Cumulative 2nd Pref. (£8 pd) .. | 10 | 10½ | 10¼ | 10¾ | 4 9 7 | ,, ,, | .. | .. |
| 209,750 | 1 | ½% | South of England, Ordinary ........................ | ⅛ | ⅜ | ⅛ | ⅜ | .. | — | .. | .. |
| 20,000 | 5 | 2/1 | Do. 6 per Cent. Cumulative Pf. (£3 10s. pd) .. | 2¾ | 3¼ | 2¾ | 3¼ | 6 9 0 | .. | .. | .. |
| 58,000 | 5 | 1/0 | United River Plate ........................ | 3 | 4 | 3 | 4 | .. | January and July .. | .. | .. |
| £146,128 | Stock | 5% | Do. 5 per Cent. Debenture Stock .......... | 90 | 95 | 90 | 95 | 5 5 3 | .. | .. | .. |
| £3,200 | 100 | 7% | Do. 7 per Cent. Debentures ........................ | .. | | .. | | .. | — | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | | | |
| 200,000 | 5 | .. | London Electric Supply ........................ | 1⅜ | 1⅝ | 1¼ | 1¾ | .. | — | .. | .. |
| 43,900 | 10 | .. | Metropolitan Electric Supply (£8 paid) .......... | 7¾ | 8¼ | 7¾ | 8¼ | .. | — | 8 | 7⅞ |
| 42,853 | 5 | .. | Westminster Electric Supply (£3 paid) .......... | 3¾ | 4¼ | 3¾ | 4¼ | .. | — | 4⅛ | 4 |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | | | |
| 63,416 | 3 | .. | Brush Electrical Engineering ........................ | 2⅜ | 2⅝ | 2⅜ | 2⅝ | .. | .. | 2 9/16 | 2⅜ |
| 63,416 | 2 | 0/10 | Do. 6 per Cent. Preference ........................ | 1½ | 2 | 1½ | 2 | 6 0 0 | June and December | 2 | 1⅝ |
| 20,000 | 5 | 3/6 | Crompton and Co., 7 per Cent. Pref. Shares ...... | 5 | 5½ | 5 | 5½ | 6 7 3 | January and Jul .. | 4⅞ | .. |
| 17,139 | 5 | .. | Edison and Swan United ........................ | .. | | .. | | .. | .. | .. | .. |
| 45,000 | 10 | 6% | Electric Construction ........................ | 6¼ | 6¾ | 5½ | 6½ | .. | .. | .. | .. |
| 70,000 | 2 | 10/0 | Elmore's Patent Copper Depositing .............. | 6¾ | 4¼ | 3 | 3½ | .. | .. | 3½ | 2⅞ |
| 20,000 | 5 | .. | Fowler-Waring Cables (£4 paid) .............. | 2½ | 3½ | 2½ | 3½ | .. | .. | .. | .. |
| 41,600 | 10 | 10/0 | India Rubber, Gutta Percha & Telegraph Works... | 19 | 20 | 19 | 20 | 5 0 0 | February & August | 19⅝ | 19½ |
| £200,000 | 100 | 4½% | Do. 4½ per Cent. Debentures, 1896 .......... | 103 | 105 | 103 | 105 | 4 5 9 | March & September | .. | .. |
| 11,334 | £10 | 6/4 | International Okonite Limited Ordinary ........ | 9¼ | 9¾ | 9¼ | 9¾ | 10 4 7 | .. | .. | .. |
| 11,334 | £10 | 5/0 | Do. Preference ........................ | 9¼ | 9¾ | 9¼ | 9¾ | 8 4 1 | .. | .. | .. |
| 78,949 | 5 | 4/10½ | Swan United (£3. 10s. paid) ........................ | 4½ | 5 | 4½ | 5 | 6 19 10 | May and November | 4½ | .. |
| 37,350 | 12 | 12/0 | Telegraph Construction and Maintenance........ | 47 | 49 | 46 | 48 | 5 0 0 | March and July..... | 48½ | 47½ |
| £150,000 | 100 | 5% | Do. 5 per Cent. Bonds, red. 1894 ............ | 102 | 105 | 102 | 105 | 4 15 3 | January and July . | 103¼ | .. |
| | | | **RAILWAYS.** | | | | | | | | |
| 50,000 | £10 | .. | City and South London Railway ................ | 6 | 7 | 6 | 7 | .. | .. | .. | 6½ |


# IMPROVEMENTS IN DYNAMOS.



## STATTER-BRUNTON DYNAMO.

**The latest design in the market, made with all the advantages of the latest scientific knowledge and the highest mechanical skill.**

The woodcut represents our B TYPE DYNAMO. A most efficient machine, working noiselessly, and without sparking or overheating; is highly finished and well proportioned. The output is so rated in our Catalogue that the machines may be worked very much in excess of their stated full output for short periods.

**STOCK SIZES UP TO 77 KILOWATTS.**
**MACHINES BUILT TO 500 KILOWATTS.**

**THE ELECTRICAL ENGINEERING CORPORATION, LIMITED,**
[STATTER'S] [UNITED]
**68, Victoria Street, London, S.W.**
WORKS:—ALLIANCE ENGINEERING WORKS, WEST DRAYTON, NEAR LONDON.

# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 667.—Vol. XXVI. FRIDAY, FEBRUARY 27, 1891. Price Fourpence.

## NOTES.

The election of Dr. Oliver Lodge as President of Section A, for the British Association Meeting at Cardiff, will be hailed with satisfaction on other grounds than his attainments in physical and mathematical science. Dr. Lodge is fully alive to the many shortcomings of the Association. He realises the very unsatisfactory arrangements of the meetings, which greatly diminish the usefulness of the Association both by failing to attract many of the leading men of the day, and by wearying those who do attend. The "root and branch" reformers stay away altogether, and the duty of reorganising the Association in accordance with modern requirements consequently devolves upon such men as the President of Section A.

The letters which appear in our Correspondence columns, with reference to the Barking-road cars speak for themselves as far as the misunderstanding is concerned; and, as we expected, the figures upon which we commented in our last issue were neither official nor taken from the very latest returns. We hope that Mr. Kapp's suggestion that their mere withdrawal will not be so effective as the substitution of correct figures will elicit the true facts. The latest corrected figures will prove the more interesting by comparison with the results of the earlier stages of the work.

The report of the Committee appointed to make recommendations with regard to the electric lighting of the proposed Chicago Exhibition, an abstract of which will be found in another column, contains some figures of interest. The complete publicity which ought to be given in the details of exhibition lighting should afford much useful information as to the economy of various methods of illumination. Unfortunately for us in this country, it is suggested that the tower system, which has often been tried and is far from popular, should again be used. We say unfortunately, because the experience gained with this mode of lighting in the clear air of Chicago can be of little service to an English engineer, particularly to one who has to provide for the lighting of London. When the sun itself cannot succeed in penetrating our fogs for days together, it is unadvisable to place a lamp more than eighteen feet from the ground. But it is not proposed, in the present case, to erect the enormous structures that have been frequently designed and occasionally tried in America, the height of 75 ft. being suggested as the best elevation.

The report of the Chicago committee, asserts, as if it were a well-known fact, that for the best effect, the height of the lamp should be seven-tenths of the radius of the area to be illuminated by it. The study of the distribution of illumination has been very much neglected, and the literature of the subject is very meagre, but we cannot admit that there is any *best* ratio between the height of a lamp and the radius of the area which it lights. The closer the lamps are placed the more uniform is the illumination, and the greater will be the expense. Considering the outermost ray in the present case, the angle of incidence is 55deg., being that angle whose cotangent is ·7. The illumination on the ground is proportional to the cube of the cosine of the angle of incidence, the maximum under the lamp being unity, supposing there is no shadow. The illumination is, therefore, ·1885 of the maximum, and if the light from the other lamps fall on the same spot, the value will be about ·4 of the maximum, that is, the variation of the illumination will be about 60 per cent.

It is proposed to place arcs of 2,000 candle-power 40ft. from the ground and 122ft. apart. Assuming that the lamps really give a mean light of 2,000 candles, the maximum illumination below the lamp would be 14 bougie-metres or deci-luces, or equivalent to one candle at ·895ft., or to $1\frac{1}{4}$ candle at one foot. It is also proposed to place eight arc lamps on the 75ft. towers. With the above candle power, the maximum illumination would be equal to one candle at ·593ft. or 2·85 candles at one foot, that is 32 bougie-metres, or more than two and a-quarter times that of the first case. Since 500 candles at 75ft. distance give an illumination on a plane facing the light equivalent to one bougie-metre, it is evident that 7,000 candles, instead of 16,000 candles, on the 75ft. tower would give the same illumination as the 2,000 candle arc at a height of 40ft.

It is very satisfactory to find that our recent article on Indoor Illumination has called forth some reply, but the letters which will be found in our correspondence columns come from writers who imagine that they have been attacked. We admit that the Brockie-Pell arc lamp, to which, at all events, one of our correspondents evidently alludes, is the nearest approach to perfection, and we have seen the General Post Office sorting rooms, and in describing the lighting there, remarked (*Electrician*, January 30, page 398) that these lamps "run with their usual perfect steadiness." But, on the one hand, the Brockie-Pell lamp has not yet driven all

Digitized by Google

other lamps out of the field; had it done so, in speaking of arc lighting one would, of course, be speaking of no other make. On the other hand, the article alluded to treated more of domestic lighting than of the large buildings. If we were to admit that in each and all of the cases mentioned by "B. P." the lighting could not be improved upon, we should still maintain that at present, average arc lighting would not be suitable, for example, in the reading-room of a club or for any domestic purposes.

ANOTHER letter over well-known initials is very amusing, but is less easy to understand, containing as it does several obscure allusions to chocolate and green colours, which do not appear to refer to the tints of lamp shades, but are connected in some way with candidates and corporations. Allegorical designs are often admirably adapted to cover up lamp holders and wires; but such allegorical language as that used by our correspondent somewhat obscures his meaning. The article in question was of a mildly suggestive character, and contained but a dozen lines about arcs, and those were introductory to the question of dazzling. Fittings were dealt with in only three lines, and the words "glaring copper and ormolu" may have brought down this tirade. A bold criticism of the design of electric light fittings, their gradual development from gas brackets turned upside down, and the massiveness of style and exuberance of ornament which drove people of quiet taste to simple pendants, would be of more interest than use. Let the eye be pleased and deceived, by all means. The use of ground glass lamps for decorative purposes was not condemned; a scientific dictum only was combated. But the gist of the correspondence is that if Brockie-Pell lamps were more generally used, arc lighting would be more satisfactory, and that in the opinion of a gentleman of considerable experience the "artistic and charming effects" have "been brought to such perfection" that no "artistic genius" need further trouble himself "to make electric lighting comfortable and beautiful." He is thoroughly justified in being satisfied with his own work; but a little more originality in arrangement, distribution, and diffusion of light for domestic purposes is what was suggested; and no amount of pretty metal work tacked on to the lamp and its wires will make it more comfortable, and will only contribute in a secondary sort of way to its beauty.

THE sparking distance between conductors under high voltage has of late assumed a considerable degree of importance. The numerous experiments which have been made in this direction cannot, unfortunately, be compared together, since so many different sources of electrification have been used. SNOW HARRIS used Leyden jars; SPOTTISWOODE, a large induction coil with a De Meritens alternate current dynamo; and GORDON, a coil with 10 Grove's cells, but in these experiments it was impossible to estimate the voltage. Sir W. THOMSON and DE LA RUE obviated this difficulty by using merely a series of batteries, the former measuring the volts by an electrometer, the latter relying, with very good approximation, on the number of cells employed. The battery method eliminates all the uncertainties which may be caused by the undulatory or intermittent current and the abrupt changes and discontinuity of the pressure; but the results are not of much use as a guide to those who have to deal with the high voltage of alternate-current supply. Some very careful measurements are now being conducted by able experimenters, and their arrangements are of a thoroughly practical kind; in the meantime, we give in another column an abstract of a paper by Mr. SHAND describing Prof. ELIHU THOMSON's recent measurements. The curves do not exhibit that regularity which might be expected, and more information should have been given about the details of the pointed electrodes, for DE LA RUE found that a terminal of a paraboloidal shape gave a distinctly smaller spark length than a sharp point, and it is clear that the shape must therefore be a matter of some importance. A full account of Mr. DE LA RUE's researches was reproduced in the *Electrician*, vol. ix., from the *Proceedings* of the Royal Institution; the shape of the paraboloidal point is shown on page 103 of that volume. A flat plate opposed to a slightly convex plate has been used by other experimenters, the convexity being only just sufficient to localise the spark.

IN the February number of the *Philosophical Magazine* appear some noteworthy measurements, by Mr. BLATTNER, of the energy efficiency of glow lamps. The energy imparted to the lamp was measured electrically in the ordinary way, and also by calorimeter. Two calorimeters were used, one opaque to both light and heat, the other having glass sides transparent to the light rays. The latter measured all the energy given out by the lamp, except that corresponding with the light emitted; and by comparison of the measurements made with the two instruments it was possible to deduce the energy efficiency, or the ratio of the energy given out in light rays to the total energy given to the lamp. This ratio has been determined by the thermopile method by various experimenters in England and America, and is generally believed to be about 5 per cent. for the glow lamp, and 10 per cent. for the arc. According to Mr. Blattner, the percentage is slightly less than five for the Swan lamp and a little over six for Edison and Bernstein lamps, when these are run at normal brightness. The calorimeter method can hardly be a very accurate one, owing to the many sources of error, and to the difficulty of the measurements, but in the present instance it appears to have yielded good results, and observations have been made of the energy efficiency of the same lamp at several different candle-powers. The light efficiency increases more rapidly than the energy supplied to the lamp, but not nearly so quickly as the candle-power. Thus a 16 candle-power Edison lamp had an optical efficiency of 3·6 per cent. at four candles, and one of 8·5 per cent. at 28·7 candles. While the candle-power increased over seven times, the optical efficiency increased 2·4 times, and the watts supplied to the lamp increased 1·9 times. The optical efficiency increases with the temperature, and may, in the case of a much over-run glow lamp, become as high as 10 per cent., but it must not be supposed that any simple relation connects its value with the ratio between candle-power and the watts absorbed. The change in the character of the light as the voltage is increased would alone be sufficient to prevent any simple law from being true,

Digitized by Google

The results, although of great interest, must be accepted with some caution, as the figures given for the energy supplied to each lamp at the rated candle-power are far too high for glow lamps run at normal brightness, and would seem to show either that the measurements are erroneous in some particular, or that the lamps used were not of modern type.

Although many eminent men of science have vexed themselves over the question whether the lines of force caused by a magnet do, or do not, rotate with it as it revolves, no one, as far as we are aware, has suggested a crucial experiment capable of deciding the matter. This task has been attempted by Mr. Tolver Preston, who, in the February number of the *Philosophical Magazine*, proposes to rotate a cylindrical magnet near a metal disc placed perpendicular to the axis of revolution. If the lines rotate with the magnet the disc will become charged to a higher potential at the edges than at the centre, owing to its behaviour as a disc dynamo. If, however, the field remains fixed while the magnet revolves, the poles will become charged to a higher potential than the middle portion, owing to the tendency to induce currents through the magnet itself. This polar charge will act by ordinary static induction on the disc, the two faces of which will exhibit electricities of opposite kind. Tests made with a delicate electrometer of the electrical state of the disc should therefore decide between the two hypotheses. Unfortunately the experiment can only be made by those who have very delicate apparatus at command, as it appears that otherwise very high velocities of revolution are necessary to produce the effects predicted; but the attempt should be made owing to the great theoretical interest attaching to the question. Perhaps the fact is that the rotation of the lines takes place in accordance with some law of least action. When little waste of energy can take place by the production of induced currents in adjacent bodies, the lines may revolve with the magnet, but otherwise they may remain fixed in space while the magnet turns.

Those of our readers who are able to be present at the meeting of the Physical Society this afternoon will find their attention well repaid, as a glance at the list of Papers announced will show that they are all of interest to electrical engineers. We would also direct attention to the fact that Prof. Fleming will on Friday, March 6th, deliver a lecture at the Royal Institution on "Electro-magnetic Repulsion."

**Newport (Mon.)**.—The Town Council have decided to apply for a Provisional Order.

**Sunderland**.—At a special meeting of the Town Council last week it was resolved to apply for a Provisional Order.

**Mica**.—A great mass of mica is stated to have been discovered in the mountains of British Columbia, near the head of the Tête Jaune Pass.

**Obituary**.—Mr. Walter Glover's numerous friends will regret to hear of his bereavement in the death of his wife, which occurred on the 23rd instant.

**Electrical Bills in Parliament**.—The House of Commons Select Committee which will consider the Central London and City and South London Railway Bills, consists of Mr. Hanbury (chairman), Mr. Halley Stewart, Mr. Barran, and Sir Archibald Campbell.

**Athens**.—The Athens central lighting station continues to extend its operations. At the present moment it has nearly 4,000 incandescents and more than 130 arcs connected up.

**Royal Society**.—Yesterday, the Croonian Lecture, by Mr. F. Gotch and Prof. Victor Horsley, F.R.S., on "The Mammalian Nervous System, its Functions and their Localisation determined by an Electrical Method," was delivered.

**Village Lighting.—A Correction**.—Bernstein's Elektricitätswerke inform us that the lighting of Lockstedt, to which we referred on p. 473 of our last issue, has been entrusted to them and not to the Thomson-Houston International Electric Company, as there stated.

**Madrid**.—We learn that the electric lighting of the Senado (corresponding to our House of Lords), which is supplied with current from the mains of the Electricity Supply Company for Spain, was on Wednesday night inspected by the Queen and suite. The Queen expressed her great satisfaction at the illumination.

**Anglo-American Telegraph Company**.—We are informed that this Company has opened branch offices at Hay's Wharf, Tooley-street, and at 46, Mark-lane, for the reception of telegrams to the United States of America, &c. It is stated that offices will also shortly be opened in Edinburgh, Leith, Dundee, Bradford, and Newcastle-on-Tyne.

**The Telephone in India**.—At Cawnpore the Telegraph Department will shortly complete their new telephone exchange, and it is intended to open an exchange at Mandalay. In Calcutta the Bengal Telephone Company report that on December 31, 1890, 437 exchange and private lines were at work, yielding a revenue of Rs. 76,400.

**Popular Science Lectures**.—The following science lectures will be given at the Royal Victoria Hall, Waterloo Bridge-road, S.E., during March:—3rd, Prof. Marshall Ward on "A Piece of Wood, its Origin, Structure, and Uses;" 10th, Mr. J. E. Flower on "Spain;" 17th, Mr. A. W. Clayden on "Thunderstorms;" 24th, Prof. Roger Smith on "St. Paul's."

**Brighton**.—At a meeting of the Lighting Committee of the Town Council a letter was read from the Board of Trade, requesting to be furnished with a detailed description of the system by means of which it is proposed to supply electrical energy under the Brighton Electric Lighting Order, 1883. It was also resolved that instructions to electrical fitters should be printed for circulation.

**The Electrical Standards Committee**.—The following members of the Electrical Standards Committee were present at the meeting held at the Board of Trade on Friday last:—Mr. Courtenay Boyle, Major Cardew, Mr. Graves, Mr. Preece, Sir William Thomson, Lord Rayleigh, Prof. G. Carey Foster, Mr. R. F. Glazebrook, Dr. John Hopkinson, and Prof. Ayrton. Mr. R. E. Crompton, Dr. Fleming, and Dr. Alexander Muirhead attended and gave evidence.

**Technical Instruction**.—A short Bill relating to technical instruction has been introduced by Sir Henry Roscoe, M.P. It proposes to enable a local authority to make such provision in aid of the technical or manual instruction for the time being supplied in a school or institution outside its district as may, in its opinion, be necessary for the requirements of the district in cases where similar provision cannot be so advantageously made, by aiding a school or institution within its district.

**Birmingham**.—The Public Works Committee of the Town Council, having ascertained that Mr. Henry Lea, of Messrs. Lea and Thornbery, is willing to discharge the duties of electric inspector for twelve months at a salary of £150, recommend that he should be appointed. The committee report that they are conferring with Mr. Lea as to the position of the testing station, and the fees to be prescribed as the fees to be taken by the inspector, and by him paid to the credit of the borough rate.

**British Association**.—The following have been appointed to preside over the sections at the Cardiff meeting of the British Association in August next:—A—Mathematics and Physics, Prof. O. J. Lodge, F.R.S.; B—Chemistry, Prof. Roberts-Austen, F.R.S.; C—Geology, Prof. Rupert Jones, F.R.S.; D—Biology, Mr. Francis Darwin, F.R.S.; E—Geography, Mr. E. G. Ravenstein, F.R.G.S.; F—Economics, Rev. Dr. W. Cunning-

Digitized by Google

ham; G—Mechanical Science, Mr. T. Forster Brown, M.Inst.C.E.; H—Anthropology, Prof. Max Müller.

**Liverpool.**—The Lighting Committee of the Liverpool Corporation at their meeting on the 9th inst. had before them a proposition to appoint a general assistant to the electric inspector. This is due to the rapid increase in the amount of electric testing and inspectional work carried out by this department, which has followed upon the extended operations of the Liverpool Electric Supply Company. Mr. H. J. Roscoe was unanimously appointed. Mr. Roscoe was, till his appointment, in the employ of the Liverpool Electric Supply Company.

**The Sable Island Cable Scheme.**—Our readers will remember that at the end of 1890 an article appeared in *The Electrician* calling the attention of the Imperial and Canadian Governments to the many advantages to shipping which would ensue by the laying of a cable between Sable Island and Halifax. We are pleased to learn that the Canadian Administration have included in the Estimates placed before the Council a sufficient sum for the purchase and laying of the cable.

**Personal.**—The Secretary of State for the Postal Administration of the German Empire, Dr. Von Stephan, attained on January 7th his 60th birthday. Amongst the congratulations and souvenirs which he received on the occasion was a photograph of H.M. the Emperor William II., mounted in gilt bronze and bearing in His Majesty's own hand the following inscription:—"At the end of the 19th century the world finds itself dominated by systems of intercommunication which break down the barriers separating peoples and bind together the nations in new relationships."

**The City and South London Railway.**—According to Mr. Stephen D. Field, a weak point in the London underground electric road is the placing of the armatures on the wheel axles of the locomotives. "Running at a speed of 20 miles an hour, the blow delivered on the wheel, axle, and armature by passing over so much as a grain of sand is equivalent to the blow of a large steam trip hammer." In the absence of any proof of this remarkable statement, and of the presence of any sand in the tunnel, the direct driving of these locomotives is still to be regarded as one of the most important steps that has been made in electrical traction.

**The St. James' and Pall Mall Company.**—The following extracts from the report of the Directors of this Company for 1890 may be of interest. The full report will be found in another column. At the beginning of 1890 the Company had the equivalent of 4,460 eight candle-power lamps connected, on December 31, 1890, this number had risen to 26,500, and it is now 30,000. During the year nearly £12,300 was received for current supplied, which at 7d. per unit means an output of close upon 422,000 Board of Trade units. The total expenses amount to 60 per cent. of the gross receipts, the expenses of generation and distribution amounting only to 42·4 per cent.

**Electric Cranes.**—In the abstract of Mr. Bolton's Paper on this subject in our last issue, the loss by transmission was, by error, put at 2 per cent. instead of 1 per cent. It is probable, however, that it would seldom pay to put down conductors of so large dimensions. The author sends us a further portion of the summary of his Paper, in which he observes that as to first cost, an electric crane of equal power may be made at same cost as a steam crane, the saving of the engine and boiler balancing the value of the motor, which is somewhat high. There is no raising of steam, which would be derived from the shop boilers in most cases; and where the power is taken from the mains it is always ready.

**The Electric Discharge through Rarefied Gases.**—At a recent meeting of the Cambridge Philosophical Society, a Paper was read by Prof. J. J. Thomson on the electric discharge through rarefied gases without electrodes. A vacuum tube was exhibited, in which an electric discharge was induced by passing the discharge of Leyden jars through a thread of mercury contained in a glass tube coiled four times along it. The induced discharge was found to be confined to the part of the vacuum tube which was close to the primary discharge, and it did not show striæ. It was also demonstrated that an ordinary striated discharge is strikingly impeded by the presence of a strong field of magnetic force.

**Hull.**—At a recent meeting of the Electric Lighting Committee of the Hull Corporation, the report of a deputation which visited Bradford was read and adopted. The document stated that the Town Clerk of Bradford informed the deputation that the installation of the electric light in Bradford had been an unqualified success; and that they had never looked back with regret on a single circumstance connected with their adventure. The deputation viewed the central lighting station at Bradford, and other places where the electric light is used. From all they saw and heard, they were convinced that the electric light was "the light of the future," and that its supply should be undertaken by the Corporation; but they were unwilling to say with certainty, until they have had further opportunities of inspection, which system was the safest, most effective, and economical.

**Jubilee of the Chemical Society.**—A meeting in celebration of the jubilee of the Chemical Society took place on Tuesday afternoon at Burlington House. Dr. Russell, the president of the Society, occupied the chair, and among those present were Prof. M. Foster, Lord Rayleigh, M. Gautier, M. Combes, M. Haller, and M. de Clermont, representing the Société Chimique de Paris; Professor Will, representing the Deutsche Chemische Gesellschaft; Dr. Holtz, representing the Verein zur Wahrung Chemische Industrie; Prof. V. Meyer (Heidelberg), Sir Henry Roscoe, Sir William Grove, Sir F. A. Abel, Prof. Frankland, Prof. Odling, Mr. Crookes, Sir Lyon Playfair, M.P., Dr. Müller, Prof. Thorpe, Dr. James Bell, Prof. Dewar, Prof. Meldola, and Dr. Armstrong. On Wednesday evening the members of this Society dined together at the Hotel Métropôle, the Marquis of Salisbury proposing the toast of "Prosperity to the Chemical Society."

**The Hodges Lightning Protector.**—Ever since the delivery of the "Mann Lectures," in the spring of 1888, the revived interest in lightning phenomena which these now famous lectures gave rise to has resulted in an abnormal inventive activity in this direction. One of the latest devices we have seen is that due to a Mr. Nathaniel D. C. Hodges, who breaks the metallic continuity of his lightning rod by the interposition in the path of the discharge of a box of soot placed some six or eight feet up in the air above the roof of the building to be protected. According to Mr. Nathaniel D. C. Hodges, "as soon as the electricity enters a substance of this structure, its particles fly apart, some or all of them being charged, and the potential is greatly reduced." This effect, of course, would depend largely upon the quantity of soot employed; but a cubic foot, Mr. Nathaniel D. C. Hodges asserts, will probably be found sufficient for all ordinary cases.

**Electricity and Fires.**—In the annual report to the Fire Underwriters' Association Chief Inspector McDevitt, of Philadelphia, says that there are over 5,000 buildings in Philadelphia in which electric currents are used for light and power purposes. Of this number 287 buildings have their own apparatus, varying in size from a 20-light installation to one of 4,000 lights. The number of lights furnished by these private plants aggregates 80,258 incandescent and 3,325 arc lights. There are 15 central stations. The number of lights supplied by these stations varies from 2,000 to over 40,000. The electric motors in use are of a capacity ranging from one-eighth to 30 horse-power, and are being rapidly introduced as a more ready motor in place of steam and hydraulic power in propelling machinery. The report concludes as follows:—"No insurance loss occurred in any building in our city during the past year from fire where the cause could be in any way attributed to electric wires."

**The Telegraph in Times of Agitation.**—In 1850, when the question of allowing the public to use the telegraph was being discussed in the Assemblée Nationale, one of the many objections urged against this step was, says *La Lumière Electrique*, the serious consequences to public order that might result from the use of this rapid means of intercommunication for ensuring simultaneous risings. The Government's reply was that the system, being in the hands of the properly constituted authorities, it would more likely be a powerful defence to them. Recent events in Chili and Portugal are confirmatory of this view. In Chili none but Governmental news has succeeded in passing along the wires. In Portugal the failure of the rising at

Digitized by Google

Oporto was due to the fact that the leaders of the conspiracy were short-sighted enough to despatch a number of exactly similar telegrams as a signal. The authorities, suspicious at hearing that so many sick men would not last the night, stopped the messages.

**Electrostatic Measuring Instruments.**—There would seem to be, says *Industries*, some kind of prejudice against the use of electrostatic measuring instruments. Generally, in an alternating-current station, we find the high-pressure leads connected to transformers reducing to 100 volts or so, and a hot-wire voltmeter employed to read by. The transformer takes, say, 30 watts, probably more, and the voltmeter another 30. This means 500 kilowatt hours per annum wasted. At 2½d. this comes to £5 a year, which is the interest on from £50 to £100. A laboratory electrometer was used in electric engineering by Joubert in 1881, and others have been used occasionally since by Profs. Ayrton and Perry, Ryan and Monnier. Sir William Thomson has, however, introduced a number of electrostatic instruments, reading from 100 volts upwards, and engineers who use them do not revert to electro-magnetic or hot-wire voltmeters. Electrostatic instruments not only take no power, but have no temperature errors, and do not need corrections for frequency, and no doubt they will eventually be cheaper than other forms.

**The Electric Lighting of the City.**—At the meeting of the Commissioners of Sewers on Tuesday, the Streets Committee laid before the Commission a letter from the Board of Trade intimating that they were satisfied that the Brush Electrical Engineering Company was in a position to discharge the duties and obligations imposed upon it by the City of London (Brush) Electric Lighting Order, 1890. Mr. Morton, M.P., asked whether the Commission were dealing with the two companies with whom they had contracted in regard to the electric lighting of the City or with the company of which the Lord Mayor was chairman. The chairman said that, as he understood the matter, they had nothing whatever to do with the latter company. At a later stage in the proceedings a letter was read, headed "City of London (East District) Electric Lighting," from the Board of Trade, enclosing the copy of a letter they had received from the Laing, Wharton, and Down Construction Syndicate, on the subject of the syndicate, in view of the provisions of Clause 7 of the order. The letter stated that the Board of Trade, as at present advised, were unable to express themselves as satisfied with the financial position of the undertakers to whom it was proposed to refer the undertakings. The Board of Trade expressed a wish to hear the views of the Commissioners on the subject.

**A New Use for the Hair Pin.**—Under this title a letter appears in an evening paper of yesterday, describing a somewhat dangerous expedient. Dangerous, because fuses generally melt on account of a short circuit which might give rise to fire if not protected by a proper cut-out, and a hair-pin can hardly be considered as such:—"Sir, some unkind people occasionally compare the electric light to a 'red-hot hair-pin,' and no doubt all respectable hair-pins have felt hurt at such language; but now, in a spirit of true Christian revenge, a hair-pin has come to the aid of the electric light. At a dance given recently at a private house in London part of the electric lights suddenly went out, to the consternation of the guests, who, perhaps, may have considered it a judgment upon them; for I regret to add that this dance took place in Lent. It appeared on examination that one of the 'safety fuses' had 'gone.' An electrical young man was present, however, who, borrowing a humble patient hair-pin from some fair neighbour, inserted it in place of the fuse, and turned on the light again. I venture to suggest that the least that electrical engineers can do in return is to adopt 'a hair-pin, gules, proper,' as their crest. If you wish it, I can produce the hair-pin—not necessarily for publication, but as a guarantee of authenticity.—I am, Sir, your obedient servant, A Humble Student."

**University College and King's College Extension Funds.**—A meeting in support of these funds was held at the Mansion House on Monday. The chair was taken by the Lord Mayor, and there were present the Bishop of London, Lord Reay, Sir A. Rollit, Sir Gabriel Stokes, Sir R. Fowler, the President of University College, and the Principal of King's College. The following resolutions were moved by the Bishop of London, Lord Reay, and the President of University College respectively:—1. "That it is essential to the welfare and dignity of a great metropolis like London that its institutions for University teaching should be maintained at the highest standard and in the utmost efficiency." 2. "That University College and King's College, the two institutions recognised by the Government as University colleges in London, have deserved well of this city, and merit liberal support in the interests of the vast population of London." 3. "That a committee be formed, under the presidency of the Right Hon. the Lord Mayor, to receive subscriptions in support of the extension funds of the two colleges, consisting of the committee of the University College Extension Fund, under the chairmanship of Lord Reay, and of such governors and other members of the council of King's College, under the chairmanship of the Bishop of London, as the Bishop may appoint." Among the speakers were Sir Robert Fowler, Mr. B. L. Cohen, Mr. W. H. Preece, and Mr. S. Hill, who reminded the meeting that the professors of University College had for a long time surrendered a large portion of their fees for the maintenance of University College Hospital.

**The Regulation of Factories and Workshops.**—The following are some of the more important features of the Factories and Workshops Bill just introduced by the Government. The distinguishing proposal of the Bill is the establishment of "special rules." Where the Home Secretary certifies that any machinery or process used in a factory, or the state of the ventilation of a factory, is dangerous or injurious to health, or dangerous to life or limb, or that the provision for means of escape from a factory in case of fire is insufficient, the chief inspector may either serve on the occupier a notice proposing "special rules," or a notice requiring him to adopt such measures as appear necessary. In respect of safety, it is required that *every* hoist or teagle shall be securely fenced. Another requirement is that every factory, the construction of which is commenced after this year, must be provided on every story above the ground floor with a means of escape in case of fire, independent of the staircase or other way by which the workpeople usually enter or depart. With regard to accidents, the provision in section 31 of the Factory Act is that notice is to be given in certain cases where the accident "is of such a nature as to prevent the person injured by it from returning to his work in the factory or workshop within 48 hours after the occurrence of the accident." For this it is proposed in the Bill to substitute—where the accident "is of such a nature as to prevent the person injured by it from returning to his work in the factory or workshop and attending to it during a period of five working hours within three days after the occurrence of the accident."

**Barnsley Town Council and the Board of Trade.**—At the meeting of the Town Council on Tuesday the minutes of the Park and Lighting Committee were read. They contained the correspondence which had passed between the committee, the Board of Trade, and the Westinghouse Company, the general tenor of which was as follows:—The Board of Trade having on October 13th approved of the system proposed by the Council, on January 10th withdrew the approval, and asked the Corporation to provide underground mains instead of overhead wires. The Town Clerk pointed out that the change would entail an additional cost of £20,000 on the town; that a contract had been provisionally entered into with the Westinghouse Company, and that if the underground mains were insisted upon the town would not be lighted with the electric light. The Board of Trade replied that they would not decline to approve the proposed system in the present case, but hoped the Corporation would bear in mind the desirability of placing the wires underground. The correspondence with the Westinghouse Company simply amounted to the company throwing up their contract on financial grounds, and the committee recommended that no further negotiations should be entered into with that company. Alderman Blackburn moved the adoption of the minutes, and called attention to the fact that on January 10th the Board of Trade

Digitized by Google

disapproved of overhead wires, and on February 7th approved them. They must, before going further into the question, have informtion what course the Board of Trade would take in the future with regard to the matter; as if the underground wires were insisted upon the Barnsley Electric Lighting Act would be unexecuted, and remain a dead letter.

**An Experimental Storage Cell.**—In a recent issue of the *Electrical Engineer* of New York, Mr. H. E. Dey gives the following directions for making a storage cell for experimental purposes :—Out of a piece of $\frac{1}{16}$ sheet lead cut 21 pieces, each 4in. square, with a projecting lug for connection at one corner, $\frac{3}{4}$ of an inch in height and $\frac{1}{2}$in. wide. Procure 30 rubber bands $\frac{1}{8}$in. thick. Place three of these on each of 10 plates perpendicularly, one in the centre and one at each edge. These are to be the positive plates. Place all the plates together alternately, negative and positive, the bands separating them. Let the connections of one set be all on one side, and those of the other at the other side. Stretch a few bands around the plates, to clamp them together. Cut in a board, or mould in clay, two grooves $\frac{3}{4}$in. wide, $\frac{1}{2}$in. deep, 8in. long, and $2\frac{3}{4}$in. apart, placing one four inches in advance of the other. Stand the plates on end, so that the lugs form feet standing in the grooves. Pour into the groove very hot lead to a depth of $\frac{1}{4}$in. They are now ready to place in the acid. Take a jar containing about a quart of water, and pour in *very slowly*, stirring at the same time, two pounds of sulphuric acid, making it 1·2 specific gravity. Place the plates in a suitable jar, and after the acid is cool, pour in enough to cover them. Connect the intended positive plates with the positive wire of a suitable charging current. The charging pressure should be nearly three volts; consequently it will require two bichromate of potash cells in series. Charge and discharge often, and occasionally reverse the charging current, until it is found that the capacity does not increase. It will probably be about three ampere hours. See that the outside plates are negative with the final charge. The plates may be formed much more quickly by first soaking in a 50 per cent. solution of nitric acid for twenty-four hours. In this case it is advisable to use thicker lead. Rinse off before placing in the electrolyte.

**Sources of Trouble to Telegraphic Communications.**—The following, according to the *Revue Scientifique*, are some of the dangers to which telegraph poles abroad are exposed. The American representative of our European woodpecker, the green woodpecker of California, is, it seems, in the habit of installing its dwelling and its storage places for food in the interior of the red cedar poles that support the wires of the lines of the western United States. Colonel Clowry, an officer of the Western Union Telegraph Company, in a tour of inspection made by him in the far West, found that the summits of a large number of poles were deeply pierced by this bird. In Natal, a bird belonging to the family of the widow birds, seeing the number of tufted trees diminishing, has begun to suspend its nests from telegraph poles. In Brazil we come to a new source of trouble to telegraphic communications, brought about this time by representatives of the vegetable kingdom, the telegraph wires radiating around Rio Janeiro, being covered, it appears, with huge tufts of orchids hanging in festoons and garlands. Nearer home troubles of a different character occur, Thus, at Callahane Petty Sessions the other day, a man was convicted of stealing a telegraph pole, which he had converted into a mast for his fishing boat. In Belgium, the telegraph officials were for a long time troubled by the immense damage done to their lines by mischievous peasants, who freely indulged in the ancient art of stone throwing, using the white china insulators as a target. Prolonged investigation resulted in the evolution of an unobtrusive insulator. A similar difficulty was encountered by the Indo-European Company in its early days, the natives by dint of constant insulator potting becoming crack shots with whatever in that land takes the place of the rifle. European ingenuity has, however, also provided a remedy for this complaint. Overhead telegraph communications are, it will thus be seen, exposed to attacks of all sorts and descriptions.

**Subway Railway Schemes for New York.**—The inauguration of the City and South London Railway has given rise to a decided subway railway "boom" in New York. The Reno system, described in the *Electrical World* of New York of February, is a fair sample of the many which are now being brought forward. The idea of Mr. J. W. Reno is to run four tracks, arranged in two pairs, one above the other, right across New York, the lower line to be devoted to an express service, where "a speed of as high as 40 miles an hour could be attained without causing vibration of the structure." The method of construction is to be as follows :—A trench is to be excavated 3ft. in width and 38ft. deep, and the ground thoroughly supported and braced by a plank lining. The tunnel wall is then to be made by filling in this space with the concrete. When the wall is built up to within 11ft. of the surface, the plank lining will be removed, the trench filled in and the street paving relaid. The other wall of the tunnel will then be similarly constructed. The excavation of the ground between the side walls is to be effected without disturbing the street surface, pipes, or subways, by a steel "cutting edge," resting at each end upon the completed side walls, and forced ahead by hydraulic pressure, while the channel steel roof sections are built in behind it, and the construction of the internal steel structure immediately follows. The ground adjacent to the steel roof is to be solidified by liquid cement forced in under pressure. A row of iron columns 12ft. apart through the centre of the tunnel will support a longitudinal steel girder upon which rest the roof sections. These iron columns will be braced from the side by the transverse girders supporting the track beams. The scheme, of course, contemplates the use of electric locomotives. Power, it is said, could be generated at a central station at an expenditure of two pounds of coal per horse-power hour instead of ten pounds now required on the engines of the New York elevated roads.

**The Electrolytic Generation of Hydrogen and Oxygen.**—In a Paper recently read before the Société Française de Physique, Commander Renard described his investigations on the electrolysis of water on a commercial scale, which he commenced as far back as December, 1887. Taking the back E.M.F. at 1·5 volt, and the total plant efficiency at only 50 per cent., 35·3 cubic feet (one cubic metre) of hydrogen can be produced for every 10 horse-power hours; and taking the coal consumption at 2·2lb. (one kilogramme) per horse-power hour, the cost of fuel for every thousand cubic feet at atmospheric pressure of the mixed gases comes out in France at between 1s. 10d. and 4s. 10d., according to the price of coal. To make the electrolytic production of these gases a commercial possibility, it is necessary to avoid the use of costly platinum electrodes and of airtight partitions for collecting the gases. Commander Renard employs an alkaline electrolyte (caustic soda, 13 per cent. solution) and is therefore able to substitute cheap cast-iron electrodes for platinum. As to the vessels for the collection of the gases, he finds that so long as they have a *capillary reaction* $\Delta$ equal to a few centimetres of water, the hydrogen and oxygen do not mix. Commander Renard employs porous pots of asbestos fibre, which are able to withstand a pressure of from 30 to 50 cms. of water, without permitting the passage of the gases. The actual commercial apparatus used at the Chalais works is as follows :—A large cylinder of common sheet iron serves at the same time as the containing vessel for the electrolyte and as the negative electrode. The positive electrode is a perforated iron tube, fixed on to an insulated lid, which fits hermetically on to the top of the containing vessel. This electrode is surrounded by a large asbestos bag. Two voltameters of this kind have been in continuous work at Chalais for some six months, and at the end of this period both the electrodes and the asbestos bag were in perfect condition. The gases given off are pure, and there is no ozone. According to Commander Renard a battery of 36 large voltameters could generate about 200 cubic feet of hydrogen and 100 cubic feet of oxygen per hour, which could be compressed to a pressure of from 120 to 200 atmospheres in steel tubes, and utilised for therapeutic, laboratory, metallurgical, and other purposes. The *total* cost of these gases, ready for use in steel bottles at a pressure of 120 atmospheres, when produced on a sufficiently large scale, is estimated at from 11s. 9d. to 14s. 2d. per thousand cubic feet.

Digitized by Google

## ELECTROMAGNETIC THEORY.—V.

BY OLIVER HEAVISIDE.

*(Continued from page 449.)*

§ 26. So far we have considered the two forces, electric and magnetic, producing four fluxes, two involving storage and two waste of energy, and we have defined the terminology when the state of things at a point is concerned. We reckon forces per unit length, fluxes per unit area, and energies or wastes per unit volume. It is thus a unit cube that is referred to, whose edge, side, and volume are utilised. But a unit cube does not mean a cube whose edge is 1 centim. or any other concrete length; it may indeed be of any size if the quantities concerned are uniformly distributed throughout it, but as they usually vary from place to place, the unit cube of reference should be imagined to be infinitely small. The next step is to display the equivalent relations, and develop the equivalent terminology, when any finite volume is concerned, in those cases that admit of the same simple representation in the form of linear equations.

§ 27. The line-integral of the electric force from one point to another along a stated path is the electromotive force along that path; this was abbreviated by Fleeming Jenkin to E.M.F. He was a practical man, as well as a practician. When expressed in terms of a certain unit called the volt, electromotive force may be, and often is, called the voltage. This is much better than "the volts." I think, however, that it may often be conveniently termed the voltage irrespective of any particular unit. We might put it in this way. Volta was a distinguished man who made important researches connected with electromotive force, which is, therefore, called voltage, whilst a certain unit of voltage is called a volt. At any rate, we may try it and see how it works.

The line-integral of the magnetic force from one point to another along a stated path is sometimes called the magnetomotive force. The only recommendation of this cumbrous term is that it is correctly correlated with the equally cumbrous electromotive force. Magnetomotive force may be called the gaussage [pr. gowsage], after Gauss, who distinguished himself in magnetic researches; and a certain unit of gaussage may be called a gauss [pr. gowce]. I believe this last has already been done, though it has not been formally sanctioned. Gaussage may also be experimented with.

The voltage or the gaussage along a line is the sum of the effective electric or magnetic forces along the line; the effective force being merely the tangential component of the real force. Thus, electric force is the voltage per unit length, and magnetic force the gaussage per unit length along lines of force.

§ 28. Next as regards the fluxes, when considered with reference to any area. The flux through an area is the sum of the effective fluxes through its elementary units of area; the effective flux being the normal component of the flux or the component perpendicular to the area. We do not, I think, need a number of new words to distinguish fluxes through a surface from fluxes per unit surface. Thus, we may speak of the induction through a surface (or through a circuit bounding it); or of the current through a surface (as across the section of a wire); or of the displacement through a surface (as in a condenser), without any indefiniteness, meaning in all cases the surface integral of the flux in question.

In contradistinction to this, it may be sometimes convenient to speak of the density of the current, or of the induction, or of the displacement, that is, the amount per unit area. Similarly, we may sometimes speak of the intensity of the electric or magnetic force, using "density" for a flux and "intensity" for a force.

It may be observed by a thoughtful reader that there is a good deal of the conventional in thus associating one set of vectors with a line, and another set with a surface, and other quantities with a volume. It is, however, of considerable practical utility to carry out these distinctions, at least in a mathematical treatment. But it should never be forgotten that electric force, equally with displacement, is distributed throughout *volumes*, and not merely along lines or over areas.

§ 29. Conductivity gives rise to conductance, and resistivity to resistance. For explicitness, let a conducting mass of any shape be perfectly insulated, except at two places, A and B, to be conductively connected with a source of voltage. Let the voltage established between A and B through the conductor be V, and let it be the same by any path. This will be the case when the current is steady. Also let C be this steady current, in at A and out at B. We shall have

$$V = RC, \qquad C = KV, \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where R and K are constants, the resistance and the conductance, taking the place of resistivity and conductivity, when voltage takes the place of electric force, and the current that of current-density. The activity of the impressed voltage is

$$VC = RC^2 = KV^2, \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

and represents the Joulean waste per second in the whole conductor, or the volume-integral of **EC** or of $kE^2$ before considered.

§ 30. Permittivity gives rise to permittance, and elastivity to elastance. To illustrate, for the conductor, substitute a nonconducting dielectric, leaving the terminals and external arrangements as before. We have now a charged condenser. Displacement, *i.e.*, the time-integral of the current, takes the place of current in the last case, and we now have

$$D = SV, \qquad V = S^{-1}D, \quad . \quad . \quad . \quad . \quad (3)$$

if D is the displacement, S the permittance, and its reciprocal the elastance of the condenser. This elastance has been called the stiffness of the condenser by Lord Rayleigh. It is the elastic resistance to displacement. The displacement is the measure of the charge of the condenser.

The total energy in the condenser is

$$\tfrac{1}{2}VD = \tfrac{1}{2}SV^2 = \tfrac{1}{2}S^{-1}D^2 \quad . \quad . \quad . \quad . \quad (4)$$

*i.e.*, half the product of the force (total) and the flux (total), between and at the terminals; it is also the volume-integral of the energy-density, or $\tfrac{1}{2}\Sigma cE^2$.

As the dielectric is supposed to be a non-conductor, the current is $\dot{D}$ or $S\dot{V}$, and only exists when the charge is varying. But it may also be conducting. If so, let the conductance be K, making the conduction current be $C = KV$. The true current (that is, *the* current) is now the sum of the conduction and displacement currents. Say,

$$\Gamma = C + \dot{D} = \left(K + S\frac{d}{dt}\right)V. \quad . \quad . \quad . \quad . \quad (5)$$

This is the characteristic equation of a condenser. It comes to the same thing if the condenser be non-conducting, but be shunted by a conductance, K. In a conducting dielectric the permittivity and the conductivity are therefore in parallel arc, as it were. It was probably by a consideration of conduction in a leaky condenser that Maxwell was led to his inimitable theory of the dielectric, by which he boldly cut the Gordian knot of electromagnetic theory.

The activity of the terminal voltage we find by multiplying (5) by V, giving

$$V\Gamma = VC + V\dot{D},$$
$$= RC^2 + \frac{d}{dt}\left(\tfrac{1}{2}SV^2\right), \quad . \quad . \quad . \quad . \quad (6)$$

representing the waste in Joulean heating and the rate of increase of the electric energy. Each of these quantities is the sum of the same quantities per unit volume throughout the substance concerned.

§ 31. Permeability gives rise to permeance, inductivity to inductance, and reluctivity to reluctance.

The formal relation of reluctance to reluctivity with magnetic force and induction, is the same as that of resistance to resistivity with electric force and conduction current, or of elastance to elastivity with electric force and displacement.

Permeance is the reciprocal of reluctance. In this sense I have used it, though only once or twice. Prof. S. P. Thompson has also used the word in this sense in his Cantor Lectures with good effect.

Digitized by Google

If we replace our illustrative conductor by an inductor, supporting magnetic induction, and suppose it surrounded by imaginary matter of zero inductivity, and have an impressed gaussage instead of voltage at the terminals, we shall have a flux of induction which will, if the force be weak enough, vary as the force. If H be the gaussage and B the induction entering at the one and leaving at the other terminal, the ratio H/B is the reluctance, and the reciprocal B/H is the permeance. The energy stored is

$$\tfrac{1}{2}HB = \tfrac{1}{2}\left(\frac{B}{H}\right)H^2 = \tfrac{1}{2}\left(\frac{H}{B}\right)B^2 \quad . \quad . \quad . \quad (7)$$

When the relation of flux to force is not linear, we can still usefully employ the analogy with conduction current or with displacement by treating the ratio **B/H** as a function of **H** or of **B**; as witness the improved and simplified way of considering the dynamo in recent years. I must, however, wonder at the persistence with which the practicians have stuck to "the lines," as they usually term the flux in question.

I am aware that the use of the name induction for this flux, which I have taken from Maxwell, is in partial conflict with an older use. But it is seldom, if ever, that these uses occur together, for one thing; another thing is that the older (and often vague) use of the word induction has very largely ceased of late years. It was not without consideration that induction was adopted and, to harmonise with it, inductance and inductivity were coined.

§ 32. The meaning of inductance has sometimes been misconceived. It is not a synonym for induction, nor for self-induction, but means "the coefficient of self-induction," sometimes abbreviated to "the self-induction." It is essentially the same as permeance, the reciprocal of reluctance, but there is a practical distinction. Consider a closed conducting circuit of one turn of wire, supporting a current $C_1$. As will later appear, this $C_1$ is also the gaussage. That is, the line-integral of the magnetic force in any closed circuit (or the circuitation of the force) embracing the current once is $C_1$. Let also $B_1$ be the induction through the circuit of $C_1$. Then

$$B_1 = L_1C_1, \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

where, by what has already been explained, $L_1$ is the permeance of the magnetic circuit, a function of the distribution of inductivity and of the form and position of the conducting core. The magnetic energy is

$$\tfrac{1}{2}B_1C_1 = \tfrac{1}{2}L_1C_1^2. \quad . \quad . \quad . \quad . \quad . \quad (9)$$

by using the first expression in (7), remembering that H there is now represented by $C_1$, and then using (8). This energy "of the current" resides in all parts of the field, only (usually) a small portion occupying the conductor itself.

Now substitute for the one turn of wire a bundle of wires, N in number, of the same size and form. Disregarding small differences due to the want of exact correspondence between the bundle and the one wire, everything will be the same as before if the above $C_1$ means the total current in the bundle. But if the same current be supported by each wire, practical convenience in respect to the external connections of the coil requires us to make the current in each wire *the* current. Let this be C, so that $C_1 = NC$. Then we shall have by (8)

$$B_1 = (L_1N)\,C \quad . \quad . \quad . \quad . \quad . \quad (8a)$$

to express the flux of induction; and by (9), and (8*a*),

$$\tfrac{1}{2}B_1C_1 = \tfrac{1}{2}(L_1N^2)C^2$$
$$= \tfrac{1}{2}LC^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad (9a)$$

if $L = N^2L_1$, to express the energy. This L is the inductance of the coil. It is $N^2$ times the permeance of the magnetic circuit.

Again, regarding the coil as a single circuit, $B_1N$ is the induction through it, that is, $B_1$ through each winding. Calling this total B, we have, by (8*a*)

$$B = B_1N = (L_1N^2)\,C = LC \quad . \quad . \quad . \quad . \quad (8b)$$

which harmonises properly with (9*a*).

The difference between inductance and permeance, therefore, merely depends upon the different way of reckoning the current in the coil. With one winding only, they are identical. I should here observe that I am employing at present rational units. Their connection with the Gaussian units will appear later. It would only serve to obscure the subject to bring in $4\pi$, that arbitrary and unnecessary constant which has puzzled so many people.

It will be seen that the distinction between permeance and inductance is a practical necessity. in spite of their fundamental identity. But which should be which? On the whole, I prefer it as above stated, especially to connect with self-induction. Regarding permeability itself, it would seem that this name is more particularly suitable to express the ratio $\mu/\mu_0$ of the inductivity of a medium to that of ether, which is, in fact, consistent with the original meaning, I believe, as used by Sir W. Thomson in connection with his "electromagnetic definition" of magnetic force. But to inductivity, as beforementioned, a wider significance should be attached. As has been more particularly accentuated by Prof. Rücker, we really do not know anything about the real dimensions of $\mu$ and $c$; or, more strictly, we do not know the real nature of the electromagnetic mechanism, so that $\mu$ and $c$ are very much what we choose to make them, by assumptions. The two principal systems are the so-called electrostatic, in which $c=1$ in ether, and the electromagnetic, in which $\mu=1$ in ether. But with these specialities we have no further concern at present.

*(To be continued.)*

## THE MAGNETIC CIRCUIT OF TRANSFORMERS: CLOSED VERSUS OPEN.

BY S. EVERSHED.

*(Continued from page 480.)*

§ 14. But suppose the transformer is used for house lighting. The spring or autumn load in a house may be taken at about $\frac{1}{3}$ of the lamps wired running six hours a day; with a maximum load of less than 50 per cent. of the lamps wired. So that 10 horse-power will easily provide for 400 lights wired, and its daily output will be roughly 24,000 watt hours. The loss from $C^2R$ may be neglected except during the six hours at $\frac{400}{3} \times 30 = 4{,}000$ watts when the secondary current is 40 amperes, and $C_s^2R_s = 15$ watts, and about 16 watts in the primary. The loss in $C_p^2R_p$ from the exciting current is about ·5 watt. The all-day efficiency on the stated load is given in Table V.

**Table V.**—*All-day Efficiency of Ten horse-power Transformer on 4,000 watts for six hours.*

| | | |
|---|---|---|
| Total output ................................ | 24,000 | watt hours |
| 24 hours' waste in the core at 400...... | 9,600 | ,, |
| 24 hours' waste $C_p^2R_p$ in exciting at ·5 | 12 | ,, |
| 6 hours' waste $C_p^2R_p + C_s^2R_s$ at 31. | 185 | ,, |
| | 33,797 | |

$$\text{Efficiency} = \frac{24}{34} = 71 \text{ per cent.}$$

It is worth remarking that during the great B.T. *versus* A.T. controversy a few years ago, Mr. Crompton declared that the efficiency of alternate current transformers was no higher than he could get with battery transformers. The champions of the A.T. system did all they could to crush Mr. Crompton, but he stuck to his guns, as his manner is, and after all it seems he was right. If we had chosen a 50 or 100-lighter, such as would commonly be used in a house, the efficiency would have come out nearer 60 than 70 per cent.

§ 15. It may be objected that such a large transformer as 10 horse-power would not be used in the way we have imagined, but would be placed in a sub-station, where during the day a small transformer would take its place, and so save the inordinate waste in the core. The writer may be permitted to doubt whether a sub-station transformer system will pay. The *raison d'être* of the transformer system lies in its great flexibility and economy in mains, whereby a lot of scattered lighting over a

Digitized by Google

large area can be profitably run from one station. This almost necessarily implies the use of a small transformer to every house, with a larger one occasionally where several adjoining houses require light. But the moment we begin to use sub-stations where a light-load transformer is switched on during the day-time, we sacrifice much of the flexibility and increase standing charges for rent and superintendence. In order to save the coal bill appreciably, we must use a very small day transformer so as to run it at least half load. Take an example. Put on a 1,000 watt transformer for 18 hours, and the 10 horse-power for 6 hours. The small transformer would waste at least 130 watts in its core, or $130 \times 18 = 2{,}300$ watt hours, the 10 horse-power wasting $400 \times 6 = 2{,}400$, and the total daily waste will be 4,700 watt-hours as against 9,600, almost exactly half as it happens, so there is a saving of something like 5 B.T. units, and the saving in coal and running expenses might amount to 2d. per unit, or 10d. a day for a sub-station running 400 lights. The saving in a 2,000 light sub-station may be taken at 4s. 2d. a day. The attendant would dispose of at least 3s., leaving 1s. 2d. for rent, interest on secondary mains, and sub-station fittings. Truly there is not much margin.

§ 16. It might be supposed that one attendant could look after four or five sub-stations; but in this favoured country, at all events, town districts are liable to sudden fog, and there would be some risk of damage to the small transformer unless the attendant were ubiquitous; remember that it would be overloaded with one-tenth of the lamps on.

Perhaps, however, every central station, like every railway signal box, would have a number of fogmen attached to it. Signalmen often have considerable difficulty in getting their fogmen out in time, and a central station manager would have precisely the same trouble, with the additional one that the sub-stations would be at a very considerable distance from the central station.

Of course, automatic switches might be devised to save the need for an attendant; but automatic switches in the primary circuit are not pleasant to contemplate.

In country districts, where the transformer system is without a rival, sub-stations are out of the question.

§ 17. In what follows, therefore, we shall assume that the transformer primary will be on continuously, and endeavour to get a higher all-day efficiency by reducing the enormous waste in the core. This can be effected in three ways—(1) the frequency can be diminished, (2) the maximum induction can be reduced, or (3) we can use less iron in the core, in each case increasing the number of turns of the coils to keep the volts up. Now, when we increase the number of turns we either increase the total amount of copper or have a greater drop in E.M.F. over the coils, and we ought to fix on some limit for the latter, as it is as obviously absurd to compare the efficiencies of two transformers having different full-load drops, as it is to compare two shunt dynamos without regard to their regulation. Suppose the maximum loss of volts over the mains were 1 per cent., and allow for 1 per cent. in the house switches and leads, if the loss over the transformer coils at full load is 3 per cent., we should have a total drop of 5 per cent. with evey light on; but as the maximum only amounts to about 80 per cent. of the transformer's full load, the actual drop on the lamps would not exceed 4 per cent., and that very rarely. A large variation in E.M.F. is occasionally deprecated on the score of damage to or inefficiency of lamps, but as a rule lamps are not overrun at the highest E.M.F., and a large drop merely lengthens their lives. It also tends to grumbling on the part of the consumer, and this last factor practically determines the maximum allowable loss of E.M.F.

In addition to the three methods already mentioned, an ingenious scheme for raising the commercial efficiency of transformers on any load whatever to something like 100 per cent. ought to be alluded to here. Like most really ingenious novelties, it hails from America. According to this invention, the house-meter is put on the primary mains, so transferring the whole of the loss to the unhappy consumer. This arrangement certainly has great charms—for the Supply Company. The less efficient the transformer the better they like it.

§ 18. Taking three per cent. as the limiting loss in E.M.F., let us begin by lowering the frequency in the 10 horse-power transformer from 70 to 35 ∿ per second, without making any change in the core. The coils now require twice as many turns, and as we cannot interlink a greater *section* of copper with the core, we must use wires and strip of less than half the section in each case. It would be exactly half were it not that the space required for insulation is doubled. The resistance of each coil will now be at least five times as great as those given in Table III., so that the maximum drop will be $1{\cdot}4 \times 5 = 7$ per cent. If the second plan were carried out we should come to exactly the same conclusion, for to get the same E.M.F. with half the induction would require twice the turns, and the coils would have a full load drop of 7 per cent.

§ 19. Clearly, neither a lower frequency nor a lower induction is any good unless the size of the core is altered. Keeping the core area the same, increase the mean length of the magnetic circuit by 30 per cent. We may take the core to be a square link, and shall find we have increased the area for coils by 110 per cent. Double the number of turns of 10 per cent. greater section than the original wires and strip, will make the resistances practically twice as great (the mean length per turn having been increased by 10 per cent.), and the drop will be 2·8 per cent., just under the limit. But the volume of iron is now 30 per cent. greater. Putting this modification on the same load as the original transformer, we can write down the losses at once. They are given in Table VI.

**Table VI.**—*Modified Ten Horse-power transformer, No. C. 1.*

Maximum $B = 10{,}000$ .................... $F = 35$

Load as in Table V.

| | | |
|---|---|---|
| Total output ................................ | 24,000 | watt hours. |
| 24 hours waste in core at 278 ......... | 5,500 | ,, |
| 24 ditto waste in exciting at 1 ......... | 24 | ,, |
| 6 ditto $C_p^2 R_p + C_s^2 R_s$ at 62 ............ | 372 | ,, |
| | 29,896 | |

$$\text{Efficiency} = \frac{20}{30} = 80 \text{ per cent.}$$

Full-load drop = 2·8 ,,

A distinct improvement has been made, but at the cost of an increase of 140 per cent. in the weight of copper, 30 per cent. in iron, and perhaps 50 per cent. increase in labour. Whether a gain of 9 per cent. is worth this price is doubtful.

§ 20. A better result can be got for the same outlay in materials and labour by the second plan, namely keeping the frequency at 70, and reducing the maximum B to 5,000 gausses. The hysteresis loss at 5,000 gausses is almost exactly one-third of the loss at 10,000, the results obtained by Mr. Vignoles and the present writer agreeing precisely in this respect with those published by Prof. Ewing. The eddy current loss at half the induction is of course quartered. The coils and size of core will be exactly the same as in Table VI. The efficiency of this modification is shown in Table VII.

**Table VII.**—*Modified Ten Horse-power Transformer, No. C. 2.*

Maximum $B = 5{,}000$. $F = 70$.

Load as in Table V.

| | | |
|---|---|---|
| Total output ...................................... | 24,000 | watt hours. |
| 24 hours' waste in core at 163 ......... | 3,900 | ,, |
| 24 hours' waste in exciting at ·5......... | 12 | ,, |
| 6 hours' waste $C_p^2 R_p + C_s^2 R_s$ at 62 | 372 | ,, |
| | 28,284 | |

$$\text{Efficiency} = \frac{24}{28} = 85 \text{ per cent.}$$

Full load drop = 2·8 per cent.

Here is an apparent gain of 14 per cent. in efficiency, but it must not be forgotten that the drop in the original transformer was only 1·4 per cent., and in order to compare it with those given in Tables VI. and VII. it ought to be re-wound to have the same full load drop.

In fact, the coils must be wound with wires and strip of half the section, the turns being left unchanged at 1,120 and 56 as given in Table III. The new coils occupying approximately half the space, the mean length of the magnetic circuit can be

Digitized by Google

reduced by 20 per cent. The efficiency of the arrangement is given in Table VIII.

**Table. VIII.**—*Modified Ten Horse-power Transformer.*

Maximum B = 10,000 F = 70.

Load as in Table V.

| | | |
|---|---|---|
| Total output | 24,000 | watt-hours |
| 24 hours' waste in core at 330 | 7,900 | ,, |
| 24 hours' waste in exciting at 1 | 24 | ,, |
| 6 hours waste $C_p{}^2 R_p + C_s{}^2 R_s$ at 62... | 372 | ,, |
| | 32,296 | |

$$\text{Efficiency} = \frac{24}{32} = 74 \text{ per cent.}$$

Full load drop = 2·8 per cent.

When we consider that this last transformer requires only two-thirds the quantity of iron and one-quarter of the copper taken by those in VI. and VII., we can have no doubt which would be chosen by a supply company.

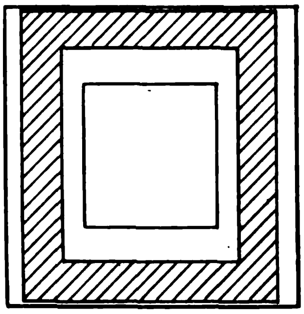


FIG. 4.—Plan of Core of 10 horse-power Ravenshaw Transformer showing portion used in No. 3 shaded.

§ 21. So far the rise in temperature of these various modifications has not been considered. The reason for this apparent neglect is very simple. When we limit the maximum loss of volts at full load to three per cent., it is almost impossible to design a transformer having insufficient radiating surface to keep its temperature below a safe limit. In this respect the transformer in Table VIII. is very much worse than any of the other modifications, yet although it would acquire undesirably high temperature if left on continuously at full load, its maximum temperature on the time load we have assumed would not exceed 30°C. above that of the surrounding air, say an actual temperature of 50°C. Probably no one but a financier would care to run a transformer with so small a margin, and we shall therefore put it out of competition. To complete the set of closed transformers, we still require one having the maximum B = 10,000 and F = 70 with a full load drop under 3 per cent., and the simplest modification of the original transformer by which these conditions can be fulfilled is obtained by reducing the sectional area of the core and increasing the number of turns on the coils in proportion.

§ 22. Suppose core plates of half the width of those in the original transformer are built up into a core of the same depth, so as to get half the sectional area, and made into a rectangular link enclosing twice the area for coil space. This alteration is shown in Fig. 4, which is a plan of the original core, the shaded portion being the new core. The coil space is not quite doubled, but the length of an average turn being now 7 per cent. less; the section of the wires and strip may be reduced in proportion, so that exactly twice as many turns can be wound on, thus doubling the resistance of each coil. The volume of iron in the core is not quite half 6,600 cub. cm.; it is actually 3,560 cub. cm. The sectional area is 29 square cms., and the average length of the magnetic circuit 122 cms. The all-day efficiency of this transformer is given in Table IX.

Thus, of the three proposals for raising the efficiency, the second is the best; but No. C. 2 is only 4 per cent. better than No. C. 3, and the latter uses considerably less material. We shall return to the question of raising the efficiency by lowering the induction after we have investigated the properties of open circuit transformers.

**Table IX.**—*Modified Ten Horse-power Transformer No. C.3.*

Maximum B = 10,000 F = 70

Load as in Table V.

| | | |
|---|---|---|
| Total output | 24,000 | watt hours |
| 24 hours' waste in core at 218 | 5,200 | ,, |
| 24 hours' waste exciting at ·5 | 12 | ,, |
| 6 hours' waste $C_p{}^2 R_p + C_s{}^2 R_s$ at 62... | 372 | ,, |
| | 29,584 | |

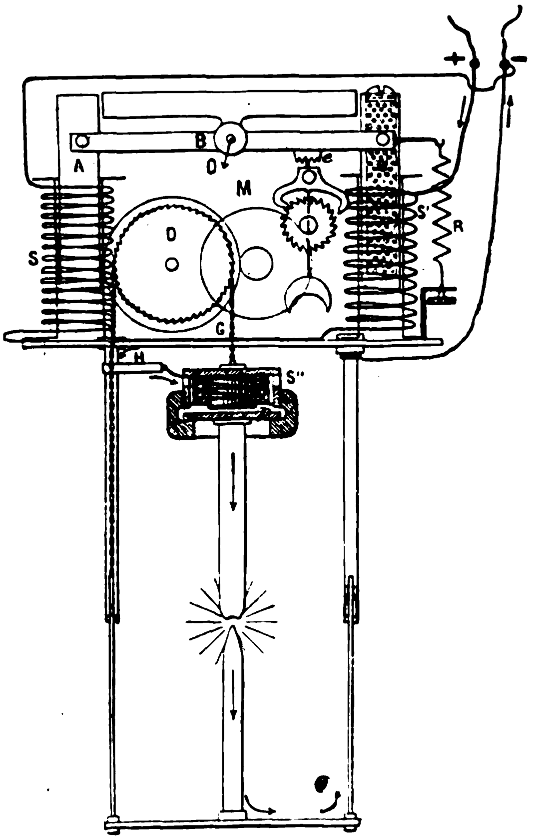
$$\text{Efficiency} = \frac{24}{29{\cdot}6} = 81 \text{ per cent.}$$

Full load drop = 2·8 per cent.

(*To be continued.*)

## THE JAPY-HELMER ARC LAMP.

The Japy-Helmer lamp, with its somewhat complicated mechanism, is a striking contrast to that due to M. Patin, and described in a recent issue (see *Electrician*, February 20th, p. 496).




Japy-Helmer Arc Lamp.

The lamp (says *L'Electricien*) consists of a clockwork arrangement, mounted on the frame of the lamp, and comprising a plate C and a toothed wheel D, which are brought into play at intervals when the action of the current releases the clockwork. The current leaving the terminal traverses the thick wire solenoid S′, and goes to the contact H, whence it passes round the coils of the electromagnet S″, which, when energised, attracts the armature *r*, and strikes the arc. The current then traverses the carbons and reaches the terminal. The fine-wire solenoid is a shunt on the arc. Each of the solenoids S and S′ have soft iron cores A and A′, connected by the balanced beam B pivoted at O. This beam carries a catch *e*, which stops the motion of the escapement when required. When the lamp is out of circuit the spring R keeps this catch pressed against the escapement-wheel. After the arc is struck and the carbons begin to burn away the current in the shunt coil S increases, and the core A is sucked in and the beam B tilts over, freeing the escapement-wheel, and allowing the carbons to feed down. Perhaps the best feature of this lamp is its compactness, a 6-ampere 7½-hour lamp being only 2ft. over all.

A few slight modifications are required to make this lamp work with alternate currents. The number of turns in the solenoids is reduced, and the armature *r* is no longer rigidly attached to the upper carbon-holder, which then merely passes through a hole in the middle of *r*. When the current is not passing, *r* is not attracted, and falls to the bottom of the box-like arrangement shown in the figure, and compressing a spring brings the carbons together.

Digitized by Google

## ELECTRICITY AT THE CHICAGO EXHIBITION.

The following is an abstract of a Report drawn up by the World's Fair Committee of the Chicago Electric Club, at the instance of the consulting engineer to the Chicago Exhibition authorities. The full text of the Report appeared in the *Western Electrician* of February 14th :—

*General Arrangement of Wires.*—We recommend that the distribution of electric current, for arc and incandescent lighting, for electric railway and power purposes, be through underground conductors exclusively, with the exception of overhead arc light wires for outside illumination, and the railway trolley wires.

*Area to be Lighted.*—From the plans submitted, we find that the indoor area to be lighted amounts to a total of 4,884,750 square feet, and the outside area to 28,000,000 square feet.

*Lighting Grounds.*—Supposing the lamps for outside illumination to be placed on poles, and allowing 15,000 square feet per 2,000-candle-power arc lamp, we require 1,866 arc lamps, or 1,866 horse-power at the power station. Such a distribution would place the lamps 122ft. apart. As the proper height of the electric arc for lighting of large areas is ·7 of the radius of the area to be lighted by one lamp, the arcs should be at a height of

$$\frac{\cdot 7 \times 122}{2} = 42\ 7$$

or practically 40ft. above ground. Should it be decided to light the grounds by a system of towers. about 75ft. high, each tower to be equipped with, say eight arc lamps, and the towers to be placed approximately 400ft. apart, it could be accomplished with about 1,400 arc lamps. This will provide a flexible method of lighting, and make it possible to increase or decrease the number of lights on a certain tower as the circumstances may warrant. It is thought that by this system, all thoroughfares and paths throughout the park can be well lighted, notwithstanding the foliage. By means of the tower system, it will be practicable to connect one tower to the other with a single conductor for carrying the current. This single conductor will be, approximately, 75ft. above ground, and at that height there can be no possible danger, so that bare wire can be used and insulating material can be dispensed with. The cost of one hundred and seventy-five towers, wired and ready to be connected with the electrical apparatus, will be, approximately, $100,000. While the committee is fully aware of the fact that the tower system of general illumination in cities is not the popular form, and is only used in perhaps half a dozen cities in the United States, the advantages of this system under the conditions that will obtain at Jackson Park, where there are but few buildings to obstruct the light, will be very marked.

*Lighting Buildings.*—Although the total floor space of the buildings is only 4,884,750 square feet we think that about 30 per cent. more should be allowed for galleries, upper stories, &c This will practically give us an area to be lighted inside of buildings of 6,000,000 square feet. If we assume one arc lamp for each 1,600 square feet, which practically puts the lamps 40ft. apart, about 3,800 arc lamps or horse-power would be required, to give a general inside illumination. The proper height for these lamps would be

$$\frac{40 \times \cdot 7}{2} = 14.$$

For practical reasons, however, and other considerations, the height of the arc above ground should be increased to say about 18 or 20ft. The total cost for arc light distribution inside the buildings will be $72,000.

While the arc lights will give a good general illuminations, the different exhibits will need a large number of incandescent lights to effectively show each object under favourable conditions. Assuming for each 120 square feet one 16 candle-power incandescent lamp, we get a total of 50,000 16 candle-power incandescent lamps, or 5,000 horse-power. We estimate that the cost of distribution for the 50,090 incandescent lamps, from the generators to the sockets, will be, approximately, $250,000.

*Recapitulation.*

| | |
|---|---|
| For outside arc lighting by towers ... | 1,400 horse-power |
| For inside arc lighting .................. | 3,800 ,, |
| For incandescent lighting .............. | 5,000 ,, |
| Total .......................... | 10,200 horse-power |

*The Proposed Railway.*—In constructing a surface railroad through the grounds of the World's Fair the same can be made unique and ornamental in many respects. The rails could be raised from the ties by means of chains to give a space of 8in., which would be covered with a rich mould, suitable for the planting of flowers and grass, and can be so arranged that the rails cannot be seen except by standing immediately over the centre of the rails. There should be space allowed between the tracks, if it is constructed with double tracks, to allow the erection of ornamental centre poles, either of iron or octagon wood with ornamental brackets, from which the wire could be suspended for conveying the current to the trolleys of the motor cars. If desired, these poles could have various kinds of vines running around them, which would make them exceedingly ornamental and pleasant to the eye. It would also be necessary, of course, to have the railroad enclosed from one end to the other with a neat and ornamental fence. We believe a surface railroad erected on such a plan as the above would be very attractive and something that has never been seen in this country or any other.

*Recapitulation.*—Horse-power required delivered at generator pulleys :

| | H.P. |
|---|---|
| For lighting Exposition at Jackson Park ..................... | 10,200 |
| Electric Railway at Jackson Park ............................ | 700 |
| For power transmission to different buildings, and drive all sorts of machinery at Jackson Park (rough estimate) ............................ | 9,000 |
| Grand total ............................ | 19,900 |

*Recapitulation.*—Cost for distributing the electric current for lighting, exclusive of apparatus, at Jackson Park :—

| | |
|---|---|
| Towers and overhead wire for outside arc lighting ......... | $100,000 |
| Conduits and wires for inside arc lighting ................ | 72,000 |
| Conduits and wires for inside incandescent lighting ...... | 250,000 |
| | $422,000 |

## MEETINGS OF SCIENTIFIC SOCIETIES, &c.

**FRIDAY, February 27th.**

Society of Arts.

*4.30 p.m.* Popular Afternoon Lecture : "The Science of Colour," by Captain Abney, C.B., F.R.S.

Physical Society.

*5.30 p.m.* Ordinary Meeting. Papers to be read : "Proof of the Generality of certain formulæ published for a special case by Mr. Blakesley." "Tests of a Transformer," by Prof. W. E. Ayrton and J. F. Taylor. "Further Contributions to Dynamometry," by T. H. Blakesley. "Note on Electrostatic Wattmeters," by J. Swinburne "Interference with Alternating Currents," by Prof. W. E. Ayrton and Dr. W. E. Sumpner.

Institution of Civil Engineers.

*7.30 p.m.* Students' Meeting. Paper to be read: "Dis integrators," by Bertram Chatterton, S.I.C.E.

Electro-Harmonic Society.

*8 p.m.* Ladies' Night. Concert in St. James' Hall Restaurant.

**SATURDAY, February 28th.**

Royal Institution.

*3 p.m.* Afternoon Lecture: "The Forces of Cohesion," by Lord Rayleigh, F.R.S.

**MONDAY, March 2nd.**

Institution of Civil Engineers.

*2 p.m.* Students' Visit. The Locomotive and Carriage Works of the Great Eastern Railway at Stratford.

Royal Institution.

*5 p.m.* General Monthly Meeting.

Society of Engineers.

*7.30 p.m.* Ordinary Meeting. Paper to be read : "The Balancing of High Speed Steam Engines," by Arthur Rigg.

Society of Arts.

*8 p.m.* Cantor Lecture III. 3. "The Electric Transmission of Power," by Gisbert Kapp.

**TUESDAY, March 3rd.**

Institution of Civil Engineers.

*8 p.m.* Ordinary Meeting. Paper to be read with a view to discussion : "On the Subterranean Water in the Chalk Formation of the Upper Thames, and its Relation to the Supply of London," by John Thornhill Harrison, M.I.C.E.

**THURSDAY, March 5th.**

Royal Institution.

*3 p.m.* Afternoon Lecture : "Modern Chemistry in Relation to Sanitation," by Prof. C. M. Tidy, M.B.

**FRIDAY, March 6th.**

Society of Arts.

*4.30 p.m.* Popular Afternoon Lecture : "The Science of Colour," by Capt. Abney, F.R.S.

Royal Institution.

*9 p.m.* Evening Discourse : "Electro-Magnetic Repulsion," by Prof. J. A. Fleming, D.Sc.

Digitized by Google

# The Electrician.

**Published every Friday, Price Fourpence; Post Free, Fourpence Halfpenny**
**Editorial, Publishing, and Printing Offices:**
**SALISBURY COURT, FLEET ST., LONDON, E.C.**
*Telephone No.* 2714. *Telegrams:* "ELECTRICIAN NEWSPAPER, LONDON."

*All Letters relating to Subscriptions, Advertisements and other business matters should be addressed to the Publisher,* "THE ELECTRICIAN," *Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to* "THE ELECTRICIAN" *Printing and Publishing Company, Limited, and be crossed* "Coutts and Co." *All other letters to be addressed to the Editor.*

*All letters intended for insertion in* "THE ELECTRICIAN," *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

THE ELECTRICIAN" *is published every Friday morning, in time for the morning mails. Subscribers should receive their copies by the first post on Friday morning.*

"THE ELECTRICIAN" *is on sale at the railway bookstalls throughout the Kingdom on Friday morning, and can be obtained of all Booksellers and Newsvendors; or direct from the Publishing Offices as above.*

*New Volumes of* "THE ELECTRICIAN" *commence in May and November.*

## SUBSCRIPTION RATES.

**The rates for Subscriptions to "THE ELECTRICIAN" are as follows:—**

| | 3 months. s. d. | 6 months. s. d. | 12 months. s. d. |
|---|---|---|---|
| For the United Kingdom | 5 0 | 10 0 | 19 6 |
| For Foreign Parts and Colonies:— Within Postal Union | 6 6 | 12 6 | 24 0 |
| For Aden, Borneo, Ceylon, China, India, Japan, Java, Labuan, Mozambique, New Caledonia, Persia, Philippine Islands, Siam, Transvaal, and Zanzibar | 7 6 | 14 6 | 28 0 |



## TO ADVERTISERS.

"THE ELECTRICIAN" *offers exceptional advantages to Advertisers.*
**It has by far the largest circulation of any English Electrical paper, and circulates all over the World.**

*Particulars relating to Advertisements will be promptly forwarded on application to the Offices as above.*

TRADE ADVERTISEMENTS *intended for the current issue must reach the Offices not later than First Post on Thursday morning. Renewals of expiring advertisement orders and alterations to standing advertisements should be in the Publisher's hands by Wednesday at latest. No alteration can be made in Wrapper advertisements after Wednesday evening.*

SMALL PREPAID ADVERTISEMENTS *(for Rates see page xvii.) are accepted up to 4 p.m. on Thursday.*

## TECHNICAL PRINTING.

"THE ELECTRICIAN" PRINTING AND PUBLISHING COMPANY (LIMITED) *inform Electricians, Electric Light Engineers, &c., that they make a specialty of Technical Printing, and have a large Staff thoroughly acquainted with Electro-Technology. They can, therefore, promise Accuracy and Despatch in the Printing of Electro-Technical Literature, &c.*

## "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. (Royal 8vo.)

*Early in each year is issued* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. *The* DIRECTORY *was established in 1883, and the 1891 Edition, published on the 23rd February, consists of 900 pages of printed matter. The names and addresses of all persons engaged in the Electrical Industries at home and abroad may be relied upon as accurate. Useful Tables and Electrical Formulæ, and information specially compiled for this work are given, together with popularly-written Biographical Notices of the leading Electricians, Electrical Engineers, &c., accompanied in many cases by Portraits.*

*The issue for 1891 is ready, and should be ordered at once. Price 6s., post free 5s. 9d. Abroad postage extra. Full particulars on application.*

## ELECTRICAL BOOKS AND PUBLICATIONS

*All Books, Newspapers, and other publications, dealing with Electrical and kindred subjects, can be ordered direct of* "THE ELECTRICIAN" *Printing and Publishing Company, who are proprietors of the well-known* "ELECTRICIAN" *Series of Standard Electrical Works, and are agents for all the leading publishing houses at home and abroad.*


## CONTENTS OF THE CURRENT NUMBER.


NOTES ........ 501
Electro-magnetic Theory, V. By Oliver Heaviside. Continued ........ 507
The Magnetic Circuits of Transformers: Closed versus Open. By S. Evershed. Continued Illustrated ........ 508
The Japy-Helmer Arc Lamp. Illustrated ........ 510
Electricity at the Chicago Exhibition ........ 511
Meetings of Scientific Societies. 511
TRANSFORMER DISTRIBUTION ... 512
The Electric Current and its Laws. By John T. Sprague 513
Transformer Distribution. By J. Swinburne. Illustrated... 514
The Striking Distance of Alternating Electromotive Forces. By Robert Shand. Illustrated ........ 518
Paris Notes ........ 519
Vienna Notes ........ 519
CORRESPONDENCE—
Electric Theories — Silvanus P. Thompson ........ 520
The Barking Road Cars — Gisbert Kapp and W. G. M. Mackenzie ........ 520
CORRESPONDENCE—*Continued.*
The Insulation of the Bath Electric Light Circuits — George Forbes ........ 520
Electric Theories — Ether — J. Gray ........ 520
Indoor Illumination—J. B. V., B. P., and Progress ........ 521
Trade Notes and Notices ........ 521
COMPANIES' MEETINGS, &c.—
The City and South London Railway ........ 522
The St. James' and Pall Mall Electric Light Company (Limited) ........ 524
Westminster Electric Supply Corporation (Limited) ... 524
Liverpool Electric Supply Company (Limited) ...... 525
Manchester Edison - Swan Company (Limited) ...... 526
Telegraph Construction and Maintenance Company (Limited) ........ 526
Keswick Electric Light Company (Limited) ........ 526
Taunton Electric Lighting Company (Limited) ........ 527
City Notes, &c. ........ 527
Companies' Share List ........ 528


## TRANSFORMER DISTRIBUTION.

MR. SWINBURNE's paper on this subject, just read before the Institution of Electrical Engineers, exhibits in a remarkable manner the versatility of its author, and a mere summary of the headings of the different parts suffices to show the great extent of the ground which he has attempted to cover. The distribution of electricity by transformer sub-stations and low-tension networks, the parallel running of alternators according to orthodox and heterodox views, the theory of armature reactions, and the automatic regulation of dynamos and transformers, the relative merits of the open and closed circuit type of converter, the internal arrangements of supply stations, and the many prospective uses of condensers, when manufactured commercially for employment with alternating current systems, were all subjects of sufficient importance to merit separate treatment. It was courageous to endeavour to dispose of every one of these in the short time which could be devoted to them, more especially in view of the fact that the Institution supplied but very few printed copies of the paper to aid members in following the intricate reasoning which the author had occasion to resort to. It was certainly a pity so many matters were referred to, as by so doing the attention of hearers was somewhat distracted, and the resulting discussion is liable to become wandering and comparatively barren of result.

More than half the paper is devoted to a discussion of the subject of parallel running of alternating dynamos. The action of coupled machines is a matter of the first importance, but one on which great differences of opinion still exist. The experiments which have been made are comparatively few, while all mathematical methods of explanation are obscured by clouds of symbols, and generally involve assumptions of a more or less dubious nature. Even the geometrical treatment of the problem, although in many respects the clearest, is frequently misleading, owing to the fact that the figures are rarely drawn to scale. There still seems a confusion

Digitized by Google

of opinion as to what is really implied by the Hopkinson theory, in which successful parallel coupling is attributed to the presence of. self-induction in the armature. Some engineers appear to imagine that a highly inductive armature necessarily involves a powerful reaction on the field, and a drooping characteristic. This is by no means the case, and, whether it is so or not, depends entirely on the design of the machine. The MORDEY dynamo has the requisite amount of inductance, although its characteristic is practically straight; while in the HOPKINSON theory it is assumed that, in spite of the self-induction of the armature, the electromotive force of the machine is constant whatever the lag of the current may be. It is thus curious that Mr. MORDEY, who has called in question the orthodox theory, lays great stress on the constancy, or stiffness, of the field, a condition which is really assumed in the theory; while Mr. SWINBURNE, who has assimilated the HOPKINSON theory, appears to attribute the successful examples of parallel running to the weakening of the field produced by the reaction of the armature current. According to Dr. HOPKINSON, the tendency of each machine to fall into proper step is caused by the alteration in the output which arises when the phase between the electromotive force and current varies. The spurious voltage due to self-induction, or, according to Mr. SWINBURNE, the voltage due to armature reactions, is of no importance as regards the output of the machine, since it always lags a quarter of a period behind the current, and, consequently, the power corresponding with it is zero.

Mr. SWINBURNE's proposal to disregard the self-induction of the armature, and to take the external voltage of the machine to represent the effective electromotive force, is at first sight attractively simple. It is, no doubt, quite accurate to state, as Mr. SWINBURNE does, that, in an alternator, the effect on the field magnets of the alternating current in the moving armature is the same as that of a steady current in a fixed armature, and that if the current lags the field is weakened, while if it leads the field is strengthened. The behaviour of alternators appears to be reduced to a simple neat rule, and all trouble due to armature self-induction, or to the constancy of this quantity for varying currents and positions of the armature seems to be entirely avoided. Unfortunately, a little consideration shows that the simplicity so gained is more apparent than real. From analogy with steady currents, one would imagine that the external behaviour of a dynamo depends merely on its external voltage and current, and that the relation between these quantities is definite for a fixed speed and excitation of the generator. This, however, is not the case with alternators, for the phase of the current with reference to the voltage is a new condition of supply, whose importance in determining the output is equal to that attributed to volts and amperes. For direct current machines running at a fixed rate, the terminal voltage is perfectly definite if the external current is given, but with alternators it may have very different values, according to the character of the circuit. The terminal voltage is much less closely connected with the output, than is the case with steady current dynamos. By means of condensers it may be raised till it is many times the electromotive force of the dynamo; and, as was shown originally by Dr. HOPKINSON and verified by Mr. MORDEY, it is possible to connect two alternators of very different electromotive forces so as to run in parallel, or so that either drives the other as a motor. There is thus no such thing as the external characteristic of an alternator, unless the nature of the external circuit is defined, but although the terminal voltage is so variable, the electromotive force of the machine is a constant, whatever the phase of the armature current, except in the unusual event of its exerting a powerful reaction on the field.

With the many other important matters alluded to by Mr. SWINBURNE, we have at present no space to deal. His advocacy of distribution by low pressure networks fed from transformer substations, in place of the present system of house transformers, will probably arouse far more attention in the future than just at present; and the many uses to which condensers can be put in connection with alternate current systems will be better appreciated when the difficulties connected with their commercial manufacture are overcome. Directly fairly cheap condensers, capable of withstanding high pressures, are placed upon the market, we believe their importance will be widely recognised.

It is to be hoped that a large portion of the discussion will be devoted to the question of the all-day efficiency of transformers. This is a matter of universal interest, although the public discussion of it appears to have been carefully avoided by those most concerned. Mr. SWINBURNE, in a paper read before the British Association in 1889, astonished everybody by advocating the old open circuit form of converter, and the reasons which he then put forward in support of his views have, up to the present, not been controverted. The present discussion offers the first opportunity which has arisen since that time for debating the question before the Institution of Electrical Engineers, and full advantage should be taken of it.

## THE ELECTRIC CURRENT AND ITS LAWS.

BY JOHN T. SPRAGUE.

§ 1. As these articles have a specific purpose, viz., the comparison of two theories which differ fundamentally, it may save time and misunderstanding if I commence by clearly defining the two theories in such manner as to render the distinctions obvious, and bring out the consequences of the difference.

§ 2. I have had some considerable difficulty in understanding what the new theory really is, and even now I am by no means clear that those who hold it do not differ very materially among themselves. I hope, therefore, that if I am in any way mistaken as to the theory and its limits, my error will be at once pointed out, as I have no desire to set up any "men of straw" for the purpose of overthrowing them.

§ 3. My first conceptions of the new theory were derived from Mr. O. Heaviside's articles on "Electro-Magnetic Induction and its Propagation" (*The Electrician*, Vol. XIV., p. 148, and especially p. 178), where, beginning with "Consider the Electric Current, how it Flows," he proceeds to analyse various conceptions, which I shall have occasion to refer to later on, and probably more than once, because, though I do not agree with his conclusions, his account is thoroughly clear, and in that article does not make wings to itself and fly into the regions of mathematical cloudland.

§ 4. After letting in the ether, "There is reason to believe ('Maxwell's Theory of Light') that it is not the air, but something between the air molecules, that is the electro-magnetic medium" of "transmission of energy and pressure parallel to the wire, all round it," he says, "In the state of steady current through a submarine cable with an iron sheath outside the dielectric, the energy is transmitted wholly through the gutta percha, thus nearly parallel to the wire, except as regards the lines near the wire itself, as they all eventually meet the wire."

§ 5. I shall return to this quotation by-and-by, but just now I want to have a point made clear. In the Editorial Note (p. 444) it is said that I "take uncertain ground when I boldly champion the notion that electric energy is conveyed longitudinally in the direction of the current." It appears to me that this is the case, whatever theory of transmission we adopt.

Digitized by Google

If the energy is supplied from the source, and transmitted to the work, that is longitudinal transmission; it is in the same direction as the current. As far as I can ascertain the real meaning of the new theory, although the current and the energy are transmitted by different agents, the current by and in the conductor, and the energy by the medium outside the conductor, yet the conductor or current holds the energy in bondage; in fact, some such control is inevitable, or why should the energy travel in a definite direction, or go to the intended work at all? That is the essential characteristic of electric energy, that it is linear and controlled in direction, as distinguished from the energy of light and heat, which are radiant, though even they can be to some extent controlled in direction.

§ 6. I should wish someone, say Prof. S. P. Thompson, in continuance of his definitions, to make clear what is meant by his words which I quoted (p. 406), "The energy of a so-called electric current is not transferred longitudinally along the substance of a conducting wire, but is transferred into it sideways;" also his words (p. 464), "The doctrine of lateral transfer." Am I right in supposing that the real meaning is the longitudinal transfer of energy from the source parallel to the conductor, but outside of it, in lines which turn down on the conductor in such number as to supply the energy which we know appears in the conductor as heat?

I wish to be certain of this, because Mr. Heaviside says that Prof. Poynting "holds a different view, representing the transfer as nearly perpendicular to the wire, with a slight slope towards the wire;" and I should like to have some notion how it gets to this perpendicular position, especially as Mr. Heaviside tells us (p. 388, § 15), "the electro-magnetic equations assert that the transference of energy in any isotropic electrical conductor always takes place across the lines of conduction current," and all these lateral, transverse and cross-lines seem to form a complete maze, to which a clue will be useful probably to many besides me.

§ 7. To save time, though not now directly in the course of my argument, I will ask to have another point made clear, which will by-and-bye be of great importance. How does the energy travel which sets up magnetism? Does it go by the "medium?" What is the function of the wire as regards the magnetisation of the core, the setting up of lines of magnetic force and doing work through those lines? There is even a preliminary question. Where does the energy come from which sets up the magnetic charge of the circuit itself? Does it come direct from the source, *viâ* the "medium?" Does it continue on this route after magnetism is set up before going to the waste pipe, or does this energy issue from the conducting wire? I only ask this so that we may know what the new theory really is, as I can answer it all readily enough on the other theory.

§ 8. This magnetic charge of an electric circuit I propose to call the *magnetance*. Here I must digress for a moment; I must confess that I have tried very hard to fully understand what Mr. Heaviside tells us about this (p. 448), but my success is far from complete. I do not quite see whether, in § 25, p. 449, his $g$, which he calls the "magnetic conductivity," but thinks it needs no name, as its existence is doubtful, is intended to be the same thing as what I mean by *magnetance*, which, it seems to me, has a very certain and thoroughly-known existence. But it is likely that this difference arises from his treating magnetism as a *flux*, while I regard it as purely a *stress*. He says: "The idea of a magnetic current is a very useful one," and "the magnetic current $\dot{B}$ is, of course, real." I consider that the idea of a magnetic *current* is a pure absurdity, devised in the effort to set up a magnetic analogy to Ohm's law in electricity, while the true analogy is not to an electric current, but to a condenser charge. This is no matter of words; it involves very important theoretical considerations, which may have equally important practical results.

§ 9. In connection with this, I will make § 21, p. 448, the text of another digression to a point of importance. "All space must be conceived to be filled with a medium which can support displacement and induction." We are told it is a dielectric, and though this medium is the ether, that we may "understand by a dielectric, a medium which supports both the fluxes mentioned." That is, electric and magnetic.

I have now for several years vainly invited a reply to my proofs that electric and magnetic fluxes, lines of force (call them what you will), do not exist and cannot exist in space: that if they did, the force of gravitation would be complicated with their effects, and the cosmical bodies would play all manner of pranks.

Until this is disposed of these "conceptions," however useful for a special purpose, are wanton hypotheses opposed to known facts and the laws of nature; so this seeming digression strikes at the very roots of the theory I am opposing.

§ 10. At first it appeared to me that these new theories converted the "current," not merely into a fifth wheel to the coach, but into a mere incidental encumbrance. Mr. Heaviside (Vol. XIV., p. 179), says "The energy current becomes continuous in the dielectric, goes round an external conductor instead of entering it, as it would in the transient state, and finally reaches the conductor to which the battery is connected, penetrating which it terminates." Again, "With infinite conductivity (of a wire, that is) there can be no current set up in the wire at all" (that is, in the variable stage). As a result, we are told that the conductor has merely the function of a "waste pipe." I think this is the only instance of such an apparatus among the implements of Nature; energy is always expended in useful effect of some sort, never in pure waste; only boys need to work off superfluous energy in pure mischief, and this appears to be the case here. "What, then, is the wire? It is the sink into which energy is poured from the dielectric, and there wasted. All difficulties now disappear." Do they? Then we learn (p. 389 of this volume), that "electrical conductors act, as regards the internal propagation, not as conductors, but rather as obstructors," though it is then explained that they control the energy, as I said (§ 5).

§ 11. Then Dr. Hertz says, "It is very difficult to tell an electrician of the elder school that lightning does not go through copper or iron, but by means of air or gutta percha or insulators," and yet lightning is usually called an electric current. Dr. Lodge, too, says that the conductor does not conduct anything, not even an impulse, and its use is to dissipate energy coming from the medium. Prof. Thompson wrote about "so-called electric currents," and a merely common-sense person may naturally come to the conclusion that Ohm's law was to be thrown into the waste-pipe, or at best stored in a museum of superseded antiquities.

§ 12. Let us then understand that, as Prof. Thompson says, it is still believed, in the new dispensation, that Ohm's law is valid, and that it does yet reveal us the facts of the current, Only the current has no use except to carry off waste energy. Now this point ought to be made a little clearer, and I hope someone will explain my queries (§ 7), and let us know what is the function of the so-called conductor in magnetising, and, above all, why magnetism is proportionate to the ampere turns. It would be interesting to understand why a mere "so-called current" and the convolutions of a waste-pipe are so important.

*(To be continued.)*

## TRANSFORMER DISTRIBUTION.*

BY J. SWINBURNE.

The distribution of electrical power by means of alternating-current transformers can hardly be considered to have reached its final state, and though it may be somewhat difficult to say what system will be in general use ten years hence, there is little doubt that present practice will be largely superseded.

The method now in vogue is simple: it consists of running several independent dynamos, each with its own engine. Each dynamo supplies a few high-pressure mains, which branch off, and supply transformers placed in the houses, or wherever light is required. This system, admirable for country towns or straggling villages, is

* Paper read before the Institution of Electrical Engineers, February 19, 1891.

Digitized by Google

hardly likely to be permanent anywhere else. It has many disadvantages. Except that all the dynamos and engines are in one building, it is nothing more than a collection of little independent installations. Each engine and dynamo supplies its own circuits, which are independent of all the others. In cases of a breakdown of an engine or dynamo, and in many cases of the leads, there is a stoppage till new arrangements can be made at the station. In addition to this, great lengths of high-pressure conductor are required, and this leaves openings for breaking down of insulation. The introduction of high pressures in private houses is dangerous if not well managed, and is in any case expensive, demanding compliance with all sorts of regulations, rendered necessary for the security of the public. The greatest drawback to the present system, however, lies in the waste of power in the transformɛrs themselves. For a long time transformers were supposed to have an efficiency of about 98 per cent. More will be said on this subject presently.

It must be borne in mind that in spite of the drawbacks of the present system of putting transformers in houses, it may be, and probably has been, advisable for electric light companies to begin on that system, even in such places as London ; but I do not think such an arrangement will pay in the long run, and a time will arrive when the mains will have to be changed and a low-pressure supply system substituted. When an electric light company begins, it has to take on houses here and there, where it can get them ; but if its district is populous and wealthy, it should soon be enabled to work on some low-tension or sub-station system ; and then the question is whether it is not better to lay the low-pressure mains at first, instead of beginning on one system and changing to another. Probably none of the existing companies mean to change from one system to another. Their engineers have no doubt gone into the merits of the particular cases, and have come to their conclusions with great deliberation, and I do not think it well to offer any criticisms lightly.

*Parallel Running according to Orthodox Hypothesis.*

To begin at the beginning of my somewhat extensive subject, the first question is that of running machines in parallel. There are few matters of greater importance to engineers, and few on which opinions differ so widely. One says that machines will not run in parallel unless they have large self-induction ; another that it is necessary to have iron in the armatures ; another that they will only run together if they have no self-induction, or as little as possible. Others say that there is no difficulty in running them in parallel. No engineer who employs direct currents denies the advantages of running machines in parallel ; if independent running is advisable in alternate systems, it is equally advantageous in the case of direct currents, and direct-current stations should have separate circuits for each little district, each district being run by one dynamo. I do not think, therefore, independent running is a-lvisable.

In 1884 Dr. Hopkinson showed that alternate-current dynamos could be run in parallel, or could be run as dynamo and motor, and even that a machine giving a high pressure could be run as a motor off a circuit of lower pressure. In his Paper he assumes that machines have "self-induction." He points out that the self-induction varies, but that it would be impossible to work out the calculations if the "self-induction" were taken as variable. For some reason or other, Dr. Hopkinson's calculations have received little application. That is to say, engineers have not taken actual cases and worked them out. Calculations have been made in which the various quantities have appeared in the form of letters, and diagrams have been drawn in which they are represented by lines whose lengths have been chosen at random. The geometrical treatment of many problems of this kind shows most of the actions very clearly to students, but is not always of value in practical work, as in most cases some lines are so long and others so short that it would be difficult to avoid large errors. The result of this is that few of us, if any, have had a definite idea of how much "self-induction" a machine should have to make it work well in parallel with others. The general impression is that it is somewhat difficult to design a machine whose "self-induction" is large enough, and that most failures to run in parallel are due to deficiencies in this respect. I am using the term "self-induction" under protest, as I prefer to look at the question from another point of view. But whatever goes on in a dynamo, if the no load electromotive force is treated as constant, a value for a constant coefficient of self-induction can be assumed which would produce results somewhat similar to those found in practice. To overcome the difficulties arising from deficient self-induction in the armature circuit, Dr. Hopkinson has proposed to insert it artificially, in the form of chøking coils, or to use induction couplers to compel synchronism. Without knowing that it had been done before, I described a similar arrangement to the Institution a few years ago.

In the spring of 1890 Mr. Mordey read a most important Paper, in which he described some experiments on alternate machines. He argued from them that self-induction was deleterious, and that machines would run together best if they had none. In the discussion, Dr. Hopkinson pointed out that the experiments were quite in accordance with his theory, and that there was nothing that could not be foretold by it.

To begin with, it is necessary to get a clear idea of what is required for parallel running. It is not exactly the same as the case of alternating motors, neither is it the same as two machines of equal pressure coupled in parallel by themselves. If all the machines are coupled to two main conductors, we may consider them one at a time, and take each dynamo as coupled to a system whose pressure and variations of pressure are independent of it. Suppose the effective pressure to be 2,000 volts, for example : we have to consider a pair of mains with 2,000 volts, and we have to couple on a dynamo to add so many amperes to it. Such a machine must not be excited to give 2,000 volts on no load, being then thrown into circuit with full steam turned on immediately afterwards. It should be excited to give somewhere about half load with 2,000 volts at the terminals, and should then be thrown in. Steam can then be turned on, and the excitation raised to its normal value. The machine should be so designed that any excessive power that the engine may give shall not only not throw the machine out of step, but shall not increase the armature current to such an extent as to damage the insulation by excessive heating.

The power absorbed by a dynamo working on a parallel system is

$$P=\frac{B^2 r}{2 i^2}-\frac{A B r}{2 i^2}\cos 2\pi n \tau+\frac{A B L}{2 i^2}\sin 2\pi n \tau,$$

where A is the maximum station electromotive force—that is to say, the station pressure is $A \sin 2\pi n t$—B is the maximum "impressed" electromotive force in the armature, $r$ is the armature resistance, the impedance of the machine, and $\tau$ the angle of lead. This equation is taken from Dr. Hopkinson's Paper. When the dynamo is doing its proper share—that is to say, under normal conditions—

$$B=I c,$$

where I is the impedance of the whole circuit when the machine is isolated, and working at full load on an external resistance, and $c$ is the maximum value of the current. To find how much the driving power may increase for a small increase of current, we may differentiate with respect to $c$, and then find the value of L which makes the result a maximum.

$$c=\sqrt{\frac{A^2+B^2-2 A B \cos 2\pi n \tau}{i^2}}$$

$$\operatorname{Cos} 2\pi n \tau=\frac{A^2+B^2-i^2 c^2}{2 A B}$$

So,

$$\frac{dP}{dc}=\frac{A B r}{2 i^2}\cdot\frac{i^2 c}{A B}+\frac{A B 2\pi n L}{2 i^2}\cdot\frac{d \sin 2\pi n \tau}{d 2\pi n \tau}\cdot\frac{d 2\pi n \tau}{d \cos 2\pi n \tau}\cdot\frac{d \cos 2\pi n \tau}{dc};$$

and in the case of a dynamo working on resistance, or on a station load when supplied with just its right share of power,

$$\cos 2\pi n \tau=\frac{A+r c}{B},$$

$$\text{and } \operatorname{cosec} 2\pi n \tau=\frac{B}{L c}.$$

So,

$$\frac{dP}{dc}=\tfrac{1}{2} A+c r,$$

$c$ being the maximum, not the effective current. It will be observed that L has disappeared altogether.

This shows that for a very small increase of power the increase of current will be the same, whatever the self-induction of the machine may be. It would not matter if the machine had none. A machine with no self-induction would (Mr. Mordey notwithstanding) short-circuit the mains if the engine supplied too little power ; in fact, at full load it would be giving its minimum possible output, and any attempt to diminish this would be disastrous.

Discussing the question of a very small increase is not exhaustive ; an engine may supply a large proportion more than its share of power to one machine. For instance, suppose it supplies twice the normal power. Many engines could not give such an excessive power, but in others which have expansion gear controlled by a speed-governor, it is easy to get double power if the station is running at a slightly slower speed than that for which the governor is set.

These matters are always made much clearer by taking practical examples and working them out. The great difficulty is to obtain accurate data. I should prefer to discuss such machines as those described in Mr. Mordey's Paper read here a short time ago. Without wishing to say anything in disparagement of his excellent Paper, I must point out that an account of experiments should contain full particulars of the machines on which the experiments were made. Such omissions are exceedingly common in electrical

Digitized by Google

Papers. Mr. Mordey has not given us the details of the field magnets, air space, armature coils, or exciting coils; he has not even given us the currents in the different experiments. I have found similar omissions whenever I have tried to gain information from any of the numerous experiments which have been made on alternate machines in America. Mr. Mordey does, however, say that about half the drop in his machines is due to resistance, and half to self-induction. The machines give an output of 2,000 volts and 20 amperes, and when fully excited give 2,200 volts at no load. This would correspond to a self-induction of 0·05 henry.

Suppose, first, that the self-induction were such that $2\pi n L = r$: on increasing the power supply, the effective current increases evenly, and when the power supplied to the machine is doubled, the effective current is only about 44 amperes. It is necessary, however, that the machine should stand decrease of load, as well as increase, without injury. Keeping the same self-induction, let us decrease the load to zero with the full excitation on. The current gradually diminishes to just below 15 amperes, and then increases to just over 20 again.

These figures are extremely troublesome to work out from Dr. Hopkinson's equations, as the angle is so small that an error in about the sixth place of decimals will vitiate the results.

Many people prefer diagrams such as those used in mathematical books when dealing with harmonic variations. Mr. Blakesley has applied these diagrams to the discussion of alternate dynamos and motors, and Messrs. Kapp, Fleming, and others have applied them too. The chief drawback is that it is not always easy to draw such figures to scale. They are generally drawn with the values taken at random, to give ideas of the principles involved. So far as I know, no scale diagram of this sort has ever been published. In the case of the 40,000-watt machine such diagrams can be applied but with 100,000-watt machines, which will probably be the standard size, the diagrams are almost illegible.

Fig. 1 is a diagram to scale. The lines are all rotating positively. The diagram is made as follows:—The pressure in the mains, A, is drawn first. Instead of the maximum, it is simpler to draw the effective pressure—in this case 2,000 volts. From the end $e$, $2\pi n L c$ is drawn at right angles to it to $f$; and then $r c$ from $f$, parallel to A, B, is drawn to join the ends of A and $r c$, as shown. The lines are all pressures; but the instantaneous current is in

Fig. 1.

step with the pressure $r c$ and with the pressure A, so that the power is proportional to $B\, r c \cos f d m$. I use the expression "in step" to mean co-phasally synchronised. Thus two machines may be running at the same speed without being in step; just as soldiers may take the same number of paces per minute without being in step.

To find the current at double load, produce $i c$ to $g$, so that $d g = 2 i c$. Through $g$ draw a straight line cutting B at $k$, at an angle, $g k d$, equal to the angle $d e f$. The line $g k$ is the locus of the end of the line representing the pressure spent over the resistance and self-induction of the armature with currents giving double load. It is unnecessary to go into the proof of this. With $m$ as centre and A as radius, describe arc cutting $k g$ at $h$; join $d h$. Then the current at double load is to 20 amperes as $d h$ is to $d e$. In this case the double-load current is not much more than 40 amperes.

To find the current at half-load, bisect $d e$, and through point of bisection draw a straight line parallel to $h k$, and proceed as before. The no-load line, of course, passes through $d$.

Let us now assume the self-induction to be 0·05. The resulting diagram is shown in Fig. 2. The double-load current is almost exactly 40 amperes.

Take now the case of a 40,000-watt machine with a self-induction of 0·1. At double load the current is 50 amperes, and at no load it is only 1·6 amperes. If the machine has a self-induction of much more than 0·1 quadrant, the current at double load begins to increase rapidly. It is thus clear that the self-induction may have any value between 0·008 and 0·1 and the machine will work perfectly in parallel.

We have only taken small machines. Mr. Kapp recently described a 60,000-watt machine with an armature resistance of 1·74 ohm, and a self-induction of 0·0955—say of 0·1. We may see how it will work in parallel. The pressure is 2,000 volts, and the frequency 80. This case cannot be shown clearly in a diagram, as $r c$ is very small in comparison with $2\pi n L c$ or B. The result is, however, that the machine cannot possibly take double power from the engine; it falls out of step first. Now 60,000-watts is not a large output for central stations, and it is probable that 100,000 will be about the size adopted. The "time constant" of such a machine is considerably greater. We thus find that according to the self-induction hypothesis the difficulty does not lie, as commonly supposed, in getting enough self-induction in the armature; the trouble is that there is generally too much. But in machines from 25,000 to 50,000 watts it is exceedingly difficult to make dynamos that will not run perfectly in parallel, so great is the permissible margin of self-induction. It must be carefully borne in mind that so far the armature has been supposed to have a constant coefficient of self-induction, and the pressures of current are assumed to vary harmonically.

The orthodox hypothesis thus tells us that with ordinary sizes of machines it is exceedingly difficult to design them so that they will not run in parallel. Either, therefore, all ordinary machines run

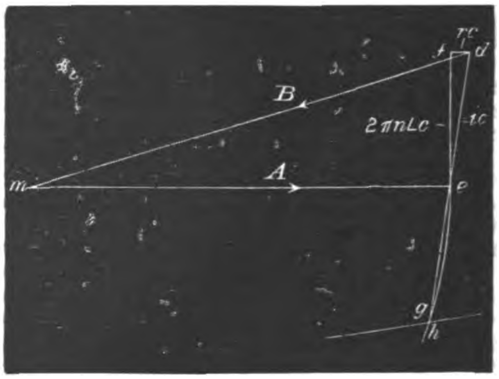



Fig. 2.

perfectly in parallel, or the assumption that alternating currents follow sine laws, that machines have coefficients of self-induction constant throughout each period, or that they have coefficients of self-induction constant for different armature currents, is too far from the truth to be useful; or, in legal language, one or some or any or all of them must be wrong.

*Parallel Running according to Armature Reaction Theory.*

Last year I had the honour of reading a Paper before this Institution on armature reactions in direct-current machines. In it I showed how the performance of large machines could be foretold; and the whole question of the effect of the armature current on the field magnets was discussed with some minuteness. I cannot pretend to treat alternate-current machines with the same exactness, but still a great deal is to be derived from the study.

It has sometimes been assumed that a machine has self-induction in the armature, and also that there are armature reactions to be considered, and the two actions are treated as if their joint effects had to be taken into account. This view is, I submit, erroneous.

Fig. 3.

Imagine a battery with its cells connected to a number of contact pieces, and imagine the middle cell connected with a terminal, to represent one terminal of the machine, and the other terminal represented by a rubbing contact which is moved backwards and forwards over the cell contacts by a crank and connecting-rod. This gives the analogue of a hypothetical machine with no self-induction. If a choking coil is put in circuit, the hypothesist's alternating machine would be produced. To get a constant coefficient of self-induction in a real machine would be almost impossible. If a coil passes between two cheeks of laminated iron, its coefficient of self-induction is constant. In a dynamo, however, half the iron is cut away, the remainder forming the pole-pieces, and this remainder is not laminated. Even if a dynamo gave a curve of sines at no load, therefore, the reasoning already given would not be accurate, as L would vary considerably from one part of the period to another.

The term "self-induction" is also used somewhat loosely. Engineers do not generally think of electrical inertia now. By a self-induction 1 in an electric circuit, is meant that if there is a

Digitized by Google

current of 1 in it, it is interlinked with one line of induction. The idea of self-induction is naturally inseparable from the notion of magnetic induction being interlinked with the circuit. Another way of looking at it is to say that if the current increases there is a back electromotive force proportional to the rate of growth of the current, and to the self-induction of the circuit. In an alternate dynamo the first definition is meaningless, because there is a field produced by the magnets; so, when the machine is still, there may be a large number of lines of induction through the armature coils without any armature current. If the second definition is taken, there is likewise an electromotive force produced by the passage through the field, apart from the effect of the armature current.

Take the case of a machine like the Siemens, with coils passing between poles. If there is a continuous current in the armature, in some positions it will assist the field-magnets, and in others it will to some extent weaken them, while in intermediate positions it has no effect on the magnets as a whole. In an alternate-current machine, though the armature current is alternating, relatively to the field-magnets, it is direct. If a series of instantaneous photographs of the armature current could be taken, each part of the air space would have its direct current.

Fig. 3 is a diagram of the field-magnet poles of a machine. There are supposed, for simplicity, to be twice as many pairs of poles as there are armature coils. If one side of a coil is between each pair of poles, if there were no armature current the fields would be inducing a maximum pressure. If the pressure curve of such a machine were traced, and placed in the diagram of the poles, it would be as shown in Fig. 4. The positive direction of the current or pressure in the armature and field-magnet coils is shown by shading, the negative by dotting. If electricity flows in the armature when the sides of the coil are in the active fields, one side of the field between the poles is strengthened and the other weakened, as shown in Fig. 3. This action is fully explained in the case of direct currents in my Paper already referred to; but in alternate machines the action is much more complicated, for there is no longer a continuous succession of conductors each carrying the same current as it passes any given position. If the pole-pieces were laminated, the distribution of field would vary as each conductor passed; but as it is not laminated, Foucault currents developed in the pole-pieces tend to check variations under influences varying from 200 to 600 per second. The field thus becomes stronger on one side. The curve of pressure thus gets displaced, as shown in Fig. 5.

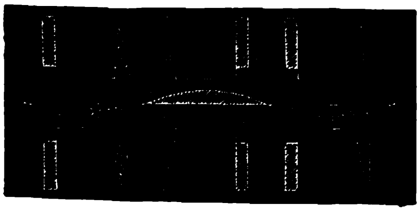


Fig. 4.

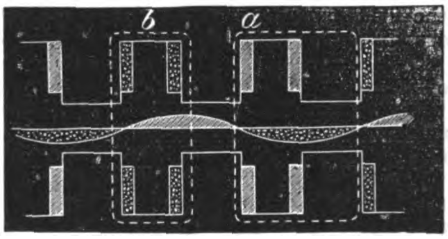



Fig. 5.

Fig. 6.

If the external resistance is non-inductive, this may be regarded as a current curve. It will be seen that each magnet is now exposed to the back induction due to the armature current. A circuit, *a*, taken round the field-magnet circuit is interlinked with the whole wave. The line integral is not changed if it is taken round any other circuit, so that the sides are the same distance apart as they are in *a*. A circuit taken as shown at *b*, however, includes only half a wave; so that from Fig. 5 both the cross and the back induction could be completely worked out. In most machines it is impossible to make such a diagram accurately; but in others, such as drum armatures, with poles and coils of given widths, it is not so complicated.

The effect of the armature current, then, is first to make the current lag relatively to the position of the field-magnets, and then to lessen the pressure as a whole. It thus resembles the effect of the insertion of artificial self-induction.

I think to call all this "self-induction," and to assume the harmonic law just to make calculation easy, is disguising the real nature of the action, and may lead to very serious errors. The armature reaction theory is also infinitely easier to understand, and to follow in one's head. The result of it is, in short, that if the current lags, the field is weakened; if it leads, the field is strengthened. If the current is in the direction agreeing with the electromotive force of the machine, it tends to lag, owing to cross induction; if it is against the electromotive force of the machine, as in the case of a motor, it tends to cross-magnetise the fields in the opposite direction.

We may now examine the question of parallel running from the armature reaction point of view. Though it may be out of its proper place in the Paper, the question of motors may be to some extent discussed at the same time.

Suppose, as in the first case, a pair of terminals in connection with a station, so that the electromotive force on them is independent of any current, or of the machine under discussion connected to them. It is necessary to keep clear, for the moment, of any ideas connected with L. The armature circuit must be regarded as devoid of "self-induction."

A machine without friction may be imagined, and when its field-magnets are separately excited, so as to give an electromotive force exactly equal to that of the mains when it is connected so as to be in step, it runs as a motor taking no current. At each instant the electromotive force of the machine is exactly equal to the electromotive force of the mains, so no current passes. On putting on some load the machine begins to lag. As soon as the machine lags, a current passes through the armature. The current due to the difference of two equal alternating electromotive forces is not in step with either of them. This is shown in Fig. 6, where two pressure curves are drawn a little out of step. The current through resistance is proportional to the shaded parts. If the electromotive force of the machine were still the same as that of the mains, it would still develop no power as a motor, because at some parts of the period it would be supplying power to the mains, and at other parts the mains would be supplying power to the armature; for at any instant the armature current would be equal to the difference of the two electromotive forces divided by the resistance of the armature. The average current curve is shown in Fig. 7. The electromotive force of the machine does not, however, remain equal to the main electromotive force, merely differing from it in phase, but is decreased by the reaction of the armature current on the field-magnets. The average current curve shows that there would be considerable back induction, or many ampere-turns tending to weaken the field. This weakening of the field by the armature reaction allows the main also to supply a current against the electromotive force of the machine, so that it acts as a motor, and power can be taken from it. If the load is altered, the machine will increase or decrease its lag, so that its effective field is reduced to just the right value to allow the machine to absorb electrically the power taken from it mechanically. As lag is necessary in order to weaken the effective field, so the current in the armature is no longer in step with the electromotive force of the mains. The result of this is that it is not at the maximum value at the same instants as the electromotive force is; so that

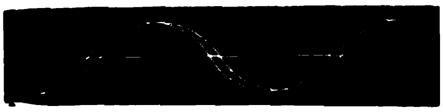


Fig. 7.

the power taken by the motor is less than the product of the effective electromotive force of the mains and the effective current of the machine. The electromotive force and current may be so much out of step that the power of the motor is small, though the armature current is large. The availability of the machine as a motor thus depends on the resistance of the armature, and on its reaction on the field. For instance, if the machine has very little armature resistance, a very small reduction of its electromotive force will allow a large armature current to pass. If, on the other hand, the armature resistance is high, the armature must have a large reaction on the field so as to reduce the effective electromotive force. If, at the same time as the load is put on, the field of the motor is artificially weakened by reducing the excitation—for instance, by the insertion of resistance in the field circuit—the electromotive force of the machine may be reduced enough to allow current from the mains to act in step with the main electromotive force. For instance, if the supply circuit is of 2,000 volts, and if an ordinary separately excited 2,000-volt machine is connected, and excited so as to give 2,000 volts with the same frequency, and if this machine is loaded as a motor with 40,000 watts,

or 54 horse-power, it will lag until the field is weakened enough to let enough current pass to give the power. This current will be more than 20 amperes. But if the machine as a dynamo can give 20 amperes with the loss of 100 volts in the armature, due to the resistance, and if the machine is excited so as to give 1,900 volts on open circuit at the normal speed, and is then thrown into the circuit at an instant when it is in step, and a load of 38,000 watts, or 51 horse-power, taken out, it will remain in step; for the electromotive force of the machine is always just enough below the main electromotive force to allow the right current to pass. The effective current is then 20 amperes. The main circuit thus supplies 2,000 volts and 20 amperes; 2,000 watts are lost in overcoming the resistance of the armature, and 38,000 are available at the pulley. The losses by friction and Foucault currents are here neglected for the sake of simplicity. In practice a little less than 51 horse-power would be obtained for external use. If the field has not been weakened by reducing the excitation, the effective current—that is to say, the root of the mean square of the current, or the current as measured by an electro-dynamometer—would be more than 20 amperes, so that there would be extra loss of power in the armature.

If the machine is to be worked as a generator in parallel with the main circuit—that is to say, if it is to supply power to the mains instead of to take it from them—the same reasoning holds good. If the machine is excited so as to give 2,000 volts at no load, and is thrown into circuit at an instant when it is in step—if the engine supplies just enough power to overcome friction, there will be no armature current, as the electromotive force of the machine will, at every instant of the period, be exactly equal and opposite to that of the mains. If the engine supplies just a little too much power, the machine will begin to lead, and an armature current will pass, which will strengthen the fields by reaction, and the machine will at some instants act as a generator, because its electromotive force is now a little higher, as the armature current has strengthened its field. Similarly, if the steam of the engine were completely shut off, the machine would lag until it worked as a motor. If now the steam is turned on until the dynamo supplies 40,000 watts to the mains, the machine will increase its lead until the armature current strengthens the field enough to give the full output. The armature current must be out of step with the electromotive force of the machine.

In these examples back induction has alone been considered; but the effect of cross induction must also be taken into account. Cross induction, in the case when the machine is working as a dynamo, makes the current lag. This weakens the field, and counterbalances to some extent the effect of the leading current, due to the pressures being out of step. A still greater lead is therefore necessary to make the machine work as a dynamo. Suppose, however, that the field excitation is strengthened to balance this back induction, as well as the loss by armature resistance—that is to say, suppose it is excited to give 2,000 volts, and 20 amperes on resistance, in spite of the armature reactions—it will run in step on the mains.

*(To be continued.)*

## THE STRIKING DISTANCE OF ALTERNATING ELECTROMOTIVE FORCES.*

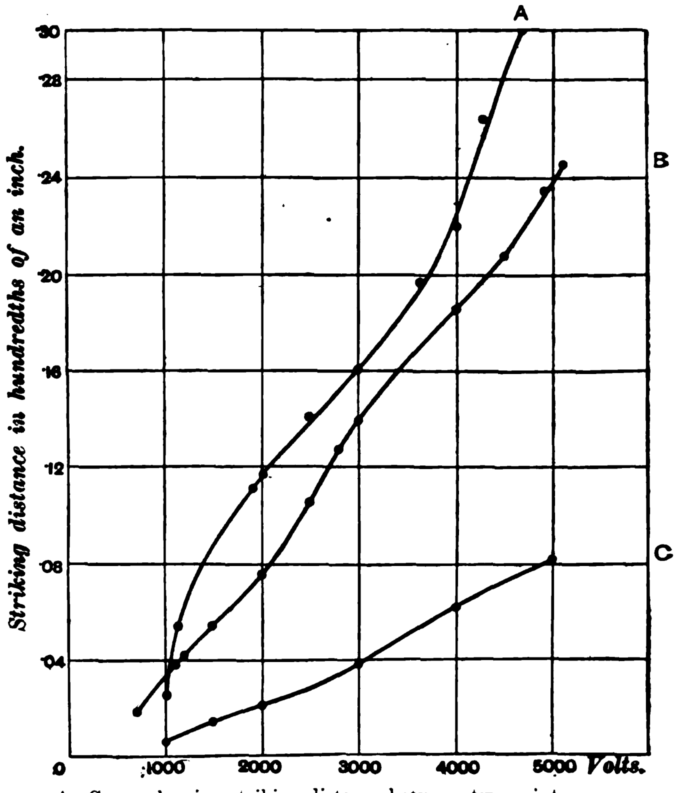
BY ROBERT SHAND.

Prof. Elihu Thomson, while engaged upon experiments involving the use of alternating currents having a pressure of several thousand volts, found it necessary to ascertain the spark lengths which the pressures he employed were capable of producing, and also the charge of spark length produced by increase in the density of the air through which the discharge occurred.

It is well known that numerous and elaborate experimental inquiries have at different times been made, having for their object the determination of the ratio of spark length or striking distance of a discharge of electricity in air (and various other gases) to the electromotive force producing it, and the determination of the law governing the increase of striking distance with decrease in the density of the air. For the production of the high electromotive force required in the experiments, plate machines, Leyden jars, the Ruhmkorff coil having a vibrator in the inducing circuit, and voltaic batteries, consisting of a very large number of elements, have been employed. The results obtained have been represented by formulæ, and arranged in tables which can undoubtedly be applied with certainty to cases the conditions of which correspond with those obtaining in the experiments the results of which they represent.

* From the *Electrical World* of New York.

None of these experiments, however, afforded data fitting the special cases occupying the attention of Prof. Thomson, who, therefore, with the object of satisfactorily deciding the matter, caused to be made at his laboratory experiments, the results of which are graphically recorded on the accompanying diagram, which explains itself. The discharges took place inside a spherical glass vessel five inches in diameter, and having three openings fitted with brass caps and leather collars. Through two of the openings, situated opposite each other, passed the discharge rods. The third opening could by means of a tap be opened to the outer air or connected with a pipe leading to a pressure pump. To indicate the distance separating the electrodes between which it was arranged the discharge should occur, one of the rods had a screw thread of one-fortieth inch pitch cut along that part of its length which worked through an opening in the glass sphere. It was also fitted with a graduated disc, which rendered small fractions of a revolution of the rod readily observable. Wires from the secondary terminals of a small transformer were led to the discharge rods, the potential difference between which could be varied between the limits of 600 and 7,000 volts. The voltmeter used was one of Sir William Thomson's vertical scale electrostatic instruments reading to 6,000 volts. An ordinary steam pressure gauge having large scale divisions was calibrated and used for the measurements of air pressures.




A, Curve showing striking distance between two points.
B, " " " point and sphere.
C, " " " two spheres.

In making the experiments the electrodes were brought toward each other until contact was indicated. The position of the discharge rod carrying the graduated disc was noted, and it was then withdrawn to a distance indicated by the number of revolutions of the rod.

The primary circuit through the transformer being closed, the pressure was increased until discharge occurred, the potential difference indicated by the voltmeter at the instant of such discharge being noted. In order to have the points of the voltmeter move steadily over its scale without vibration, it was found necessary to increase the pressure very slowly.

When observing the effect of increased air density on the spark length, the air pressure and electric pressure were maintained at a constant value and the electrodes moved nearer together until discharge occurred; the spark length was then the remainder of the distance the electrodes would have had to move through before making contact.

The object in using pointed electrodes was to find the lowest potential difference capable of producing the spark; consequently the points were made as sharp and as perfect as the means at command rendered it possible to make them. It is obvious, nevertheless, that however great the care exercised, they must necessarily be more or less imperfect after each restoration. To this cause is undoubtedly due, in large measure, a somewhat irregular form of the curves showing spark lengths where a point or points were employed.

Digitized by Google

An inspection of the point and sphere curve shows a discharge through ·019 of an inch of air produced by a potential difference of 700 volts. It serves to show the delightful uncertainty of points. This one was, doubtless, well made. When compared with point curves, the smooth, regular character of the sphere curve is noticeable, also the fact that the decrease of potential difference per unit length of air sparked through, with increase of potential difference and spark length, is more marked than in the case of points.

It was observed that when the spark occurs under pressures exceeding one atmosphere, the slope of the curve grows less steep as the spark length is shortened by increase of air density. It would thus appear that the dielectric strength of air is not simply proportional to its density for pressures above two atmospheres. At pressures below two atmospheres, however, it would appear to be approximately so. A remarkable elongation of the spark was effected by heating the electrodes ; the elongation was greater than the rarefaction of the stratum of air included between the heated electrodes would appear to explain.

The results of these experiments being required for application under practical working conditions, no special care was taken to dry or filter the air in which they were made.

## PARIS NOTES.

(FROM OUR OWN CORRESPONDENT.)

PARIS, *February* 25, 1891.

At the meeting of the Société Française de Physique on Friday last, M. Hospitalier made some remarks on electricity meters which, in view of the fact that he is one of the committee engaged in examining the instruments sent in to compete for the Paris municipal prize, were of considerable interest. The meters have, I understand, all undergone the preliminary tests, and a select few are now being further examined. M. Hospitalier divides electric meters into two classes, namely integrating and registering instruments. The first class he further divides into time counters, current meters, energy meters, and integrating conductivity meters, according as they measure T, $E\int I\,dt$, $\int E$, $I\,dt$, $E^2\int \frac{1}{R}\,dt$.

The instruments belonging to the three last sub-divisions are not all equally suitable, and M. Hospitalier showed by a series of curves that if the pressure is below the normal, the price of the kilowatt-hour will come out differently for different instruments. Thus, the indications of a watt-hour meter will not be affected by variations of pressure ; but in the case of an ampere-hour meter the consumer is charged for more energy than he receives, since such an instrument takes no account of the diminished pressure at which the current is supplied, and the same holds good, only more so, in the case of a "mho-hour meter." "Mho-hour meters" are, therefore, the least suitable apparatus of all. With regard to watt-hour meters, it must be remarked that although variations of pressure do not affect their indications they affect the consumer in a most injurious manner. If he is wired with 100 volt lamps, no amount of current at 90 volts pressure will make his lamps burn brightly, and if the pressure rises to 110 volts there are lamp breakages to pay for. An ideal meter, therefore, would be one which, as was pointed out by Prof. Forbes at the Society of Arts in January, 1889, registered according to the *quality* of the energy supplied. M. Hospitalier concluded his address with brief descriptions of several meters, such as the Elihu Thomson, Hartmann and Braun, Richard, Batault, and Laurence-Scott, which had been brought out since his Paper of 1888.

The experiments on the de Meritens cell, which re being carried out at the Ecole de Physique et de Chimie, have already resulted in demonstrating that the cell works just as well without as with the platinised lead foil on the carbons.

I have just learnt that Woodhouse and Rawson United have purchased M. Mildé's concession for the sector starting from the Madeleine and comprising the St. Lazare Station, the Boulevards Malesherbes, Haussmann, the Arc de Triomphe, de l'Etoile, and the Porte d'Asnières. The same firm also intend founding a French manufacturing branch. The Brush Company, Mr. Ferranti, Messrs. Mather and Platt, the Thomson-Houston Company, and the De Khotinsky Company, all propose, I believe, to go in for genuine manufacture in France if they find that they are able to obtain protective rights under the new customs tariff.

As the question whether electric supply is a paying business or otherwise is as much a moot point with you as with us, it may not be without interest to give a few figures relating to the profit and loss account of the municipal station at the Halles during the first three quarters of 1890. The plant at this station comprises six 50-kilowatt Edison machines and three 110-kilowatt Ferranti alternators, the high and low tension mains being kept entirely distinct. The outlay at the generating station amounted to £23,900, and the mains cost £16,500, a total expenditure, therefore, of over £40,000 was incurred. As the alternating plant has only come into operation quite lately, its earnings do not figure in the balance-sheet. Taking the low-tension supply only, we find that its working expenses amounted to £6,920 and the receipts to £11,840, leaving a balance of £4,920, and reckoning depreciation, water, and miscellaneous expenses at £3,200 we arrive at a net profit of £1,720, which means that the low-tension plant earns a net revenue of 10 per cent. on the money sunk on it.

The large shop known as "Old England" has just been switched on to the mains of the Société Anonyme d'Éclairage Electrique, which employs the five-wire system. The installation comprises 14 8-ampere, and 22 6-ampere arcs and 50 16 candle-power incandescents. The Gare d'Orléans is about to be lighted by electricity on the Ganz system. At Marseilles the gas company propose to erect a number of miniature electric lighting central stations, each one to serve a block of buildings, and the motive power to be derived from gas engines.

## VIENNA NOTES.

(FROM OUR OWN CORRESPONDENT.)

VIENNA, *February* 21, 1891.

The Empress of Austria is building a magnificent château in Corfu, supplied with every luxury, and among others the electric light. The contract has been given to the International Electric Company. Their manager, Mr. Max Déri, will personally supervise this installation.

In Vienna the effect of the electric light in St. Stephen's-place, Kärnterstrasse and Ring has been curious. Formerly these streets were practically deserted after half-past seven, though in the daytime filled with fashionable pedestrians. Since a large number of the best shops have introduced the electric light these streets have quite altered their evening character. Instead of being deserted early they are now crowded till quite late.

The Austro-Hungarian State Railway Company have decided to light their express trains by electricity. The first experiment is to take place with a train of eight carriages, and Tudor accumulators are to be used. The towns of Mähr and Chozen have decided to adopt the electric light. The Mähr installation is to consist of 28 1,000 candle-power arcs and 2,400 16 candle-power glow lamps. The sugar factory in Tobischau, the large brewery in Liesing, near Vienna, and a large number of factories in Bohemia are also introducing the electric light.

An interesting power transmission installation has been carried out near Linz. There are two factories belonging to the Klein-münchen cotton mills. These lie on the Traun Canal, 2 kilometres distance from each other. In the one, lying higher up the canal, new turbines with larger power were put up, resulting in a loss of power in the lower factory. The upper factory had now more power than required, whereas the lower factory had not enough. This has been equalised now by putting up an 80 horse-power dynamo in the upper factory and transmitting the current by 6mm. copper wires overhead to the lower factory. The additional horse-power obtained is 60 or 75 per cent. of the original 80 horse-power.

In the telephone world there is not much doing at present. The various exchanges are flourishing, and the new Vienna-Brünn trunk line has been opened and works well. Prag has been connected with the Bohemian coal district, and Reichenberg with some of the neighbouring small towns. This year Prag is to be connected with Brünn, also perhaps with Pilsen, and a new wire is to be added to the existing line, Vienna-Prag. This seems almost a pity. Conversation between Vienna and Prag is so good now that the line is most extensively used. If a second wire be added it is to be feared that induction will interfere with the present satisfactory working. Over 200 calls a day take place, and as the charge is at least 1fl. per call the gross annual receipts are very considerable, and show a large net profit on the cost of the line, which was about £10,000. By far the largest number of calls take place between exchange subscribers.

The Vienna Compressed Air and Electric Company have received a concession from the Town Council for supplying the various workshops with power, either compressed air or electricity. There was a fight in the Town Council as to whether the town should not monopolise the business, but finally it was decided to grant the concession, though the terms seem to an outsider rather onerous.

The Hungarian Minister of Commerce is now being approached with a view to the granting of a concession for the construction and working of the proposed electric railway between Vienna and Buda-pest. The undertaking is under the patronage of the Commercial Bank of Budapest, and the initial expenditure necessary to carry out the scheme is estimated at 38.000,000fl. The railway would consist of a double line 250 kilometres long, and the current would be furnished by six generating stations placed at intervals of 40 kilometres.

Digitized by Google

# CORRESPONDENCE.

## ELECTRIC THEORIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I accept gladly Mr. Sprague's amendment to proposition No. 4, of p. 464, substituting the words "by the agency of the magnet" for the words "from the magnet," as these words satisfactorily embody what I desired we might both agree to. Now what we are agreed as to preliminaries, the course is cleared for a discussion of the *some way or other* by which the energy is transferred. I therefore propose to write in support of the modern views in your next issue, unless in the mean time Mr. Sprague himself sees fit to begin to set forth his own views.—Yours, &c., SILVANUS P. THOMPSON.

[Prof. Thompson will find that Mr. Sprague begins with his first article in the present issue, and we therefore invite him to hear Mr. Sprague first, and to prepare for championing the cause of orthodoxy at a later date. Meanwhile, if any ambiguity should arise as to terminology and definitions, we will forward to Mr. Sprague any suggestions which may clear the way, since the controversy, important as it is, is largely "one of mere interpretation of terms," as Prof. Thompson put it in a former letter.—ED. *E.*]

## ELECTRIC THEORIES.—ETHER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I think Mr. Sprague is mistaken if he supposes that Sir W. Thomson has suggested that there is such a thing as a "massless" fluid really existing in nature. In his Presidential Address to the Institution of Electrical Engineers, 1889, Sir W. Thomson introduces the idea of a "massless" fluid to illustrate the distribution of alternating currents in a conductor; but he makes it perfectly clear that this is merely for the sake of mathematical analogy. In the last two lines of page 21, *Journal* of the Institution of Electrical Engineers, Vol. XVIII. (referring to the above), he says, "The analogy I have just sketched cannot be considered as in any respect a physical analogy."—Yours, &c., J. GRAY.

National Liberal Club, Whitehall-place, S.W.

## THE BARKING ROAD CARS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The Secretary of the General Electric Power and Traction Company (Limited) informed me of his intention to publish his letter to me of the 20th and my reply of the 21st inst. I answered that I had no objection whatever, but must request him in this case also to publish my letter to the Company dated the 20th, which was written and sent a day before I received his letter. In case he should not do so, I enclose copy of it, and shall feel obliged if you will publish it with the other letters. You will see that the moment I discovered that my tables were given under a misapprehension, I did spontaneously what any gentleman would do, namely, offered to correct the figures, and that there was no need for Mr. Mackenzie's threat of legal proceedings to make me do what was right and just.—Yours, &c., GISBERT KAPP.

[COPY].

Erba, Wimbledon, February 20, 1891.

Messrs. The Electric Traction and Power Company (Limited), Maldon-crescent, Prince of Wales-road, Kentish Town.

Dear Sirs: I was surprised to hear last night from your Mr. Snell that he considers the figures I gave in my Cantor Lecture, with reference to the Barking Road Tramway, incorrect. When, towards the end of last year, I applied to Mr. Frazer for information about the working of battery cars, I was under the impression that this gentleman was the member of your Company who had the entire control of your traction work, and I, therefore, took the figures which he gave me as authentic and correct. If, however, as Mr. Snell asserted last night, the figures are not correct, it appears desirable that the necessary corrections should be made in the tables I gave at the Society of Arts lecture, and I shall do this if you will kindly supply me with the exact figures.—Yours faithfully, GISBERT KAPP.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Herewith I beg to hand you copies of correspondence between Mr. Gisbert Kapp and myself, relative to particulars given by him concerning our Barking installation.

As the report of this lecture appeared in your last publication, I shall be glad if you will find space in your columns for the publication of the enclosed in this week's issue.—Yours, &c.,

W. G. M. Mackenzie, Secretary,

THE GENERAL ELECTRIC POWER AND TRACTION COMPANY (LTD).

London, Feb. 24, 1891.

[COPY.]

The General Electric Power and Traction Company (Limited), New Broad-street House, 35, New Broad-street, London, E.C., February 20, 1891.

GISBERT KAPP, Esq.

*Re Cantor Lecture on Monday, 16th inst.*

Dear Sir: I am requested by the Managing Director to draw your attention to the enclosed printed matter with reference to data relating to the Barking-road electric installation, which is the property of the General Electric Power and Traction Company (Limited). The figures thus given are entirely misleading, and the publication of them is calculated to seriously injure our interests, as well as those of the North Metropolitan Tramways Company, and we must request you accordingly to withdraw the Tables 4 and 5, and the statement made by you based thereon, at the next Cantor Lecture in such a public manner as will be likely to reach all persons before whom the original tables and statements have come.

If the statements have been based upon information obtained from Mr. Frazer, we may call your attention to the fact that he left the Company's employ in July last, and has since had no opportunity of acquiring any knowledge as to the improvements that have taken place since then, which renders the data published by you still further misleading.

In the event of your failing to comply with our request, we shall, in the interest of our shareholders, be compelled to consult our solicitors on the subject.—Yours faithfully,

(Signed) W. G. M. MACKENZIE, Secretary.

[COPY.]

31, Parliament-street, S.W., February 21, 1891.

The General Electric Power and Traction Company, 35, New Broad-street, E.C.

Dear Sirs: In reply to your letter of yesterday, the statements to which you object were based on figures obtained from Mr. Frazer, and were given at the Society of Arts distinctly on his authority, and not on mine. After your explanation, which puts a totally new complexion upon the matter, I am, of course, myself, desirous to withdraw from my lecture any statement or table the accuracy of which is questioned; and I shall on Monday withdraw the two tables 4 and 5 and statements connected with them. At the same time allow me to point out that in your interests, as well as in mine, withdrawal alone would not be so effective as withdrawal combined with the substitution of the correct figures, and I should feel obliged if on Monday you would send me a telegram authorising me to state that when the lectures appear in print the obsolete figures of Mr. Frazer's will be replaced by figures corrected up to date and supplied by you.—Yours faithfully, (Signed) GISBERT KAPP.

## THE INSULATION OF THE BATH ELECTRIC LIGHT CIRCUITS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It having been represented to me that my remarks on Major-General Webber's paper on the distribution of electricity at the Institution of Electrical Engineers, as reported in the technical journals, may give rise to a false impression, I beg to enclose for insertion a letter from the electrician-in-charge at the Bath Electric Light Works, the correctness of which I have not the slightest reason to doubt. According to this, the defective insulation was not due to the mains, but from faults in the lamp-posts, which alters my view of the suitability of the insulation. The defective circuits were arc-light circuits. The tests of the other circuits were quite satisfactory, as shown by the accompanying figures:—

*Insulation-resistances of Incandescent Circuits.*

| | | | |
|---|---|---|---|
| Circuit No. 1 | ......... | Over | 15·89 megohms. |
| " 2 | ......... | " | 15·89 " |
| " 3 | ......... | About | 5·73 " |
| " 4 | ......... | " | 3·99 " |
| " 5 | ......... | " | 0·89 " |
| " 6 | ......... | " | 0·89 " |
| " 7 | ......... | " | 0·89 " |
| " 8 | ......... | " | 0·53 " |

*Insulation-resistance of Private Arc-light Circuit.*

About 0·19 megohm.

The incandescent circuits included the transformers when the above figures were obtained.—Yours, &c.,

GEORGE FORBES.

34, Great George-street, Westminster, S.W.,
February 24, 1891.

Digitized by Google

[Copy.]

Bath Electric Light Works, Dorchester-street, Bath,

T. O. Callender, Esq. February 21, 1891.

Dear Sir,—In reply to your inquiry with reference to the visit of Prof. Forbes here, I beg to inform you that all the tests made were on circuits with lamps in series, or transformers connected, and that no tests were taken of the mains by themselves. The two results to which you specially refer, viz., resistances to earth of 40 and 60 ohms, were on the public arc lines supplying 36 and 45 lamps respectively, and Prof. Forbes knew when testing that his figures included lamps and leading-in wires, and did not give, by any means, the actual insulation resistance of the mains. The low readings in question arose, as a matter of fact, from faults in the lamp posts. They had just been localised by means of the fault-finding apparatus to which he refers, and on being put right on the following day the resistances were ·124 and ·146 megohm. It may be well to point out that Prof. Forbes tested all our circuits, 11 in number.—I remain, dear Sir, Faithfully yours,

(Signed) Martin C. Olsson, Electrician-in-Charge,

## INDOOR ILLUMINATION.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: The concluding paragraph of "Problems connected with Indoor Illumination" in your last week's issue should cause quite a flutter among the members of Art Guilds and other culture excrescences, as showing still something to be done before the realisation of the beautiful is complete. But what *is* it all about? *Cacoethes scribendi* I fear, with the usual symptoms.

Nowhere in the world has electric lighting, in all its artistic and charming effects, been brought to such perfection as in large numbers of London houses, and yet the writer of this somewhat discursive article holds up his hands imploringly for some artistic genius to make electric lighting comfortable and beautiful. Artistic genius, indeed! what about all those who have been toiling in the field while this carping critic has possibly been engaged in arc lighting among the Cimmerii? Prof. Forbes also comes in for a great amount of unnecessary criticism because he advocates the use of ground-glass lamps, but the artistic genius of the future who is so hysterically appealed to would most certainly be of the Professor's opinion; and it has often been said that, although obscured lamps *may* absorb a great amount of light, they *appear* to give a greater body of light; and if the eye is deceived, what more does one want?

I trust some kind friend who has time, or who devotes special attention to the study of backward youths, will show the writer of "Problems Connected with Indoor Illumination" the different works that have been done in London during the last five years. The campaign colours of rival candidates for fame are strung up on many a house; the black and white, of course, he is at liberty to inspect, the ubiquitous chocolate and white, also the blue and white must be seen; the green and white should certainly not be neglected, nor the wooden board of a Corporation despised, while many of undoubted taste and ability scorn such soapy allurements. Our critic will thus have a better opportunity of considering the "physiological questions" that "do not often come into the work of an electrical engineer," as I am afraid his present knowledge of the subject is not much greater than the Marchioness's acquaintance with beer. "She once had a sip of it."—Yours, &c.,

31, King-street, Covent Garden, W.C., J. B. V.
February 25, 1891.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: The writer of the article on "Problems Connected with Indoor Illumination," in your issue of 20th inst., makes the statement that "great improvements must be made in arc lamps and carbons before they can be admitted for interior use." I agree that there is a great prejudice against arc lighting in this country, but as both lamps and carbons very closely approaching to perfection are now to be found in the market, I cannot help thinking that this prejudice will soon disappear and the question generally of arc lighting prove worthy of discussion, for it is in this form of lamp that the *economic* illumination of halls and large lofty rooms must be sought. It is fortunate for arc lamp makers that there are at the present moment many persons who do not agree with the author of your article, and possibly that gentleman's opinion might be changed if he were to pay a visit to the sorting rooms of the General Post Office, in St. Martin's-le-Grand; the large hall and passages of Winchester House, Madame Tussaud's Exhibition, Messrs. Spiers and Pond's new shops in Water-lane, or any of the numerous other places I could mention, where "absolutely steady" arc lamps of various powers are used for interior lighting.

When I say that a single arc lamp has displaced 500 (five hundred) gas jets for illuminating the entrance hall and grand staircase at Madame Tussaud's Exhibition, I cannot more strongly emphasize the importance of this kind of lamp being used in all cases where large units of light are required.

I am quite aware that even the best arc lamps in the market do not always burn so well as could be desired, but this is due in some cases to the carelessness or ignorance of the trimmer, and in others to inferior carbons being made use of with a view to greater economy, rarely, if ever, to the lamp itself.—Yours, &c.,

Blackheath, February 24, 1891. B. P.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I am afraid facts are against the writer of the article in your last issue on "Problems Connected with Indoor Illumination," as far as his remarks on arc lighting are concerned, and he must be somewhat unobservant if he does not see that absolutely steady arc lighting is the rule and not the exception nowadays. I see the "prejudice" against arc lighting for interiors of even moderate dimensions fast disappearing; moreover, the writer to a journal like yours should know that "*prejudice*," however "deeply rooted," can never long delay progress, and has no place in the vocabulary of the scientist. This is an age where very short work is made of a prejudice.—Yours, &c.,

February 24, 1891. Progress.

[These letters are referred to in our editorial columns.—Ed. *E.*]

## TRADE NOTES AND NOTICES.

"THE ELECTRICIAN"

**ELECTRICAL TRADES' DIRECTORY & HANDBOOK for 1891**

The new edition of our well-known Directory and Handbook is now ready, price 5s., postage extra. The book consists of over 900 pages, and has entailed this year a heavy amount of work. The Handbook Division contains a mass of most useful information. The Directory Division consists of 430 pages, and contains a very carefully compiled Alphabetical and Classified List of Firms and Persons engaged in the Electrical and Allied Trades in all parts of the world. This Division has been corrected up to date, and the book is thoroughly reliable, the very numerous changes which take place at the beginning of the year being incorporated. By the aid of this Directory, makers of Electrical Machinery, Apparatus, Instruments, Fittings, Sundries, Novelties, and other goods, may safely communicate direct with probable customers without the annoyance and great expense consequent upon using books which are mere lists of Members of Scientific Societies repeated again and again. A large number of copies have been already subscribed for from the Colonies, the Continent, the United States, and other Foreign Countries, whilst at Home orders have been received from Local Authorities, Railway, Tramway, Mining, and other large Industrial Corporations, as well as from those for whom the Directory and Handbook is primarily compiled. The Colonial and Foreign Division will be found extensive and reliable. *Orders should be forwarded at once.*

Tenders Wanted—Extension of Time.—Our advertisement columns contain an announcement that the period for sending in tenders in connection with the Glasgow Corporation electric lighting scheme has been extended from the 28th current to the 14th proximo.

Erratum.—In our notice on page 466 (*The Electrician*, February 13th) of the dissolution of the co-partnery carried on by Messrs. Mathew Edwards and David Reid under the style of James White, of Cambridge-street and Sauchiehall-street, Glasgow, by an unfortunate printer's blunder the former gentleman's name appeared as Mathew Hall. This has caused Mr. Edwards some annoyance, which we much regret.

Endolithic Ivory Company (Limited).—We are notified that the Endolithic Ivory Company (Limited), of Pomona-buildings, Fore-street, E.C., were awarded the only prize medal and diploma for address tablets and switch-board labels at the Exhibition recently held in Edinburgh.

Personal.—Mr. William Leslie, consulting engineer, 93, Hope-street, has been appointed agent in the Glasgow district for the Gülcher (New) Electric Light and Power Company (Limited), Battersea Foundry, London.

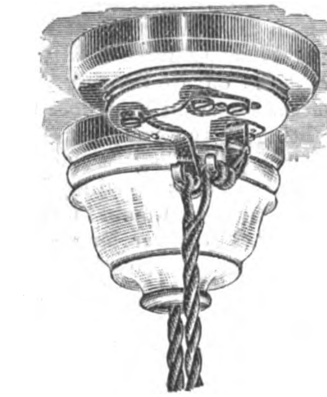
Digitized by Google

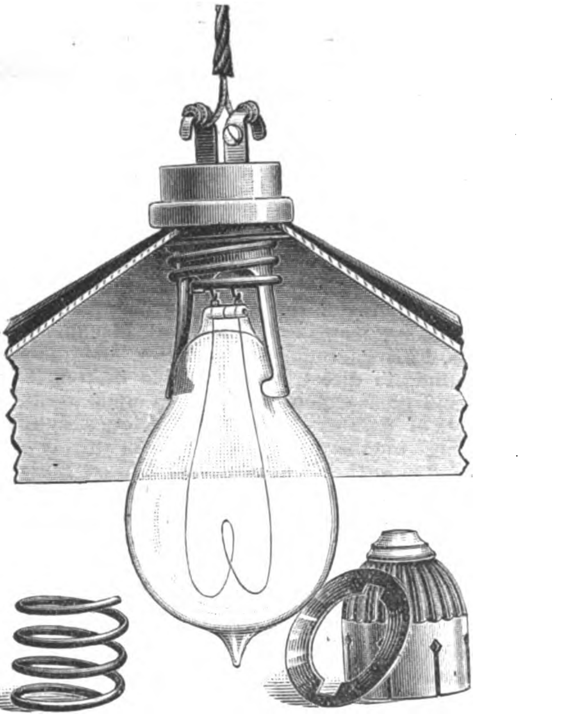
REMOVAL NOTICE.—Messrs. J. W. Gray and Son, electrical engineers, have removed from 115 to 86, Leadenhall-street, London, E.C.

BANKRUPTCY.—The *London Gazette* of Tuesday announces that a receiving order has been issued in the affairs of Leslie Watt Winnall and William Howard Winnall (lately trading as Watt Winnall and Co.), electrical engineers, of Bromley-street, Stepney, London, E.

CONSOLIDATED ELECTRIC COMPANY, LIMITED (IN LIQUIDATION).—A meeting of the shareholders will be held at Messrs. King and Read's, St. George's House, Eastcheap, London, E.C., on March 26th, at 3, to receive an account of the winding up.

D. AND S. PATENT SUSPENSION PENDANTS.—The common forms of cord grip present several disadvantages: some kinds do not allow for variations in the size of the conductors, while the common method of knotting is apt to throw an uneven stress on the wires. Messrs. Dorman and Smith have sent us a specimen of a simple contrivance capable of bearing a considerable weight. The ends of





the conductors are fastened under screws, and an inch or so is wound two or three times round the projecting horns shown in the illustration. The base and cover are of porcelain, and contain a fuse. In the lamp-holder shown, the same arrangement is adopted. The shade-holder is provided with a spiral spring easily screwed on and off, and is not liable to break the shade through over-screwing, as it slips back when over-screwed.

WOODHOUSE AND RAWSON ELECTRIC MANUFACTURING COMPANY (LIMITED).—At a meeting held on February 9th a resolution passed at a previous meeting that the Company be wound up was confirmed; and it was further resolved—"That T. H. Lambert, Albert Hoster, and F. L. Rawson be liquidators; and that the liquidators be authorised to carry into effect the agreements made between the Company of the one part, and the Woodhouse and Rawson Electric Supply Company of Great Britain (Limited), Woodhouse and Rawson (Limited), Woodhouse and Rawson United (Limited), and the British Electric Light Company (Limited), of the other part."

MESSRS. NALDER BROTHERS.—This firm, which has recently removed to No. 16, Red Lion-street, Clerkenwell, close to Farringdon-street station, has issued a supplement to the third edition of their catalogue of electrical instruments. They are making several Post Office pattern instruments, including portable galvanometers and resistance coils, and they have a new pattern ballistic galvanometer with two controlling magnets, and an astatic needle system. The Holmes leakage testing board for central stations, and other new instruments, are also described.

THE STANHOPE WATER ENGINEERING COMPANY.—We are in receipt of a printed circular containing illustrated particulars of the new Stanhope Water Softener and Purifier, manufactured by the above Company, for which it is claimed that an economy of from 20 to 25 per cent. is obtained.

THOMSON-HOUSTON ELECTRIC COMPANY (BOSTON, MASS.).—We have received from this Company a handsome catalogue well printed and fully illustrated, giving some interesting statistical information relating to the electric lighting and railway systems in use in the United States, in each case showing a large total in favour of the Thomson-Houston systems. The figures given for electric lighting show that this system is used in 666 installations in the various States of the Union out of a gross total of 1,985—a proportion of about one-third of the entire systems in use. This proportion is still larger in the case of electric railway systems, as out of a gross total of 230 no less than 103 are installed on the Thomson-Houston principle. Included in the book are a series of maps of the States, showing at a glance the positions of the various installations, and it is needless to say that the points shown in red (representing the Thomson-Houston installations) occupy a conspicuous position on the maps. The book marks a distinct advance in catalogues of electrical companies. There are 114 large folio pages in all.

## COMPANIES' MEETINGS & REPORTS.

### City and South London Railway Company.

The thirteenth ordinary general meeting of the proprietors of this Company was held on Tuesday at Winchester House, Old Broad-street, Mr. Charles Grey Mott presiding.

The SECRETARY (Mr. H. H. M. Smith) read the notice convening the meeting, and the report of the Directors and statement of accounts were taken as read.

The CHAIRMAN: Gentlemen, in moving the adoption of the report, I have to say that I have the pleasure of meeting you at last with a line open and at work. Now you all know that in new undertakings of this kind, where so much is novel, and where you cannot fall back upon past experience to guide you, there is always a feeling of uncertainty that however much you may have studied matters, and however much care you may have exercised in the execution of your works, that in all the arrangements you have been making, there may yet be something which you have overlooked, and which after all, may render your labours and your care of no effect. In an undertaking so new in all its parts as this has been, we were especially open to such a possibility, but I am thankful to feel that, in the experience which we have had of this line since its opening, we have the satisfaction of knowing that no serious defect in our calculations has been apparent. I consider that for a line new in point of construction, in working, and in fact in all its arrangements, it is an unqualified success. You will recollect that the principle of construction of this line had never before been adopted; but we successfully overcame all obstacles, and we have now a railway which, so far as we at present see, has been satisfactorily made. There will no doubt be certain minor points with regard to which improvements can from time to time be made, but we can congratulate ourselves in point of construction it has turned out satisfactorily. The next and most important question is the motive power. You know we were told that electricity was new for a line of this kind, and that it would probably fail. A great many objections were taken outside to the course we proposed to adopt, and, I confess, it was with very considerable anxiety of mind that I and my co-Directors came to you and recommended the adoption of a system which was so absolutely untried. It is satisfactory to feel that we have not been disappointed. The success of our running these engines has been decidedly marked. We have had no serious drawbacks. You have seen in the newspapers a great deal about the breakdowns on this railway, but I venture to assert that with such a new system and with the enormous number of trains that we have run, it is surprising that the breakdowns have been so few and unimportant as they have been. We have now carried by the line, with perfect safety, 900,000 passengers since we opened the line two or three days before Christmas, and we have run our trains 60,000 miles over the line. We have received in money £7,500, or a sum equal to 15 passengers per train mile. Of course, in a metropolitan system like this, you expect a much larger number of passengers than you would do, for example, in the case of the London and North-Western and Great Western systems, where it is only 3½ passengers per train mile. But, considering that it is so new, that we have never advertised once in any way, that we have only dealt with the traffic which has come to us—and we have been compelled to deal with that—we have done nothing to attract traffic to the line, we may say that on the whole it has been very satisfactory. We have not encouraged it in any way, because we felt that the first thing we had to do was to work satisfactorily what

Digitized by Google

came to us voluntarily, and, therefore, you must not be surprised that the receipts are not so large as we had hoped, and as, I have not the slightest doubt, they will be in the future. You will no doubt wish, if I can, that I should say something about the expenses of the line. Well, I do not feel justified in really making any definite statement on this subject. You must know that at the commencement of a railway of this kind there are a great many extra expenses, because we had to make security doubly secure, but as the line is now settling down to more steady working we trust week by week to reduce the expenses, and find out from experience various small economies. But we have had so short an experience that it would be utterly wrong for me to give you anything like an approximate statement of the working expenses of the line; but so far as I have investigated the matter I feel quite sure that, as regards the motive power (of course I may be making a mistake), when we come to settle down we shall find that the cost of working the line by electricity will be decidedly cheaper than it would be by steam. The receipts of the line per train mile run I can deal with, because these are ascertained facts at the present moment. Our actual receipts per train mile run have been 2s. 6d. Now, the receipts on large railways, such as the North-Western and Great Western, amount roughly to something under 5s per train mile—or double what ours are at the present moment. But you must remember, on the other hand, that the trains we are running are only about one-fourth—perhaps, one-fifth—of the weight of those which are run upon those lines, and that, therefore, we have really, weight for weight, nearly double the actual earnings per train mile run of those railways, and I have good hopes and expectations that we shall raise our receipts per train mile to an amount similar to that earned by them. Then you will at once see that we stand in a very much better position to deal with our traffic, having only one-fourth of the weight to move in order to earn the same money as those Companies. These are about the only approximate figures that I can place before you. I hope when we meet next that we may be able to deal more definitely with the cost of working the line; but as yet we have only five or six weeks' traffic to go by, and I could not give you any actual information as to receipts and expenditure. We have found in the course of our operations that we could work the line more economically and with greater regularity if we had additional sidings underground. Of course we did not know, until we tried, what was absolutely requisite on this head, and we therefore propose, as mentioned in the report, to construct some additional sidings at the Stockwell end of the railway. We shall make a small portion of the Clapham Extension line, so that the money we propose to spend in providing these additional underground sidings will not be wasted. The Board of Trade suggested in their report that, as a matter of security, it would be desirable that we should have a fourth engine and dynamo. At Stockwell depôt we have a reserve engine, and we considered it sufficient; but still, looking at all the possible risks connected with electricity, upon which no one has very correct knowledge, we thought it better to comply with the Board of Trade's suggestion. We have, therefore, an engine and dynamo to be put up in the engine house, and they are now in course of construction. We shall then be supplied with power double what we ordinarily require, and if we ever carry out the Clapham extension that plant will come into use and save expenditure afterwards. Then we find also that we are short of rolling stock. We want a little more, in order to multiply the number of trains. You know that at certain times of the day, morning and evening, our trains at present are over crowded. We are gradually increasing the number of trains, and we hope to be able very shortly to give such a service at those hours as will enable us to deal with the traffic completely and satisfactorily. But in order to do this we should want some additional rolling stock, and we propose to order some additional engines and carriages. In all undertakings of this kind, I daresay, those who have had any experience of them know that at the end of their construction there is generally between the Company and the contractors a difficulty which unfortunately too often ends in legal proceedings—in a long arbitration or a lawsuit. Our contractors, as is usual, made certain definite claims upon us for extra works, about which there were differences of opinion between our engineers and them. The dispute might have resulted in a long and expensive lawsuit, but not desiring to have any contentious matter with them, and, above all, not desiring to waste any money in that way, we had a friendly conference with our contractors the other day, and I am glad to say that, after fairly discussing the subject, we have arrived at a settlement which has been approved by both parties. I refer to the contractors for the construction of the line itself, not to those for the other works and rolling stock, &c. We have settled the whole matter with them, and have arranged for the payment of the retention fund, and the balances due to them. This is so far satisfactory that we are, at all events, saved heavy law expenses, and both sides are satisfied. I had perhaps better now deal with the extension of the line to Islington, referred to in the report. I confess for my own part—and I think my feelings are shared by my co-directors—that if we could have avoided extensions of any kind at the present moment we should have done so. We got, as you know, power for the Clapham extension, but we have not exercised it, and we do not intend to proceed with that line until we are satisfied that it is going to add to and improve our present returns. But we find in working this line that there are certain circumstances, and which, as far as we can see, using our best judgment and discretion, make it desirable that the line should be extended in the direction in which we now propose to ask Parliament to grant us powers to do. We have, of course, learned a great deal in the last few months as to the probable traffic of the future of this line, and we have applied our best knowledge, derived from all that information to the subject and have come to the conclusion that it is in your interests that power should be asked for that extension and that it should be made. We have certain difficulties to deal with in regard to our city traffic at the present moment, which this line would help us to get over. We want the middle of the day, as well as the early morning and evening, to be filled up by traffic, for which we have abundant room and for which the expense will not be much; and we do not think that it can be filled up by the traffic from the district where the line now is. It will have to be supplied by traffic from a more populous area. We have chosen a line where the traffic is great, and I am sure it will prove most remunerative. But in addition to this it will attract exactly that traffic of which we are now deficient, and consequently greatly improve the value of the property. Much as we object to go in for extensions—and no one objects more than I do to hastily extending the line in its early days—still we think that there is no doubt at all that this would be a good line, and my advice is that you should go for this proposed extension. In the Bill you are only asked to approve the application for powers to construct the works, but we shall have to come to get your consent to carry them into execution. We want merely now to obtain the Act authorising them. I think these are all the important questions that I need bring before you. There are a few shares which are stated to have been forfeited, as you will observe from the report. Some of these have since been claimed and paid up, but there are certain others which from various causes are not likely to be paid up. There are 15 of them, and therefore there is no alternative but to forfeit them, which we propose to do by a formal resolution after this meeting. I now beg to move—

"*That the report and statement of accounts for the half-year ended December* 31, 1890, *be and they are hereby adopted.*"

Mr. ALEXANDER HUBBARD seconded the motion.

Mr. DRAKE said he thoroughly concurred in acknowledging that the line was a tentative one; that it was, in point of fact, largely a new departure, and he was pleased to have it as the opinion of the Board that the shareholders might take it for granted that the motive power was satisfactory, and that it had now passed out of the range of mere experiment. No doubt there would be many difficulties to face in the future, as there had been in the past, but after the experience which had been gained in dealing with the concern in its initial stages, they might rest assured that those difficulties would be grappled with successfully by their able engineer. As a resident at Clapham, he would like the extension in that direction carried out. He did not think that Stockwell was an adequate terminus for the line. The bigger scheme now proposed required very careful consideration. They did not want the success which was within their grasp to be swamped by an extraordinary scheme of the kind, but he was sure that the Board would give them, when the time came, every opportunity of discussing its details. He had much pleasure in supporting the resolution.

Mr. SYDNEY SHEPHERD asked whether it was possible to enlarge the King William-street station, so as to provide two sidings instead of one.

Mr. TRESS BARRY, M.P., asked whether their present engines could carry more weight than they now do. He wished to get some idea of the expense of getting the proposed Act of Parliament, because there would no doubt be great opposition to it.

The CHAIRMAN, in reply, said it would be extremely difficult to enlarge King William-street station because the Monument was so close, and they would not be allowed to go near it. They had the matter under their careful consideration. They were quite aware of the difficulties of having so small a space there, but he was afraid it was not capable of being greatly improved. This was one of the questions involved in the proposed extension, which would help them to overcome the difficulty, but it would not do for him to discuss the plans at present. They would observe that the approach to the station from the City was exceedingly bad. Everyone had to get over one of the very worst crossings in the City, and undoubtedly it did great damage to their traffic. They would be able by their proposed extension to give access to King William-street station from the Lombard-street end, which would get over the difficulty they complained of.

Mr. SHEPHERD asked whether it was possible to run four cars instead of three?

The CHAIRMAN said the question was now under the consideration of the Directors and their engineer. As regarded Mr. Barry's question, as to whether their engines could carry more weight, he could only say that the Board were satisfied with the present power of their locomotives. They were not so fast as, perhaps, was desirable, but they were considering whether they could not in the new engines have additional power and speed from them. He did not suppose that their Bill would be very costly. They had now before them all the opposition to it, and there was no very serious question raised in it. Most of the petitions were really based on a misunderstanding of their whole line.

The motion was carried unanimously.

The CHAIRMAN then proposed, and Mr. HUBBARD seconded, the re-election as Directors of Mr. Walter Robinson and Mr. Sampson Hanbury, which was agreed to *nem. con.*

The auditors were afterwards reappointed, and a resolution was carried forfeiting the 15 shares in arrear of calls.

The adjourned extraordinary general meeting was afterwards held for the consideration of the Company's Bill before Parliament.

The CHAIRMAN briefly recapitulated his views as to the advisability of proceeding with the proposed extension, remarking that if the shareholders disapproved of the Bill the Directors would be relieved of all responsibility. At the same time, they advised the proprietors to allow the scheme to go on. He concluded by moving a resolution approving the Bill.

Mr. HUBBARD seconded the motion.

Mr. COURT said that having, since the adjournment of the last meeting, gone fully into the question, it seemed to him that they could not do better than support the Directors in going to Parliament for the Bill, on the understanding that the shareholders did not commit themselves to the work of the extension at the present time. The Board now only asked their approval to obtaining Parliamentary sanction for the construction of the work.

Digitized by Google

Mr. BROAD objected to the Bill, and he thought that the Directors ought to devote their time and energies exclusively to the development of the traffic of the present line.

A SHAREHOLDER thought that if the enterprise were made a separate undertaking, bearing the cost of the Bill itself, that would obviate all difficulties.

The CHAIRMAN said it would be impossible to say what the Bill would cost, but he should say, considering the nature of the opposition to it, possibly £2,500. If it had been unopposed, probably £700 would have passed it. They had given the proprietors their best advice in the matter, and it was for them to use their discretion. He might say that it had been suggested (and he thought it was an advisable thing to do) that they should take power, if necessary, to make the new undertaking with a separate capital, so that the present one would in no way be subject to it.

Mr. GODFREY suggested that the question should be deferred.

The CHAIRMAN said although the Board were decidedly averse to unnecessary extension of the line, it must not be taken for granted that they did not think that the proposed project was very important. They attached, in fact, very great importance to it. He could not publicly give them all their reasons for saying so, but, from the knowledge they now possessed, such was the opinion of the Directors. If they put the matter off, they would find themselves one day in a position which they would very much regret.

A SHAREHOLDER asked what the line would cost.

The CHAIRMAN said that the present line cost about £240,000 per mile; but where they proposed to go in the City they would have to purchase expensive property, and it would be impossible to say what it would cost.

Mr. DRAKE asked if the Directors were unanimous with regard to the scheme.

The CHAIRMAN replied in the affirmative.

Mr. GODFREY said he would, under the circumstances, support the resolution.

The motion was then put and declared carried, with one dissentient.

Mr. BROAD demanded a poll, but being informed of the hopelessness of gaining his object, he did not persist in having it taken.

Afterwards, a resolution was carried enabling the Directors to take power if they thought necessary to construct the proposed extension as a separate undertaking.

On the motion of Mr. GODFREY, seconded by Mr. BROAD, a vote of thanks was passed to the Chairman and Directors, and the proceedings terminated.

## The St. James' and Pall Mall Electric Light Company (Limited).

An extraordinary meeting of the shareholders of this Company will be held at Winchester House, Old Broad-street, E.C., on Monday, March 2nd, at 2.30, when the following resolutions will be proposed :—

1. "*That the capital of the Company be increased to £200,000 by the creation of 20,000 shares of £5 each, to be called Preference Shares, and to be entitled to a Preferential Dividend at the rate of 7 per cent. per annum on the amount for the time being paid up on such shares, payable out of the net profits of the Company for each year.*"

2. "*That the Articles of Association before the meeting be adopted as the Articles of Association of the Company in lieu of those at present in use as such.*"

In the event of the above resolutions being carried, a further extraordinary general meeting will be summoned to confirm the resolutions passed at the meeting so as to make them special resolutions.

---

An ordinary general meeting will be held at 3 o'clock, to consider the accounts, balance sheet and report of the Directors; to elect two Directors in place of those retiring; to elect auditors for the ensuing year and settle their remuneration.

The following is the report of the Directors, which will be presented to the shareholders :—

The Directors, in submitting their annual report for 1890, with accounts as certified by the Company's auditors, congratulate the shareholders on the satisfactory progress made by the Company during the past year.

At the commencement of the period under review, the number of lights connected amounted to the equivalent of about 4,460 8 candle-power lamps. This number gradually increased up to September 30th, when the number of lamps connected amounted to about 12,150. In the last quarter of the year remarkable progress was made, and on December 31st the lamps connected amounted to about 26,500, and this total has since been increased to about 30,000.

On July 23rd last, a prospectus was issued inviting subscriptions at par for 3,670 ordinary shares. All these shares have been taken up, the bulk of them being subscribed for by the Directors and their friends, the shareholders subscribing for a very small number. On January 9th, the balance of the original issue of shares, viz., 980, was allotted. These subscriptions have enabled the Board practically to complete the existing station, which is now in every way working satisfactorily.

Of the £50,000 Debentures, which, as will be seen from the accounts, were outstanding on December 31st, £43,000 have since been converted into ordinary shares under the powers contained in the Debentures. On the conversion of the balance of £7,000 of the Debentures, the capital account of the Company would stand as follows :—

| | | | |
|---|---|---|---|
| 19,980 Ordinary shares of £5 .................... | £99,900 | 0 | 0 |
| 100 Founders' „ „ £1 .................... | 100 | 0 | 0 |
| Making a total of .................... | £100,000 | 0 | 0 |

The conversion of these Debentures places the Company in a position to at once raise moneys for the purposes of the northern station, which the Company has to erect to satisfy the requirements of the district covered by the Provisional Order granted by the Board of Trade, and approved by Parliament during its last Session.

The question of the amount of damages payable by the contractors for delay was referred by consent to the arbitration of Mr. J. Fletcher Moulton, Q.C., who awarded the sum of £1,806. 11s. 6d. to the Company for loss of income. The Directors, being of opinion that this sum represents the equivalent of depreciation up to December 31, 1890 (a large part of the machinery having been in work for but a short period), have written this amount off capital expenditure.

By reference to paragraph 2 of this report it will be seen that the station has practically been at work for three months only in 1890, and that the dividend has been earned during that period. The Directors have therefore, after consultation with the Company's auditors, charged £963. 3s. 1d., being one moiety of Directors' fees and management salaries for the year, to capital expenditure. On statement III. it will be seen that the account of capital is charged with £65,981. 11s. 9d. as expended to December 31, 1889. The balance-sheet at that date displays that this sum is made up of capital and general expenditure, from which is deducted a small sum received for current supplied, &c.

During the first six months of the year the Company's revenue showed a debit of £183. 7s. 11d. During the last six months the profit amounted to £5,161. 8s. 8d., which, after deduction of the debit referred to, leaves a balance of £4,978. 0s. 9d. to be dealt with. Of this sum £2,412. 8s. has been provided for payment of interest, and out of the balance of £2,565. 12s. 9d., the Directors recommend a dividend of 5s. per share, free of income-tax, on the 9,000 ordinary shares in existence on December 31, 1890, absorbing £2,250, leaving a balance of £315. 12s. 9d. to carry forward.

The experience gained since September has satisfied the Directors that the shareholders possess a very valuable property, which will yield a large steadily increasing income on their investment.

The Directors regret the loss of their esteemed colleague, Mr. James Hemmerde, who died in the autumn of last year; they have, under Article 84, appointed Mr. Egerton H. Clarke to a seat on the Board in his stead. Two of the Directors, namely, Mr. Eustace J. A. Balfour (the Chairman) and Mr. Latimer Clark, F.R.S., retire under Clause 79 of the Articles of Association, and, being eligible, offer themselves for re-election. The auditors, Messrs. Deloitte, Dever, Griffiths, and Co., also retire, and, being eligible, offer themselves for re-election.

Referring to the notice of the extraordinary general meeting, should the shareholders adopt the suggestion of the Directors to increase the capital of the Company by the creation of Seven per Cent. Preference shares, it is the intention of the Directors to offer 10,000 of such shares to shareholders now on the register in the proportion of one preference share to every two ordinary shares. It being necessary to alter the Articles of Association to entitle this Company's shares to a quotation on the Stock Exchange, the Directors have taken the opportunity to remodel them.

## The Westminster Electric Supply Corporation (Limited).

The fourth ordinary general meeting of the shareholders of this Corporation was held at the offices, 32, Victoria-street, S.W., on Wednesday, February 25, 1891, under the presidency of the Right Hon. Lord Suffield, K.C.B.

The SECRETARY (Mr. Frank Iago) read the notice convening the meeting.

The report of the Directors and statement of accounts were taken as read.

The CHAIRMAN: Gentlemen, I am sorry to see so few shareholders present. Still, I may say that nothing could be more satisfactory in my opinion, and that of the other Directors, than the state of your affairs, so far as we have been able to investigate and explain it. The dreadful state of the weather has, no doubt, prevented a great many from coming to the meeting, but I think what we have got to say to you will be acceptable to all concerned. The Report, which has been sent to each shareholder, will have already made you acquainted with the fact that the business of the Corporation is going on satisfactorily. Since our last general meeting, on November 5th, the Millbank-street central supply station has been completed, and current has been supplied therefrom continuously, day and night, in a most satisfactory manner. It frequently occurs that when a station is first opened some unexpected flaw, either in the machinery or the mains, is brought to light, causing a serious break down, but I am happy to be able to inform you that this has not been our experience. Some slight irregularities in the light did occur for a few days, but this was before we got on to the batteries. Since then, the the light has been perfectly steady and satisfactory, notwithstanding the unusual demand throughout the whole of several days in consequence of fogs. You will hardly need to be told that fogs, however unpleasant they may be from a sanitary point of view, are from an electrical point of view a very different matter. We find that our heaviest loads come on during fogs, so that to us they are a source of profit instead of loss. I am glad to be able to inform you that since taking over the Millbank-street station from the builders we find that we have every reason to be satisfied with the work, and that the building is in every way suitable to our requirements. Here I may say that a very distinguished engineer, Sir Wm. Thomson, who was accompanied by Sir Douglas Dalton, went over that station the other day, and he not only expressed himself satisfied with it, but I think he said it was the best he had ever seen.

Digitized by Google

We have now sufficient plant and machinery erected there to supply all the lights likely to be required for the next six months, and as the demand increases so shall we increase our machinery. I may here point out a great advantage which the Westminster district possesses over many others, which is, that within it are a large number of offices, in addition to private houses and shops and that these offices, requiring, as they do, to be lighted in the winter months, through many hours each day before the chief part of the lighting of the private houses comes on, enables us to use our Millbank-street station to great advantage. We are, at present, supplying from the Millbank-street station some 9,000 lamps of 8 candle-power each. The cost of running at that station is now about £60 per week. This includes the cost of coal, water, stores, salaries and wages. To this has to be added £90 per week for maintenance, depreciation of machinery and mains, establishment charges, rent and sinking fund on buildings, &c., making in all £150 per week. At the beginning of the month of January, the income per week for current supplied had already reached £150, which has now increased to £200, so that even in this early stage, a profit is already being made. Of course, as the days lengthen, the same ratio will not be kept up, nevertheless it is to be noted that though the days have been lengthening of late, and the demand for current has, in the case of other Companies which have been longer established, been falling off in consequence, our receipts have augmented. This is, of course attributable to the increased number of lights which are daily being installed in the district. The temporary station in Dacre-street, at the back of these, offices which is supplying the remainder of the lamps on circuit, has been of great service to us, in enabling us to supply current to the Western portion of our district, while the station at Eccleston-place was being built. In a few days the Eccleston-place station will be delivering current, and the temporary station will then be closed as soon as possible. I may tell you that yesterday some of the Directors visited Eccleston-place, as well as the new station at Davies-street, and were very much gratified by the progress made there. There has been great delay on account of the frost, but things are really progressing in a most satisfactory manner now, and, as I have said, we shall be able to deliver current in a few days. At our Davies-street station great progress has been made, and from there we expect to be supplying current by the end of next month. Had it not been for the severe and prolonged frost, which brought all building operations to a standstill for two months, current would have been supplied from both Eccleston-place and Davies-street before now. You will observe, by looking at the map on the walls, with what rapid strides the work of laying the mains has proceeded since you were last called together. There were then about 11 miles laid. To-day, notwithstanding interruptions, there are about 18 miles completed. This includes the principal streets throughout the district, in which there is the greatest demand. The others will be completed in the order in which the demand arises. I should mention that our consumption of coal already bears favourable comparison with that of the most economical of the older established companies, and that when the condensing plant, now on order, is erected, which, in the case of the Millbank-street station, will be in the course of the next two months, a still greater saving will be effected. Now, as to the question of capital and expenditure, you will see from the accounts sent with the report the expenditure under the different heads to the 31st December last. Owing to the demand for light caused by the stoppage for about two months or more of the supply of the only other company having powers in the same district as ourselves, it was considered desirable by the Board to increase the amount of copper in the mains, especially in the Mayfair district, for which large numbers of applications have been received. This has largely increased the expenditure on mains, but of course will result in the earlier sharing of profits, as we shall be enabled to take on a much larger number of lights without delay. The Board are pleased to say that so far the whole of the works, whether of buildings, mains or plant, have been carried out well within the estimated cost, and that the total cost of the works to give enough current to supply the whole of our districts for some time to come will not exceed the amount of capital asked for in the original prospectus of the Company, viz., £300,000. The amount actually subscribed was £214,765, in 42,953 shares of £5 each, leaving a balance of £85,235 in 17,047 shares of £5 each. To provide for the extra cost of laying mains, completing the present work in hand, and making provision for any extra work the Board may consider it desirable to enter upon, they suggest to the shareholders that the balance of capital should now be issued. They feel justified in asking them to increase their holdings, as there is no doubt of the future financial success of the undertaking. The Directors have also passed a resolution to issue, if required, £100,000 Debentures at 5 per cent. interest, to run for a term of ten years, but not to a greater extent than an amount of one-third of the share capital for the time being. I will now say, gentlemen, and I think it is a very gratifying thing to be able to do so, that the calls on the shares have been very well paid up. Out of the whole number that have been made, there remains but a very small balance still to be paid, and I have no doubt that they will come in shortly.

I now beg to move the adoption of the report and accounts for the past year. If any shareholder has any question to ask, we shall be pleased to give him every information in our power.

Mr. BOULNOIS, M.P., in seconding the resolution, thought it was unnecessary for him to travel over the ground which had been so very well covered by the Chairman; but perhaps the shareholders would like to hear something about the inner working of the Corporation. He was not going to reveal anything, or tell them the details of what was done at the Board meetings; but he wished the shareholders to know that he had never sat at any Board of Directors where there was more unanimity evinced. They had their discussions, but there were no differences of opinion amongst them, all their proceedings ever since he joined the directorate having been conducted with the utmost unanimity. He might say further (and he was sure he interpreted the views of his co-Directors), that no staff could exhibit more ability, more zeal, or more loyalty than theirs from the highest to the lowest. They were especially happy in having so able an engineer as Prof. Kennedy, so skilful a manager as Captain Bax, and so active a secretary as Mr. Iago. As far as he could see, there was a great future in store for the Company. What the shareholders would have to do—and he admitted that it required some patience—was to have confidence in the Board they had elected—a confidence which, he believed, would not be placed in vain.

Mr. COOPER asked whether the item in the general balance sheet—"expenditure during the year but applicable to future business £3,957," should be charged to capital or to revenue.

Mr. WALLACE, in reply, said that in starting a new Company of this kind there was a vast amount of work to do which would become remunerative in future years, such as getting the customers, on advertising, travelling, and the work of the staff employed in making arrangements for the future. Now, of course, that could not be placed at once to capital account, because it was not, strictly speaking, a capital charge, but it would be written off the profits in future years. At the next meetings perhaps they would be able to give some account of it.

Mr. MARK STEWART, M.P., asked whether it was intended to issue any debentures just now, and if so whether this was provided for in the Articles of Association.

The CHAIRMAN, in reply, said that they had no intention of issuing debentures without giving the shareholders an opportunity of subscribing for them, nor had they any immediate necessity for them, although they had taken power to issue them, according to the custom of other companies, in their Articles of Association.

Mr. BROWNE MARTIN thought that they must know that in all companies there was power taken to issue debentures. By issuing them at 4 or 5 per cent., companies gained a very great advantage, because, in an undertaking like theirs, if they borrowed capital, they must pay 7 per cent. upon it, whilst if they issued debentures they would have to pay only 5 per cent., which was a clear benefit of 2 per cent. to the shareholders.

The motion was carried unanimously.

Mr. S. R. SCOTT said that it would be within the recollection of most of them that, when the allotment of shares took place, there was a surplus not applied for. The time had now come when, having a great deal of money to spend in laying down mains and building stations, so that they might at as early a date as possible begin to reap the profits of their work, they thought it desirable to issue the balance of their share capital and, accordingly, he had great pleasure in moving

"*That the Directors be authorised, at their discretion, to issue all, or any part of the* 17,047 *shares.*"

A SHAREHOLDER seconded the motion.

The CHAIRMAN, in reply to a question, said that the shareholders would certainly have the option of taking up the issue.

The motion was agreed to *nem. con.*

The auditors, Messrs. Cooper Bros. & Co., were, on the motion of Mr. F. A. WHITE seconded by Mr. J. W. SCOTT, unanimously reappointed.

Mr. S. R. SCOTT proposed, and Mr. LEWIS THOMAS seconded a vote of thanks to the Chairman and Directors for the care and ability which they displayed in looking after the interests of the shareholders.

The resolution was carried unanimously, and

The CHAIRMAN having briefly acknowledged the vote, the proceedings terminated.

---

## Liverpool Electric Supply Company (Limited).

The annual meeting of the shareholders of this Company was held on Tuesday at the Law Association Rooms, Cook-street, Mr. Arthur Hill Holme, CC., Chairman of Directors, presiding.

The Directors' report stated that the amount of net profit available for dividend was £4,878. 9s. 6d., and out of this sum they recommended a dividend of 3½ per cent., which would absorb £4,074. The expenditure on capital account during the year had been £54,019. The number of lamps supplied from the Company's stations on January 1, 1890, was 6,700, and on January 1st of this year 11,750. It was anticipated that during the present year there would be still greater progress in this direction, with corresponding advantages as regarded profits. The Directors had applied for Parliamentary powers to extend the present area of supply to London-road, Prince's-road, Prince's-park, and Sefton-park. The assent of the Toxteth Local Board had been given, but the Liverpool Corporation withheld their assent, as the Directors were unable to accept the conditions which were sought to be introduced into the Draft Order.

The CHAIRMAN, in moving the adoption of the report and statement and accounts, remarked that the Company had made a considerable addition to their business during the past year. They had also adopted all the latest improvements in electric lighting, and everything possible had been done to secure a good and steady light. In this they had succeeded, with the result that they were now giving their customers a supply of electricity second to none in England. They had increased their number of fixed lamps from 6,700 to 13,074, although they had engines of sufficient power to supply 25,000 lamps. The Directors had written off a sum of 3 per cent. for depreciation on all underground mains laid since the commencement of the Company, including those which were not yet in use. Serious thoughts had been expended on a project for extending the business of the Company, and, as stated in the report, they were contemplating carrying the electricity to London-road, and to Prince's and Sefton Parks. They had had considerable difficulty with the Corporation as to a Provisional Order for London-road, but permission for the other areas had been readily granted by the Toxteth Local Board. The Directors saw the importance of taking the light to London-road, for there was a demand for it, and they would have diffi-

Digitized by Google

culty in attending to their business if an opposition company occupied so important a position as London-road. The necessity of making a call upon the shareholders would probably not occur before January next, and then the call, it was anticipated, would not exceed 10s. per share.

Sir DAVID RADCLIFFE seconded the Chairman's motion, which was unanimously agreed to.

Messrs. Von Sobbe and Samuel H. Holme were then re-elected as Directors, and the remuneration to the Directors was, on the proposal of Mr. CHARLES BIRCHALL, increased from £150 to £250.

## Manchester Edison-Swan Company (Limited).

An extraordinary general meeting of the Manchester Edison-Swan Company (Limited) was held on Monday at the Victoria Hotel, Manchester, for the purpose of considering the advisability of obtaining additional capital by the issue of debentures or otherwise.

Mr. VERNON K. ARMITAGE (the Chairman of the Company), who presided, explained that the meeting was called in accordance with a promise made by the Directors that the shareholders would be consulted before any scheme involving any considerable expenditure of money was entered upon. There had recently been a very marked dimunition in the demand for small installations of the electric light, and the Directors thought that, in view of the large number of Provisional Orders which had been recently granted to local boards and corporations, it was desirable that they should have the ability, if they had the opportunity, to do such large work as the carrying out of such Provisional Orders would involve. Another reason why it was thought that it might be necessary to raise additional capital was, that at present they were seriously handicapped in their competition with other companies by the circumstance that they were not manufacturers as well as installers. With facilities for making what they required, they would save much money which at present went to manufacturers of fittings, &c. The Directors felt that if they were placed in a position to raise such money as they might consider necessary, there was a future for the Company, especially in a place like Manchester, where a Provisional Order for electric lighting had been obtained. He thought there was not the smallest doubt that for the current year they would make 7 or 8 per cent. on the capital that had been called up.

In reply to a question by Mr. F. B. ROSS, the CHAIRMAN stated that it was not yet known what amount it might be necessary to raise. That would depend altogether on the extent to which they were entrusted with orders. Their manufacturing work would be carried on in a small way to begin with.

Some discussion followed, at the close of which, without any formal resolution being passed, it was left to the Directors to obtain such additional capital as they consider necessary.

## Telegraph Construction and Maintenance Company (Limited).

The following is the report of the Directors, to be submitted to the members at the twenty-seventh ordinary meeting to be held at the offices of the Company on Tuesday, March 3rd, at one o'clock :—

The accounts for the year show a net profit of £113,681. 4s. 8d., after charging the interest on the Debentures. To this sum must be added £37,483. 7s. 3d. brought forward from last year, making a total of £151,164. 11s. 11d. From this amount is deducted the interim dividend of 5 per cent., paid July 15, 1890, amounting to £22,410, leaving £128,754. 11s. 11d. to be dealt with. Of this sum the Directors propose to distribute a dividend of £1. 16s. per share, absorbing £67,230, being at the rate of 15 per cent., and making, with the amount already paid, a total dividend for the year of £2. 8s. per share, or 20 per cent., free of income-tax, leaving £61,524. 11s. 11d. to be carried forward to the next account.

During the past year the cable factories at East Greenwich and at Wharf Road have been fully occupied, and the increase in the general business at the latter works mentioned in the last report has been fully sustained ; a length of over 9,000 miles of telegraph wire has been insulated for submarine cables and land lines during the year.

The company's ships have duplicated the Eastern Extension Telegraph Company's cable between New South Wales and New Zealand, have repaired and partially renewed the lines across Cook Strait, have partially renewed the Madras-Penang Cable, and have quadruplicated the Eastern Telegraph Company's line down the Red Sea. A cable has also been laid between the north-east coast of England and Sweden for the Great Northern Telegraph Company, and repairs have been effected in the German Government cable between Greetsiel and Valentia.

The factories at East Greenwich and Wharf-road and the Company's steamships are in efficient working condition.

The retiring Directors are Sir George Elliot, Bart., and Mr. Philip Rawson, who, being eligible, offer themselves for re-election. The meeting will have to appoint auditors for the ensuing year. Mr. John Gane (of the firm of Messrs. Gane, Jackson and Jefferys), and Mr. Patrick A. Glegg (of the firm of Messrs. Welton, Jones and Co.), who retire, offer themselves for re-election.

Notice is given that the transfer books of the Company will be closed from the 23rd inst. to the 3rd proximo, both days inclusive, preparatory to the payment of dividend to all shareholders on the register on the 23rd inst.

## Keswick Electric Light Company (Limited).

The following is the Directors' Report to be presented at the annual general meeting of this Company, which was adjourned from January 31st, and will be held at the Court House, Keswick, to-morrow (Saturday) at 4 p.m. :—

In presenting their first report, the Directors have to congratulate the shareholders that the experimental portion of the history of their undertaking has been successfully passed, and that the arrangements for the distribution and supply of electricity from their station for illuminating purposes have obtained such general favour that the demands of consumers now far exceed the capabilities of the Company's original plant. They have, therefore, been compelled to increase the productive power of the station by the addition of another dynamo, and are making arrangements for the introduction of a second turbine.

The accompanying statements show the condition of the Company's accounts to December 31, 1890. The profit and loss account extends over 11 months, and shows a credit balance of £31. 15s. 8d., sufficient to allow of a small dividend, but your directors consider that for the present this balance should be held in reserve.

It will be remembered that the station commenced to run on February 1, 1890. On that date only a portion of the present consumers were in a position to use their lights, owing to the incompleteness of the works and the want of connection of a large proportion of the lamps with the outside mains. In some cases this continued for several months. The receipts, therefore, contrast unfavourably with the expenses, the latter being the full cost of the working from the date of the opening of the station, without any compensating diminution during the time of the shorter output.

The Directors feel the importance of curtailing as far as possible the capital expenditure, and have charged to the profit and loss account some items which might legitimately have been included in the capital outlay.

The total number of lamps now connected with the station is 705, including one 500 candle-power arc lamp.

PATENT

SILICIUM BRONZE AND SILICIUM COPPER WIRE.

The best for overhead Telephone and Telegraph Lines,

AND ALL ELECTRICAL PURPOSES.

Hard Drawn High Conductivity Copper Wire.

ROLLED AND DRAWN PHOSPHOR BRONZE.

PHOSPHOR BRONZE VULCAN PHOSPHOR DURO METAL

PHOSPHOR BRONZE BEARINGS, BUSHES, AND OTHER PARTS OF ELECTRICAL MACHINERY

*SOLE PROPRIETORS of the British, Indian and Colonial Patents,*

THE PHOSPHOR BRONZE COMPANY (Limited),

*87, Sumner Street, Southwark, London, S.E.*

WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

Digitized by Google

On October 13th last, a circular was issued to the shareholders offering them, *pro rata*, the unissued shares of the Company, in order that the necessary provision might be made for meeting the Company's increasing business. The shareholders have in response accepted £1,000 of these shares, leaving £1,645 still for disposal. It was hoped that the whole number would have been taken up, so that further necessary expenditure would be amply met by calling up only one-half of the amount.

## Taunton Electric Lighting Company (Limited).

The report of the Directors of this Company for presentation at the fourth annual meeting is as follows:—

"The number of shares allotted is 2,556, on which the sum of £12,780 has been received. During the year the new buildings in St. James's-street, referred to in the last annual report, have been completed. These buildings, with the new machinery and plant laid down, make the works of the Company quite a model depôt. But the completion of these works took a much longer time than had been anticipated; and during the early part of the year there was the expense, for a time, of running two works, in consequence of which the cost of coal and other items was very much higher than would have been the case under normal conditions. Further than this, the work of the construction of the new circuits in the town was much delayed in consequence of the stringent requirements of the Board of Trade; thus retarding the whole business of the Company for several months, during the most important part of the year for constructive work. Under all these exceptionally adverse circumstances, it will hardly be matter for surprise that the accounts show a deficit on the year's working of £438. 17s. 5d.; but now that the works are in good order, and the business of the Company constantly increasing, there is every reason to believe that the next year's working will show a different result. Towards the close of the year it was found necessary to obtain more capital than the issue of ordinary shares secured, and your Directors therefore determined to issue £5,000 Debentures, such sum to include the previous issue of £3,000; and they confidently appeal to the present shareholders to come forward and take up this issue of £5,000 Debentures. Since the issue of the last annual report, Mr. John Withycombe has resigned his seat on the Board of Directors, in consequence of his having gone to reside at Minehead. Your Directors appointed Mr. Arthur A. Chapman to fill the vacancy thus created, and they ask the shareholders to confirm the appointment. The Directors who retire by rotation are Messrs. Alfred Lewis, H. G. Massingham, and A. Steevens; the two former offer themselves for re-election. The auditor, Mr. Albert Goodman, retires; but being eligible, offers himself for re-election."

## NEW COMPANIES REGISTERED.

**MAZAPIL COPPER COMPANY (LIMITED).**—Registered by Jordan and Sons, 120, Chancery-lane, W.C., with a capital of £50,000 in £10 shares. Object: To acquire the Mazapil Copper Mines, Mazapil, Zacaticas, Mexico, and to carry on generally the business of miners, smelters, &c.

**SOCIETE ANONYME D'ELECTRICITE INDUSTRIELLE.**—This Company has just been formed in Paris, with a capital of 4,000,000fr., represented by 8,000 shares of 500fr. each. Of this number 7,600 are considered as fully paid. The object of the Company is to supply electric light and power, and to manufacture and sell the De Meritens battery.

## CITY NOTES, &c.

**BELL'S ASBESTOS COMPANY (LIMITED).**—At the third annual meeting, held on Monday last, the Directors' report for the year ended December 31st last, which showed a net profit of £18,095, and recommends the payment of a dividend of 5s. per share, being, with the interim distribution, 15 per cent. for the twelve months, leaving £2,034 to be carried forward, was carried. The trade of the Company in manufactured asbestos and machinery had exhibited a decline during the twelve months, but the Directors believe that this is only temporary. The Chairman referred to some adverse criticisms which had been made upon the Company's system of working, but assured the shareholders that there was no truth whatever in the statements referred to, and he complained of the way in which the tittle-tattle of irresponsible sections of the press was listened to and acted upon by persons in high places, resulting in a loss of business to the Company. This would, however, he felt sure, right itself in the long run.

**BRAZILIAN SUBMARINE TELEGRAPH COMPANY.**—The receipts of this Company for the week ended February 20th amounted to £6,114.

**BRUSH ELECTRICAL ENGINEERING COMPANY.**—This Company notifies the payment of a half-yearly interim dividend at the rate of 6 per cent. per annum on the Preference shares.

**CITY AND SOUTH LONDON RAILWAY COMPANY.**—The receipts of this Company for the week ended February 21st amounted to £718.

**SANITAS COMPANY (LIMITED).**—The Directors of this Company have resolved to recommend the payment of a final dividend of 5 per cent., making, with the interim distribution, 10 per cent. for the year 1890, besides the addition of 2½ per cent. to the reserve fund.

**LONDON PLATINO-BRAZILIAN TELEGRAPH COMPANY (LIMITED).**—It is intimated that the coupons on their debentures due March 1st next will be paid on presentation at the banking-house of Messrs. Glyn, Mills, and Co., Lombard-street, E.C.

**MUNTZ'S METAL COMPANY (LIMITED).**—The Directors have resolved, subject to the approval of the accounts by the auditors, to recommend the payment of a dividend of 7½ per cent. for the half-year ended December 31, 1890, making 10 per cent. for the year, and a bonus of 5 per cent. on the ordinary shares, and a dividend of 2½ per cent. on the Preference Shares, making 5 per cent. for the year.

**SOCIETE ANONYME D'ELECTRICITE INDUSTRIELLE.**—This Company has just been formed in Paris, with a capital of 4,000,000f., represented by 8,000 shares of 500f. each. Of this number, 7,600 are considered as fully paid. The object of the Company is to supply electric light and power, and to manufacture and sell the De Meritens battery. (See *The Electrician*, February 13th, p. 463.)

**STOCK EXCHANGE.**—The Committee have appointed Tuesday, March 3rd, a special settling day in the Eastern Extension, Australasia, and China Telegraph Company (Limited) £320,000 Four per Cent. Mortgage Debenture Stock, and have ordered this security and shares Nos. 1 to 66,750 of Elmore's French Patent Copper Depositing Company (Limited) to be quoted in Official List. Application has been made to the Committee to allow shares Nos. 142 to 6,459 of the Notting Hill Electric Lighting Company (Limited) to be quoted in the Official List.

**THE WESTERN COUNTIES AND SOUTH WALES TELEPHONE COMPANY (LIMITED).**—The Company have posted warrants for the dividend upon Preference Shares at the rate of 6 per cent. per annum. for the half-year ending December 31st, 1890.

**WEST INDIA AND PANAMA TELEGRAPH COMPANY.**—The traffic receipts for the half-month ended Feb. 15th were £3,213, as compared with £3,585 for the corresponding period of 1890.

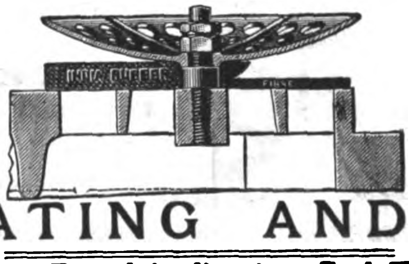
**WESTERN AND BRAZILIAN TELEGRAPH COMPANY.**—The traffic receipts of this Company for the week ending February 20, 1891, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £4,928.

**WEST AFRICAN TELEGRAPH COMPANY (LIMITED).**—Notice is given that the half-yearly interest on the £300,000 Five per Cent. Mortgage Debentures, due on March 1st next, will be paid on and after Monday, March 2nd, by the National Bank of Scotland, 37, Nicholas-lane, London, E.C. Coupons must be left three clear days for examination.

**CRICKET.**—The Cricket Club of the Electric Construction Corporation, formerly known as the E.P.S.C.C., held their third annual smoking concert at Limehouse Town Hall, on Friday last, the 20th inst. The Managing Director, Mr. Joseph Ebb-Smith, presided; he was supported by several well-known friends of the Club. Among those who regretted their inability to be present were the Chairman, Sir Henry Mance, and Mr. J. Irving Courtenay, from whom letters of apology were read. During the evening the best batsman of the season (Mr. A. Shaw) was presented with a handsome bat, and the best bowler (Mr. J. A. Munro) with a travelling bag. A most enjoyable evening was spent by all present.


NEW VALVE

No Rubber, Percha, or Leather.



One-half the price of Rubber or Metal.

FOR CIRCULATING AND AIR PUMPS.

Unaffected by any Lubricating Oils. Does not Expand in diameter. Feed Water may be worked at any temperature. Suitable for any shaped guards. Only one quality manufactured.

"12, John-street, Sunderland, 20th Sept. 1886.

"DEAR SIRS,—In reply to your letter of the 25th inst., the Valves I got from you have done their work well, and ARE AN UNQUALIFIED SUCCESS. I will continue get them from you as required.—Yours faithfully, JAMES WESTOLL."

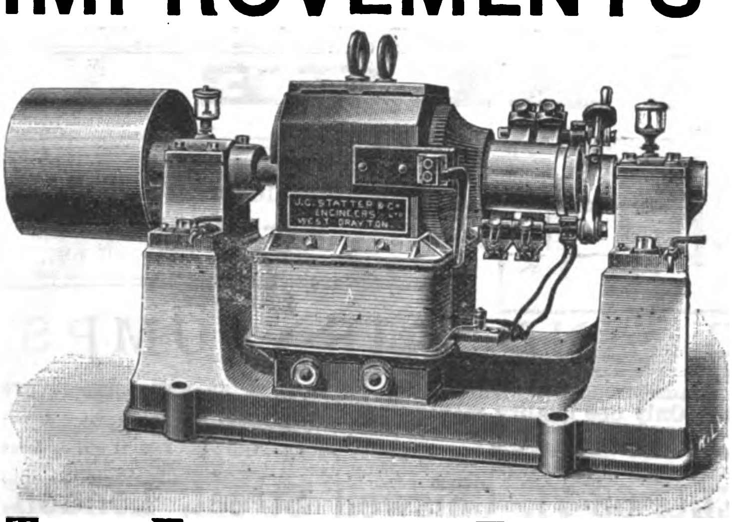
For further Testimony and Prices, apply to **MOSSES & MITCHELL, 68-71, Chiswell Street, London.**


Digitized by Google

## COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name. | Previous Week's Price, Feb. 18. | | Price Wednesday, Feb. 25. | | Rate per Cent. Yielded. | Dividend Due. | Business Done During Week Ending Feb. 25. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **TELEGRAPHS.** | | | | | £ s. d. | | | |
| £1,381,380 | Stock | 15/0 | Anglo-American | 48 | 49 | 47 | 48 | 5 19 9 | Jan., Apr., July, Oct. | 48½ | 47½ |
| £2,809,310 | Stock | 30/0 | Do. Preferred | 84½ | 85½ | 84 | 85 | 6 15 4 | " " | 85¾ | 84¾ |
| £2,809,310 | Stock | .. | Do. Deferred | 12 | 12½ | 11½ | 12 | .. | " " | 12½ | 11½ |
| £250,000 | 100 | 4% | African Direct, Telegraph 4% Debentures | 99 | 102 | 99 | 102 | 3 18 5 | January and July .. | .. | .. |
| 130,000 | £10 | 3/0 | Brazilian Submarine | 11¾ | 12¼ | 11¾ | 12¼ | 6 2 5 | Mar., June, Oct., Dec. | .. | .. |
| £84,500 | £100 | 5% | Do. 5 per Cent. Bonds | 100 | 103 | 100 | 103 | 4 17 1 | January and July .. | .. | .. |
| £75,000 | £100 | 5% | Do. 5 per Cent. Bonds (2nd Series, 1906) | 103 | 107 | 103 | 107 | 4 13 6 | June and December | .. | .. |
| $7,216,000 | $100 | 7% | Commercial Cable Capital Stock | 107 | 109 | 107 | 109 | 5 19 3 | April and October .. | 108½ | 108½ |
| 16,000 | 10 | 8/0 | Cuba Submarine | 10½ | 11½ | 10½ | 11½ | 6 19 2 | February and August | 11½ | 11 |
| 6,000 | 10 | 10% | Do. Preference 10% | 16 | 17 | 16 | 17 | 5 17 8 | " " | .. | .. |
| 12,931 | 5 | 2/4½ | Direct Spanish (£4 paid) | 3¾ | 4¼ | 3¾ | 4¼ | .. | April and October .. | .. | .. |
| 6,000 | 5 | 10% | Do. Preference 10% | 9 | 10 | 9 | 10 | 5 0 0 | " " | .. | .. |
| 60,710 | 20 | 8/6 | Direct United States | 10½ | 10⅝ | 10½ | 10⅞ | 6 15 0 | Jan., Apr., July, Oct | 10⅞ | 10⅜ |
| 400,000 | 10 | 2/6 | Eastern | 14⅛ | 14⅜ | 14 | 14¼ | 4 11 3 | " " | 14⅜ | 14 |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference | 15 | 15½ | 15 | 15½ | 3 17 5 | " " | 15⅛ | .. |
| £1,200,000 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock | 107 | 110 | 107 | 110 | 3 12 9 | May and November | 108½ | 108 |
| £200,000 | 100 | 5% | Do. 5 per Cent Debentures, 1899 | 107 | 110 | 107 | 110 | 4 10 11 | February & August | 109½ | .. |
| 250,000 | 10 | 2/6 | Eastern Extension | 14¾ | 15¼ | 14¾ | 15¼ | 4 11 10 | Jan., Apr., July, Oct. | 15⅛ | 14⅞ |
| £320,000 | 100 | 6% | Do. 6 per Cent. Debentures, 1891 | .. | | .. | | .. | February & August | .. | .. |
| .. | £100 | .. | Do. 4 per Cent. Debentures Stock | .. | | 104 | 107 | .. | .. | .. | .. |
| £91,800 | 100 | 5% | Do. 5 p. c. (Austin. Gov. Sub.) Debs. 1900 | 103 | 106 | 103 | 106 | 4 14 4 | January and July .. | 106½ | 104 |
| £145,300 | 100 | 5% | Eastern & S. African 5 per Cent. Mor. Deb., 1900 | 103 | 106 | 103 | 106 | 4 14 4 | " " | .. | .. |
| 180,227 | 10 | 1/9 | Globe Telegraph and Trust | 9 | 9½ | 9 | 9½ | 5 5 6 | Jan., Apr., July, Oct. | 9½ | 9 |
| 180,042 | 10 | 6% | Do. 6 per Cent. Preference | 14¾ | 15¼ | 15 | 15½ | 3 18 8 | " " | 15⅛ | 14⅞ |
| 150,000 | 10 | 5/0 | Great Northern | 16¾ | 17¼ | 16¾ | 17¼ | 4 6 11 | Jan., April, and July | 17⅟₁₆ | 16⅞ |
| £230,000 | 100 | 5% | Do. 5 per Cent. Debentures, 1883 | 105 | 108 | 105 | 108 | 4 12 7 | March & September | 107⅜ | .. |
| 17,000 | 25 | 12/6 | Indo-European | 36 | 38 | 36 | 38 | 6 11 7 | May and November | 37½ | – |
| 38,348 | 10 | 4/0 | London Platino-Brazilian | 6½ | 7½ | 6½ | 7½ | 5 14 4 | " " | .. | .. |
| £100,000 | 100 | 6% | Do. 6 per Cent. Debentures | 108 | 111 | 108 | 111 | 5 8 1 | March & September | .. | – |
| 9,000 | 8 | 4/0 | Reuter's | 8½ | 9 | 8½ | 9 | 5 11 1 | April and October .. | 8½ | .. |
| 3,381 | £100 Cert. | 6% | Submarine Cables Trust 6% | 113 | 117 | 115 | 120 | 5 0 0 | " " | .. | .. |
| 15,609 | 10 | 4/0 | West African Telegraph | 8 | 9 | 8 | 9 | 5 11 1 | January and July .. | 101¾ | 101 |
| £290,900 | 100 | 5% | Do. 5 per Cent. Debentures | 100 | 103 | 100 | 103 | 4 17 1 | March & September | 101¾ | 101½ |
| 30,000 | 10 | 3/0 | West Coast of America | 2 | 4 | 2 | 4 | .. | January and July .. | .. | .. |
| £150,000 | 100 | 8% | Do. Debentures 8% 1902 | 94 | 99 | 94 | 99 | .. | June and December | .. | .. |
| 88,321 | 10 | .. | West India and Panama | 3⅛ | 3⅜ | 2¾ | 3¼ | .. | .. | 3¼ | 3 |
| 34,563 | 10 | 6/0 | Do. 1st Preference 6% | 11½ | 11¾ | 11½ | 12 | 5 0 0 | May and November | 11⅞ | 11¾ |
| 4,669 | 10 | £3 | Do. 6 p. c. 2nd Pref. | 11 | 12 | 11 | 12 | 5 0 0 | " " | .. | .. |
| 64,174 | 15 | 6/0 | Western and Brazilian | 12½ | 12⅞ | 12 | 12½ | 4 16 1 | " " | 12⅜ | .. |
| 27,873 | 7½ | 6/0 | Do. 5 per Cent. Cumulative Preferred | 6¾ | 7¼ | 6¾ | 7¼ | .. | – | 7 | 6⅞ |
| 27,873 | 7½ | 4/6 | Do. 5 per Cent. Deferred | 5¼ | 5¾ | 5 | 5½ | .. | .. | 5½ | .. |
| £200,000 | 100 | 6% | Do. 6 per Cent. Debs., Series "A" 1910 | 103 | 106 | 103 | 106 | 5 13 2 | February & August | .. | .. |
| £250,000 | 100 | 6% | Do. 6 per Cent. Mort. Debs., Series "B" 1910 | 103 | 106 | 103 | 106 | 5 13 2 | " " | .. | .. |
| $1,336,000 | $1,000 | 7% | Western Union 7 per Cent. 1st Mortgage | 120 | 125 | 120 | 125 | 5 12 0 | May and November | .. | – |
| £175,100 | £100 | 6% | Do, 6 per Cent. Sterling Bonds | 99 | 103 | 101 | 105 | 5 14 3 | March & September | .. | – |
| | | | **TELEPHONES.** | | | | | | | | |
| 224,850 | 14/0 | 0/4½ | Consolidated Telephone Const. & Maintenance. | 7/16 | 9/16 | 7/16 | 9/16 | .. | May and November | .. | – |
| 220,000 | £1 | 3% | Oriental (11s. paid) | 3/16 | 5/16 | ¼ | ⅜ | .. | Yearly | .. | .. |
| 433,984 | 5 | 2/6 | National | 4⅜ | 4⅞ | 4¾ | 5 | 5 10 0 | June and December | 4⅞ | 4⅞ |
| 15,000 | 10 | 6/0 | Do. 6 per Cent. Cumulative 1st Pref. | 12½ | 13 | 12¾ | 13¼ | 4 10 7 | " " | 13 | .. |
| 15,000 | 10 | 4/9¾ | Do. 6 per Cent. Cumulative 2nd Pref. (£8 pd) | 10½ | 10¾ | 10½ | 10¾ | 4 9 7 | " " | .. | .. |
| 209,750 | 1 | ½% | South of England, Ordinary | ¼ | ¾ | ¼ | ¾ | .. | – | .. | .. |
| 20,000 | 5 | 2/1 | Do. 6 per Cent. Cumulative Pf. (£3 10s. pd) | 2¾ | 3¼ | 2¾ | 3¼ | 6 9 0 | .. | .. | – |
| 58,000 | 5 | 1/0 | United River Plate | 3 | 4 | 3 | 4 | .. | January and July .. | .. | .. |
| £146,128 | Stock | 5% | Do. 5 per Cent. Debenture Stock | 90 | 95 | 90 | 95 | 5 5 3 | .. | .. | – |
| £3,200 | 100 | 7% | Do. 7 per Cent. Debentures | .. | | .. | | .. | – | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | | | |
| 200,000 | 5 | .. | London Electric Supply | 1¼ | 1¾ | 1¼ | 1¾ | .. | – | .. | – |
| 43,900 | 10 | .. | Metropolitan Electric Supply (£8 paid) | 7¾ | 8¼ | 7¾ | 8¼ | – | – | 8 | 7 3/16 |
| 42,853 | 5 | .. | Westminster Electric Supply (£3 paid) | 3¾ | 4¼ | 3¾ | 4¼ | .. | – | 4⅛ | 3⅞ |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | | | |
| 63,416 | 3 | .. | Brush Electrical Engineering | 2⅜ | 2⅝ | 2¼ | 2¾ | .. | .. | 2⅜ | 2¼ |
| 63,416 | 2 | 0/10 | Do. 6 per Cent. Preference | 1½ | 2 | 1½ | 2 | 6 0 0 | June and December | 1⅝ | .. |
| 20,000 | 5 | 3/6 | Crompton and Co., 7 per Cent. Pref. Shares | 5 | 5½ | 5 | 5½ | 6 7 3 | January and July .. | .. | .. |
| 17,139 | 5 | .. | Edison and Swan United | .. | | .. | | .. | – | .. | .. |
| 45,000 | 10 | 6% | Electric Construction | 5½ | 6½ | 5½ | 6½ | .. | – | 6⅛ | 5⅞ |
| 70,000 | 2 | 10/0 | Elmore's Patent Copper Depositing | 3 | 3½ | 3 | 3½ | .. | – | 3¼ | 3 1/16 |
| 20,000 | 5 | .. | Fowler-Waring Cables (£4 paid) | 2½ | 3½ | 2½ | 3½ | .. | .. | .. | .. |
| 41,600 | 10 | 10/0 | India Rubber, Gutta Percha & Telegraph Works | 19 | 20 | 19 | 20 | 5 0 0 | February & August | 19 9/16 | 19⅜ |
| £200,000 | 100 | 4½% | Do. 4½ per Cent. Debentures, 1896 | 103 | 105 | 104 | 106 | 4 4 11 | March & September | .. | .. |
| 11,334 | £10 | .. | International Okonite Limited Ordinary | 9½ | 9¾ | 9½ | 9¾ | 10 4 7 | .. | .. | .. |
| 11,334 | £10 | .. | Do. Preference | 9½ | 9¾ | 9½ | 9¾ | 8 4 1 | .. | .. | .. |
| 78,949 | 5 | 4/10½ | Swan United (£3. 10s. paid) | 4½ | 5 | 4½ | 5 | 6 19 10 | May and November | 4¾ | 4 9/16 |
| 37,850 | 12 | 12/0 | Telegraph Construction and Maintenance | 46 | 48 | 46 | 48 | 5 0 0 | March and July | 48½ | 46¾ |
| £150,000 | 100 | 5% | Do. 5 per Cent. Bonds, red. 1894 | 102 | 106 | 102 | 106 | 4 15 3 | January and July | 102½ | .. |
| | | | **RAILWAYS.** | | | | | | | | |
| 50,000 | £10 | .. | City and South London Railway | 6 | 7 | 6 | 7 | .. | .. | 6⅜ | .. |


# IMPROVEMENTS IN DYNAMOS.



## STATTER-BRUNTON DYNAMO.

**The latest design in the market, made with all the advantages of the latest scientific knowledge and the highest mechanical skill.**

The woodcut represents our B TYPE DYNAMO. A most efficient machine, working noiselessly, and without sparking or overheating; is highly finished and well proportioned. The output is so rated in our Catalogue that the machines may be worked very much in excess of their stated full output for short periods.

**STOCK SIZES UP TO 77 KILOWATTS.**

**MACHINES BUILT TO 500 KILOWATTS.**

**THE ELECTRICAL ENGINEERING CORPORATION, LIMITED,**

[STATTER'S] [UNITED

68, Victoria Street, London, S.W.

WORKS:—ALLIANCE ENGINEERING WORKS, WEST DRAYTON, NEAR LONDON.

# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 668.—Vol. XXVI. FRIDAY, MARCH 6, 1891. Price Fourpence.

## NOTES.

The fact, published for the first time at the Physical Society on Friday last, that Mr. Blakesley's method of measuring power is equally true whether the alternate currents vary according to a pure sine law or not, is one of very great importance, as several experimenters have shown that the current variations occurring in practice are in many cases far from sinuous. It is, however, very important to note that the method is only accurate in the case of a transformer on the assumption that the induced voltages in the primary and secondary circuits are strictly proportional to each other at every instant of time. This will not be the case if the secondary circuit is inductive, and in particular it is not true if there is magnetic leakage in the transformer. Such leakage is known to take place in all transformers used in practice, and is shown by the drop in the electromotive force acting in the secondary circuit, which occurs as the load is increased. The waste due to hysteresis, calculated by such a method, may differ considerably from that which really occurs, so that the results announced by Prof. Ayrton, relating to the waste for different loads, must at present be accepted with great caution. Of course, if these results can be taken as correct, the controversy about the merits of open and closed circuit transformers is put upon an entirely new basis.

The discussion on the Papers read at the last meeting of the Physical Society having been postponed until the members have had an opportunity of seeing them in type, the adjourned discussion on Mr. Swinburne's Paper at the Institution of Electrical Engineers will intervene, and it is possible that the solid facts which were interspersed amid a tangle of complicated mathematics on Friday last at South Kensington may receive some attention on Thursday next at Westminster.

It is fortunate for the members of the Institution of Electrical Engineers that mathematicians who turn their attention to engineering problems have another outlet for their discoveries, for it is not one engineer in twenty who can take in the meaning of an abstruse mathematical Paper by hearing bits of it read, and seeing a few of the equations chalked on the blackboard to be wiped off again a few moments after, and replaced by others. It would, indeed, be but a small compliment to the talents of the authors if their work could be appreciated by a *viva voce* rendering alone, unless, indeed, the audience were composed of trained mathematicians accustomed to follow such discourses.

The assertion of Prof. Ayrton that the losses in the iron core of a $2\frac{1}{2}$ kilowatt transformer fell off on full load to the insignificant amount of three watts, though it is enthusiastically welcomed and confirmed by the designer, will not be readily received among engineers without some very much more intelligible explanation than has yet been given. It is to be hoped that such an explanation will be speedily forthcoming, and that other perplexed transformer makers may soon learn whether Ewing's theory of magnetisation is to be discarded, or whether the method of testing only takes into account certain matters that are of interest to mathematical minds, and ignores others that are of considerable importance to engineers. Mr. Mordey, in speaking of his thermometric method, has applied to it some rather strong expressions, such as "conclusive," "absolutely, and entirely correct." He, too, must give us considerably more information as to whether the temperature which he measures "with a shilling thermometer" is uniform all over the transformer, although he warms the iron at one time and the copper at another.

The question of nomenclature, to which attention is called in our correspondence columns, is one of considerable importance. Several of our leading physicists have shown themselves to be very fond of creating new titles for various units, and, pruning down the names of distinguished men, have applied them to most of the electrical quantities. This branch being exhausted, they have turned their attention to mechanical units, and have offered us microbarads and megaboles. Mr. Heaviside has a third style, and coins words from the ordinary language of science by a systematic use of suffixes. Some of the results have been happy, but there should be a limit to this fascinating diversion, if only on account of the difficulty of keeping the continually increasing vocabulary in mind. Mr. Heaviside's terms are sufficiently original to be free from any danger of clashing with others, but the name "gauss" has certainly been used before for the unit of magnetic induction, although it has not come into such general use as Mr. Evershed suggests in our correspondence columns, and it is not clear to whom he refers in speaking of "the powers that be." The Paris Congress is the only such power, and it has merely given an international *cachet* to names which have already attained some degree of popularity.

Life is short we know but it is long enough to allow the use of the simple expression "one line of force" without the need of any special monosyllabic name. Civil engineers do not

Digitized by Google

feel the want of a name for "one gallon per minute." The difficulty in connection with magnetic lines arises, as we have pointed out before, when we come to "half a line of force," and for this reason only, some name, or at all events, some better mode of expression might be looked for. A special committee of the British Association has been appointed to consider the magnetic units and their names, and their report, when published, will no doubt carry great weight at the next Paris Congress, and introduce a little order where chaos at present exists.

UNIFORMITY in the use of symbols is quite as important as an accepted system of names, Mr. HEAVISIDE has expressed a wish that the "antique," or "Clarendon" type, by which he invariably expresses vector quantities, shall be exclusively used for that purpose in mathematical expressions. MAXWELL used German characters, which have a clumsy appearance, are difficult to write, and are alarming to the uninitiated. By common consent, the symbols **B**, **H**, **I** are used to express induction per square centimetre, magnetising force, and intensity of magnetisation respectively. These quantities may or may not be used with a vector signification. There is an unfortunate lack of uniformity among writers as to the symbol for current; some use I, a relic of the old "intensité du courant," and others use C. It is to be hoped that these and other symbols will soon be definitely settled.

WHILST the religious sect which he founded has been celebrating the centenary of JOHN WESLEY, how many of his followers have been made aware that he was the author of a work on electricity. This curious *brochure* was published in 1759, under the title of "The Desideratum: or, Electricity made Plain and Useful by a Lover of Mankind and of Common Sense." The titles of the sections are decidedly suggestive—"Electricity the Soul of the Universe;" "The Cat in the Oven, curious Electrical Experiment;" "A Person with Small-pox cannot be Electrified;" "Electricity the greatest of all Remedies." The reverend author goes in for a serious argument to demonstrate that it is "just as *innocent* to keep our rooms tight from lightning, as from wind and water." One of the entries is as follows:—"Exp. 32. A Person standing on the Ground cannot easily kiss an electrified Person standing on the Rosin." About half the volume is taken up with narratives of cures supposed to have been wrought by electrifying, the diseases being of the most varied kind, from fistula to epilepsy. Even the cure of moral diseases is attributed to electricity. "*Felons* are speedily cured by drawing Sparks. If any disorder be superficial this Operation suffices: But if it lie deeper, then the giving of Shocks is found to be more effectual." The good old divine had probably little idea what mischief his well-meaning recommendations of electricity might work. Happily, in science more weight is attached to proven facts than to the authority of a great name. And Wesley's attempt to intervene in science was less successful than his intervention in ecclesiastical organisation.

**Tunbridge Wells.**—The Town Council have resolved to apply for a Provisional Order.

**Institution of Civil Engineers.**—At the last monthly ballot Prof. Ewing was elected a member of this institution.

**Electric Traction in Austria.**—An electric railway is to be laid down between Herculesbad and the nearest station on the Vienna-Orsova Railway.

**Old Students' Association.**—The Old Students will hold a smoking concert this evening at 8 o'clock at the Masons' Hall Tavern, Masons'-avenue, Basinghall-street, E.C.

**Dresden.**—The Royal Court House is to be lighted by electricity. About 1,000 glow lamps will be employed, and a battery of Tudor accumulators is to be put down.

**The St. James and Pall Mall Company.**—It is reported that the results of the borings to a depth of 260 feet in Mason's-yard, Jermyn-street, give a yield of water of more than 1,000,000 gallons a week.

**Royal Institution.**—Prof. Victor Horsley, F.R.S., will give a lecture on "Hydrophobia" on Friday, March 20th, in place of Prof. W. E. Ayrton, F.R.S., who is unable at present to give his promised lecture on "Electric Meters, Motors, and Money Matters."

**Obituary.**—We regret to learn of the death, on the 8th inst., at Bonny, West Coast of Africa, of Mr. J. Carruthers Allan, Superintendent, African Direct Telegraph Company. Mr. Allan was aged 25 years, and was the eldest surviving son of Mr. William Allan, of Dumfries.

**The Proposed Pacific Cable.**—According to a *Times* telegram of March 4th, the United States Senate defeated the Conference report on the Diplomatic Bill, which provided a subsidy for the Hawaiian cable. The Diplomatic Bill finally passed, omitting the cable subsidy.

**The London Overhead Wires Bill.**—An instruction to the Committee on this Bill was carried in the House of Commons on Friday evening last, by 16 votes, requesting them to assimilate the provisions of the Bill to the provisions of the law as it affected the provinces generally.

**Aranjuez.**—One of the largest central stations in Spain is about to be erected at Aranjuez by the representatives of the Allgemeine Elektricitäts Gesellschaft, of Berlin. The capacity of the station will be 30 arcs and 1,200 incandescents. The motive power will be derived from a waterfall.

**Telegraph and Telephone Wires in Budapest.**—According to the *Zeitschrift für Elektrotechnik*, the total length of the telegraph and telephone wires in Budapest is nearly 57,000 miles. The telephone wires alone account for only 1,638 miles, the number of telephone subscribers being 1,245.

**Reorganisation of the French Telegraph Service.**—M. de Selves, Director-General of Telegraphs, has just issued a circular letter to various postal telegraph officials relative to the reorganisation of the system of delivering telegrams, and calling upon them to answer a series of questions by March 31st.

**Electric Traction Concessions in Pittsburg.**—The Pittsburg municipal authorities have hit upon a decidedly novel method of taxing electric traction. All electric street railway companies seeking concessions are required to agree to furnish electric power free of cost to the mechanical street sweepers.

**The Proposed Permanent Electrical Museum.**—*Electrical Plant* has been informed that a committee will be appointed by the council of the Institution of Electrical Engineers to fully consider the proposal recently put forward in its columns that a permanent electrical museum should be founded under the auspices of the institution.

**Institution of Electrical Engineers.**—A general meeting of the students of this institution was held on Friday last, when Mr. Stanley Bone read a Paper on "Electric Lighting Safety Apparatus," some specimens being shown by the General Electric Supply Company. At the next meeting, on March 13th, Mr. H. B. Little will read a Paper on "Modern Telegraphy."

**Long Distance Telephony in Spain.**—The Madrid paper, *La Epoca*, says that among the projects in the portfolio of the Minister of the Interior is one which will shortly be published, inviting public tenders for the construction and working of long distance telephony in Spain. The project consists in telephonically uniting, within a very short period, the various large towns of Spain and placing them in communication with Madrid.

Digitized by Google

**The Kensington and Paddington Subway.**—In reply to several questions in the House of Commons on Friday evening last, it was stated that the promoters of this scheme had agreed to work by cable instead of by electricity, owing to the objections raised by the Science and Art Department. It was also stated that the objections raised by the Normal School of Science and the City of London Guilds Institute had been overcome by the promoters.

**The Croydon County Council and the Board of Trade.**—At a recent meeting of the Croydon County Council, the General Purposes Committee reported that the Board of Trade proposed to insert a clause in the Council's Provisional Order, to the effect that overhead wires were not to be erected without the permission of the Board of Trade. The report concluded by announcing that it was proposed to remonstrate with the Board of Trade on this point.

**Hours of Lighting in Milan.**—Profs. Colombo and Ferrini, of the Royal Technical Institute, Milan, have published, as the result of the working of the electric lighting station in Milan, certain data which show the relative number of hours during which various classes of consumers keep the light in use. The theatres and cafés in Milan run each lamp on an average 1,800 hours per annum; clubs, 1,300 hours; hotels, 950 hours; shops, 750 hours; offices, banks, &c., 400 hours; private consumers only 320 hours; average over all, 750 lamp hours per annum.

**The Subway Railway Bills.**—Steps are being taken to ensure the insertion of clauses in the Central London Railway Bill, the City and South London Railway Bill, and the South Kensington and Paddington Subway Bill, providing either (1) for payment to the local authority of a royalty or share of earnings after interest on capital and working expenses; or (2) for specially reduced fares on certain trains before nine o'clock in the forenoon and after six o'clock in the afternoon, the railway company being required to run a specified number of such trains daily.

**Train Lighting.**—Prof. Kohlrausch, says *Industries*, has reported on the experiments which have been carried out in the electric lighting of railway trains between Cannstadt and Stuttgart, and his conclusions are that such lighting must be independent of the locomotive, and that it must be on the accumulator system. He disapproves of carrying a dynamo, owing to the consequent increase in the number of couplings in the train, and advocates charging the accumulators by means of fixed engines at various stations, and changing the batteries when approaching exhaustion.

**Magnetic Rocks.**—At the Royal Academy of Lyncei on December 18th, Signors Sella and Oddone gave an account of some researches on the distribution of magnetism in certain regions on the Alps. They have found a number of magnetic foci, and record that the rocks which present distinct magnetic properties are magnetite, serpentine, diorite, melaphyre, and syenite. A magnetic rock was observed by Signor Sella on Punta Giufetti, in the Monte Rosa group, and, as it presented traces of fusion on its surface, as if it had been struck by lightning, it is suggested that this circumstance has endowed the rock with its magnetic properties.

**Cheltenham.**—At the last meeting of the Town Council, the Electric Lighting Committee reported that a circular letter had been received from the Board of Trade calling attention to the necessity of obtaining the approval of the Board of Trade to any system of electric supply proposed to be adopted. The Committee passed the resolution "That it is desirable to proceed, with as little delay as possible, in the exercise of the powers conferred by the Electric Lighting Order, and that the borough surveyor be directed, with such assistance as he might find to be necessary, to report as to the best system to be adopted." The Committee's report was adopted.

**High Speed Steam Engines.**—At a recent meeting of the Society of Engineers a Paper was read by Mr. Arthur Rigg on "The Balancing of High Speed Steam Engines." The author said that the present Paper was intended to take note of the external effect of the strains caused by reciprocation, and the modes by which their vibratory influence might be counteracted. A comparison was made between the effects of a compression of exhaust and an independent air buffer, showing how the former entailed a permanent loss of useful effect, which in some measure aided in producing the economy desired by an independent method for bringing these reciprocating parts to a state of rest.

**The London-Paris Telephone Cable.**—The vessel with the cable on board has been lying off Calais waiting for favourable weather, but the wind has been too high to allow the shore end to be properly laid. It has been impossible to make any experiments while the cable is disposed in coils, but it is confidently expected that communication will be satisfactory with ordinary Gower-Bell instruments. The report published in the daily papers that the London and Paris stockbrokers are strongly opposed to the telephonic communication is, we learn on good authority, entirely without foundation.

**The Distinction between Patents and Monopolies.**—If a patent, says the *Electrical Engineer* of New York, be in a proper sense a monopoly, "it is not," as a distinguished judge once said, "an odious monopoly." The distiction between patents and monopolies has never, perhaps, been better presented than in the following words, from the opinion of Justice Giles, in the sewing machine case, Singer *v.* Walmesley: "Patents are not monopolies, because a monopoly is that which segregates what was common before, and gives it to one person or class for use or profit. A patent is that which brings out from the realm of mind something that never existed before, and gives it to the country."

**An Armature Reaction.**—An American technical contemporary contains the following:—A professor of the Ricker Classical Institute took 50 of his pupils to the electric light station in Houlton one evening, to give them some practical instruction in the science of electric lighting. The professor took his place close to the armature, and, to better explain its workings to the class, he held a common door-key in his hand. At a certain stage of the exercises the key came in contact with the armature, the magnetic power was too great to break the connection, and in a few moments the insulation was torn off and the electric generator burned out. As a result of the experiment Houlton was in darkness until a new armature arrived from Connecticut.

**A Useful Application of the Chlorochromic Acid Battery.**—An interesting application of the chlorochromic acid ($CrCl_2O_2$) battery to portable incandescent lamp lighting was made last autumn in France by the underground explorers, MM. A. Martel and G. Gaupillat, who employed a battery of the Renard type (zinc platinised-silver) containing six cells, and capable of supplying current during five hours to a 12 or 15 candle-power lamp. Candles and magnesium lights were out of the question owing to the exhalations from the stagnant subterranean waters. The whole apparatus was 12in. high 8½in. in diameter, and weighed 17½lbs., which was not excessive for the purpose, since the lamp was carried on a small boat. The composition of the solution was approximately as follows:—Chromic acid, 1⅓lb.; hydrochloric acid, 1 pint; sulphuric acid, ⅓ pint; water, 3 pints.

**Aberdeen.**—The gas superintendent has prepared a report on the question of electric lighting, and submitted it to a sub-committee of the Gas Committee of the Aberdeen Town Council. The report estimates that some 150,000 units of electricity would probably have to be generated yearly within the compulsory area on the assumption that one in four of the present gas consumers took the electric light. After communication with Mr. W. B. Esson, the superintendent recommends that two machines of 1,000 lights each should be obtained, and estimates the total cost of the installation and mains at £21,300, the annual expenditure at £4,556, and the annual income at £5,875. In consequence of this report, the sub-committee have decided to issue circulars to all gas consumers within the compulsory area whose annual bill is over £5, asking them whether they would be likely to adopt the electric light.

**Electrolysis in Water Softening.**—For softening water by means of hydrated oxide of lead cheaply, it is necessary to obtain the oxide, and the following method has been devised by M. Villon. A solution of sodium nitrate is placed in a vat divided into two compartments by a diaphragm; lead electrodes of large surface are placed in the solution and the current from

Digitized by Google

a dynamo then passed through. The sodium nitrate is decomposed, caustic soda being formed in the negative compartment and nitric acid at the positive pole from which it dissolves a certain quantity of lead, forming lead nitrate. When the current has passed through the liquid for a certain time, the solutions are run from the two compartments into a second vat and there mixed by means of an agitator. The soda precipitates hydrated oxide of lead and itself forms sodium nitrate; the solution is then filtered and the nitrate solution again submitted to electrolysis.

**Granville's Electric Log.**—One of these logs, which are made by Elliott Brothers, has been fixed on board the "Orontes," and it is also in use in the Argentine Navy. Although essentially an electric log it contains no battery, the log, the iron hull of the ship and the ocean together forming the battery. It is of very simple construction and has only two moving parts, a revolving head and a small internal worm-wheel. The head is connected with the worm-wheel gearing, and every sixth revolution of the former is communicated, by means of a spring contact, through the tow-line to an indicator placed on the ship. The tow-line is insulated with braided tanned netting twine. The indicator consists of a small metal circular box with the necessary internal mechanism and external dials and pointers. The apparatus has shown itself to be an efficient means of accurately indicating, at any part of the ship where an indicator is fixed, the total distance run and the speed.

**St. Pancras Vestry Electrical Exhibition.**—At the last meeting of the St. Pancras Vestry the Electricity Committee Report stated that the Stanhope-street station was approaching completion. The vestry clerk reported with respect to the Electrical Exhibition to be opened at the Vestry Hall, Camden Town, on Monday, the 16th proximo, that there would be 35 exhibitors. The exhibition would be open for a week, a small charge being made for admission. The following firms are among the intending exhibitors:—Willans and Robinson, the Electrical Construction Corporation, Edison-Swan United, Benham and Froud, Strode and Co., Rashleigh, Phipps and Dawson; Clark, Muirhead, and Co., Johnson and Phillips, Woodhouse and Rawson United. A further report of the Electricity Committee stated that the Vestry were allowed to charge 8d. per unit. They recommended that the charge should be 6d. per unit, but that for the present no minimum charge be fixed. The reports were unanimously adopted.

**The Elihu-Thomson Motor Meter.**—At a recent meeting of the Société Internationale des Electriciens, M. René Arnoux, referring to the Elihu-Thomson motor meter (see *The Electrician*, January 16th, p. 332), pointed out that its speed must be very small if its indications are to be accurate. We have $E = c\,r + e$, where E is the potential difference at the shunt-wire terminals, $c$ the current in the shunt wire, $r$ its resistance, and $e$ the back E.M.F. of the motor meter. Now $c$ is equal to $K\,E\,\frac{\omega}{C}$, where $\omega$ is the angular velocity, and C the main current, and $e = K'\,\omega\,C$. Hence we have $E\,C = K\,E\,\omega + K'\,\omega\,C^2$, or $\omega \propto E\,C - K'\,\omega\,C^2$. Hence if the revolutions of the meter are to be proportional to E C, or the power consumed in the lamps, $\omega$ must be very small so that the term $K'\,\omega\,C^2$ may be neglected. Motor meters, it will be seen, are advantageous to consumers since this last term can never be entirely eliminated, and their indications are therefore always against the company.

**University Education.**—On Friday afternoon last a deputation waited on Mr. Goschen and presented a memorial in favour of the annual grant of £15,000 being increased. Amongst the speakers were Mr. Chamberlain, Mr. Erichsen of University College, Prof. Garnett, Sir Henry Roscoe, and Mr. Mundella. Before coming to any decision, Mr. Goschen said he should like to receive a statement from each of the colleges showing the number of students now as compared with the number of students before the grant was made, and the amount of subscriptions now as compared with the amount previously. A point which he appreciated the immense importance of was seeing that in these days, when technical education was being pushed in every direction, there was no falling off in the direction of other studies which were not bread-winning studies, but which rather appertained to the domain of general culture. He was anxious that the colleges that were engaged in the promotion of culture as well as the teaching of bread-winning studies should not be placed at too great a disadvantage by the help which was now given to technical education.

**Chelsea Vestry.**—At a meeting of this vestry last week the Electric Lighting Committee reported that they had considered a letter from Mr. R. Chamberlain, dated February 3rd, asking the Vestry to take into consideration the question of appointing an inspector under the Electric Lighting Acts, and suggesting that the duties might be performed by one of the existing officers. The Committee stated that they were unable to make a recommendation in the sense indicated by Mr. Chamberlain. The Committee also reported that they had considered a letter from the Cadogan Electric Light Company, dated February 4th, stating that they were at the present time working under an agreement with the Vestry, and being about to transfer their business to a newly-formed company, viz., the New Cadogan and Belgrave Electric Supply Company, they asked the Vestry to consent to the transfer of the agreement to the new company. On this the Committee recommended that the Cadogan Electric Light Company should be informed that the Vestry prefer that the company should obtain a Provisional Order. The reports were approved, and the recommendation adopted.

**The Counting of Press Messages.**—On Friday last, in reply to Mr. J. Maclean, who complained that figures in Press messages were counted each as a word, whereas in ordinary telegrams five figures were treated as one word, the Postmaster-General explained that before the introduction of the rate of a halfpenny a word for ordinary telegrams the regulations governing the charge for figures in those telegrams and in Press telegrams were the same, every figure being counted and charged for as a separate word. At the same time all addresses were sent free. When the halfpenny rate came into operation the addresses of ordinary telegrams were no longer sent free, and, chiefly as a concession to those who had to send telegrams to houses bearing numbers composed of several figures, it was decided to charge for five figures as a single word. But in the case of Press telegrams the addresses were still sent free, and as many as 75 words of text during the day and 100 words during the night could still be sent for 1s., whilst a copy of a telegram of the same number of words was telegraphed to any separate town for a charge of 2d. No change, then, having here been made, there appeared to be no ground for a concession in the case of Press telegrams, which were already the subject of such enormous privileges.

**The Mutual Telephone Company in Manchester.**—The first exchange of the Mutual Telephone Company was inaugurated in Manchester on Saturday last. The Mutual Telephone Company have determined to try the effect of low rates, metallic circuits and improved switching arrangements. Every subscriber is provided with a metallic circuit, so that overhearing between his line and those of others cannot take place; he also has a special wire for communicating his instructions to the operator according to the Mann system. It will no doubt be a surprise to many that an efficient exchange can be established before the use of carbon for transmitters has become free, but it must not be forgotten that the Bell telephone, specially constructed to act as a transmitter, was used for many years by the German Government on their Berlin Exchange, which is a single-wire one. This is sufficient to prove the possibility of employing it for exchange purposes. The magneto transmitters employed by the Mutual Telephone Company have been specially manufactured for them by Messrs. Siemens Brothers and Co. They are also employing an improved receiver. The result of the combination is stated to be satisfactory. The Mutual Company have no less than 2,000 lines on order in Manchester. The General Manager and Engineer of the Company is, it will be remembered, Mr. A. R. Bennett.

**Magnetic Rotation.**—At a recent meeting of the Chemical Society a brief Paper on this subject, by Prof. Ostwald, was read. The magnetic rotation of organic compounds, according to Perkin, was, he said, an additive function of their composition, and equal to the sum of the rotations of the components, but this was not the case with the rotation of inorganic com-

Digitized by Google

pounds, which was usually found greater than that calculated on such an assumption. In the case of hydrogen chloride, for instance, the calculated value was about 2·18, and as a matter of fact the value obtained for hydrogen chloride dissolved in an organic solvent, isoamyl oxide was 2·24, but when dissolved in water the value found was from 4·05 to 4·42, increasing with the dilution. The author pointed out that these exceptional values were only obtained in the case of electrolytes, and that they must therefore be referred to a fundamental difference existing between the constitution of electrolytes and that of non-conductors. That such a difference existed had been already deduced from other considerations, and had led Arrhenius to the formulation of the theory of electrolytic dissociation. The author claimed that the facts established with regard to magnetic rotation were in perfect accordance with this theory, and that any exceptional values in the magnetic rotations of electrolytes were due to the occurrence of electrolytic dissociation.

**A Simple Electrical Saw.**—In a recent issue of the *Chemical News*, Mr. H. N. Warren says, whenever a powerful electrical circuit is closed by a platinum wire of suitable dimensions, the well-known heating effect of the same is at once manifested; yet no one seems to have been struck with the idea that the simple heated wire may be employed as a most effective disintegrator of the hardest organic compounds. A similar but more convenient article may be constructed as follows:—It consists of two upright pieces of very stout brass or copper wire, connected at the lower extremities by a non-conducting medium, while across the top is secured a piece of moderately thin platinum wire. On thus connecting the apparatus by means of side binding screws to the terminals of about four Bunsen batteries, the platinum wire at once becomes heated to bright redness, and will be found to cleave the hardest wood with great facility, insomuch that a large number of useful appliances may be thus manufactured in a short space of time. Owing, however, to the platinum wire frequently breaking, probably on account of its intimate contact with the carbon whilst at an elevated temperature, the author has devised and used with advantage a modified wire, formed by depositing metallic platinum upon fine steel wire, by exposing that substance to the action of the electric current in contact with an ethereal solution of platinic chloride.

**Efficiency of Transformers.**—The following data, taken from tests made by Mr. William Stanley, Jun., and published in a recent number of the *Electrical World*, may be of interest. Mr. Blakesley's split dynamometer method was adopted for obtaining the hysteresis and Foucault current losses. It should be borne in mind, says Mr. Stanley, that the column marked "maximum efficiency" represents in reality lower values than actually are obtained in practice, because the total loss in a transformer is not the sum of the loss by hysteresis and the $C^2R$ losses, measured when the transformer is doing no work, but is less than the sum of these losses, because the hysteresis loss falls off as the load is increased upon the secondary. All transformers tested converted from 1,000 to 50 volts. In all tested, save the Thomson-Houston transformer, the current was taken from a Westinghouse alternator having a frequency of 138 ∿. In the case of the Thomson-Houston transformer, it was tested with the current from a Thomson-Houston machine having a frequency of 125 ∿.

| Type of transformer | Total weight in lbs. without case. | Capacity. Lights | Magnetising current, open circuit. | Watts expended in core. | $C^2R$ loss full load. | Maximum efficiency | Drop in volts on secondary at full load. |
|---|---|---|---|---|---|---|---|
| Stanley...... | 46 | 20 | ·053 | 37·5 | 19·25 | 94·3 | 1·9 |
| Westingh'se | 85 | 20 | ·061 | 48·0 | 20·8 | 93·1 | 2·1 |
| Slattery..... | 121 | 25 | ·056 | 45·5 | 30·2 | 94·0 | 2·0 |
| National ... | 81 | [illegible]0 | ·112 | 75·0 | 24·3 | 90·1 | 2·4 |
| T.-Houston. | 145 | 25 | ·213 | 129·3 | 27·0 | 87·5 | 1·8 |

**The Electrical Purification of Wine.**—For some time past, says *La Lumière Electrique*, M. de Meritens has been experimenting on the electrification of wine, and M. Martinotti on the application of electricity to vine diseases; and now F. Mengarini has just published a brochure extracted from the *Giornale delle Stagioni Sperimentali Agrari*, Vol. XVIII., entitled "The Reduction of Acetic Acid Present in Wine by Means of Nascent Hydrogen Generated by Electrolysis." If we take two jars filled with wine, connect them by a U tube filled with alcohol and divided at the middle by a parchment diaphragm, place platinum electrodes in the jars and pass a current, the acidity of the wine in the jar containing the kathode is diminished. It is this diminution of acidity due to hydrogenation that it has been sought to turn to practical account. The following are the results of some of the experiments. A 20·19 per cent. solution of acetic acid was converted into a 19·75 per cent. solution after four hours, and into a 16·72 per cent. solution after 28 hours electrolysis. Some sound red wine containing 7·208 per cent. of acid was exposed to the air for 24 hours, and turned sour when it contained 8·228 per cent. of acid. After eight hours of electrolysis the proportion of acid was reduced to 6·53 per cent. The current usually employed varied from 120 to 260 milliamperes, although currents of only 35 or 40 milliamperes were found to produce a beneficial effect. The apparatus intended for operations on a large scale is as follows:—A cylindrical vessel of 1 hectolitre (22 gallons) capacity, of enamelled earthenware, at the bottom of which rests a disc of compressed carbon 12in. in diameter, which communicates with the negative pole by means of a carbon rod about ½in. in diameter, encased in a glass tube containing paraffin. In the neck of the vessel slides a small earthenware cylinder, closed at the bottom by a sheet of parchment, on which rests a slab of carbon. The wine to be treated is poured into the larger vessel, the upper small cylinder containing alcohol and water.

**The Galvanic Action of Tidal Streams on Metals.**—In a Paper recently read before the Midland Institute of Mining and Civil Engineers, Mr. Thomas Andrews, F.R.S., gives a long account of experiments carried out by him on the subject of the galvanic action of tidal streams on metal structures. The general tendency in a tidal stream is to arrange the waters into layers, the lower containing denser salt water and the upper fresh water. It will, therefore, be readily understood that the upper and lower portions of a metal structure or vessel, although composed throughout of the same metal, is exposed to electrolytic disintegration from the galvanic action of two solutions of different composition. An analytical examination of the composition of the waters throughout the length of a tidal stream during diffusion of salt and fresh water, consequent on tidal action, reveals a very considerable difference in the proportion of saline constituents, between the water at the surface and that at the bottom, during certain times of tide. This difference amounts sometimes to near 100 per cent., and it may frequently be either much greater or less according to tidal fluctuations. This fact constitutes the basis of the investigation which the author undertook to obtain some approximate quantitative measurement of the resultant electromotive force. The experiments were made on large cylindrical bars of various brands of iron, of known chemical composition and specific gravity. Every bar was $2\frac{31}{32}$in. diameter, carefully turned and polished quite bright. In every instance the greatest electromotive force observed was due to hard steels, while the soft steels afforded, on the average, less electromotive force than the rolled wrought iron. The experimental results obtained afford an indication of the extent of similar action on structural ironwork in tidal rivers during diffusion between the surface and lower waters. The electromotive force observed was not only appreciable, but was in many instances very considerable, reaching not unfrequently 0·1 to $\frac{1}{7}$ volt. As similar conditions of galvanic action obtain in all our iron structures in tidal estuaries or rivers, the action of the salt and fresh water in course of diffusion constitutes a source of galvanic disintegration independent of any difference in composition of the metals. It should also be observed that in circumstances where the electromotive force arising from causes here pointed out acts in concert with any electromotive force, from differences of composition of the metals employed in structures, a very considerable total electrolytic disintegration is likely to ensue.

Digitized by Google

## THE MAGNETIC CIRCUIT OF TRANSFORMERS: CLOSED VERSUS OPEN.

BY S. EVERSHED.

(*Continued from page 510.*)

§ **23.** It will be noticed that although the $C^2R$ loss due to the exciting current is absolutely negligible in every case we have so far discussed, yet it has been inserted in all the efficiency tables. This was purposely done in order to draw attention to the enormons disparity between the two constant losses, viz., waste in the core and waste in the coils. Such a disparity might suggest that if we could reduce the core waste at the expense of the coil waste we should get greater all day efficiency, and in fact that is precisely what is done in an open transformer; with what results we shall now show.

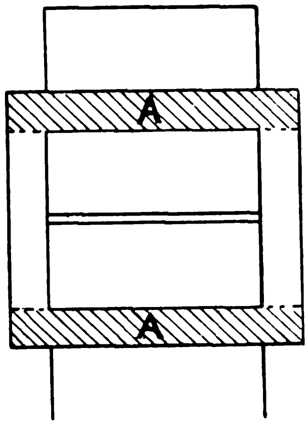



Fig. 5.—Closed Transformer No. 3.

We will first convert No. 3 into an open transformer. Take the two portions of the core AA (Fig. 5), and without removing the coils place them in one line, so as to form a transformer of Rhumkorff coil fashion, the arrangement being shown in Fig. 6. The total length of the core is now 76 cms., and

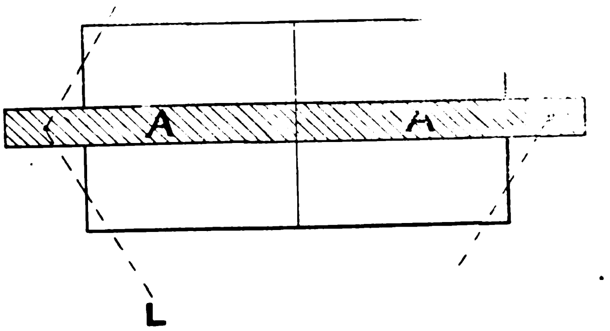



Fig. 6.—No. 3 as an Open Transformer.

of the coil 56, leaving 10 cms. of core projecting outside the coil at each end. The total volume of iron used is only 2,230 cub. cms., and if we were still able to ignore the waste due to the exciting current, we should be certain of obtaining a higher efficiency. But the exciting current will obviously be very large, and it becomes necessary to ascertain approximately what its value will be. This involves a calculation of what we are told ought not to be called the magnetic resistance of the air path from pole to pole. Imagine a long and very thin bar magnet with a sphere of iron fixed at each end, and assume that the whole of the induction through the magnet passes into the air at the surface of each sphere and so radially into space. In short, assume the old polar theory, only look at it from a modern point of view. It is clear that the magnetic resistance of an elementary spherical shell of air concentric with one of the magnet poles is $\frac{dr}{4\pi r^2}$, where $r$ is the radius of the shell. The resistance from the surface of the iron sphere to infinity will be $\int_a^\infty \frac{dr}{4\pi r^2} = \frac{1}{4\pi a}$, where $a$ is the radius of the iron sphere. The resistance from infinity back to the other pole being of course an equal amount, the resistance from pole to pole is $\frac{1}{2\pi a}$

§ **24.** So much for the imaginary magnet. When we try to apply the same theory to our open transformer we find, in the first place, that it has no convenient iron sphere fixed on each end of the core; but a little consideration shows that the resistance largely depends on the total surface of the poles, and that it makes little difference in the result whether we start from a sphere or a cylinder, or a cube, provided they expose the same surface. The surface on each projecting end of the core in Fig. 6 is 313 square cms., and a sphere of this surface would have a radius of 5cms., so we will suppose spheres of this radius have replaced the actual ends. The next difficulty lies in the fact that a considerable portion of the whole induction passing from pole to pole passes backwards through the coils, so that it will be safe to integrate over only three-fourths of the whole surface of the spherical poles, so as to include only that induction which threads both coils once. This limit, beyond which the induction is left out of account, is indicated in Fig. 6 by the dotted lines L, L. Finally, then we get $MR = \frac{4}{3}\,\frac{1}{2\pi a} = \frac{4}{30\pi}$, or $\frac{4}{90}$ roughly.

§ **25.** The maximum [H]* required for the air path is then $\frac{4}{90}$ B A; A being the area of the core = 29cms.; so that [H] = 12,900 for the air, and 6 × 76 = 460 nearly in the iron, a total [H] = 13,400 nearly enough, which, divided by 1·26 $N_p$, gives us the exciting current maximum, namely, 4·8 amperes, which is equivalent to an effective current of 3·4 amperes. In fact, the exciting current is nearly as large as the useful current at full load. However, bad as it looks, let the transformer be tried on the same load as the others, for it must not be supposed that this large exciting current implies large waste of power in the transformer; the primary E.M.F. wave, and the exciting current, differ in phase by very nearly a quarter of a period, so that practically the only loss is from $C^2R$. There is sometimes a confusion of ideas in calculating the $C^2R$ loss due to two alternating currents differing in phase. The true loss is

$$\frac{R}{T}\int_0^T \left(C_1 + C_2\right)^2 dt, \text{ that is to say,}$$

$$\frac{R}{T}\left\{ \int_0^T C_1^2 dt + \int_0^T C_2^2\, dt + 2\int_0^T C_1 C_2 dt \right\}$$

and as is well understood the integral of the last term is nothing when $C_1$ and $C_2$ differ by exactly one quarter of a period, so that we can, in the case under consideration, safely take the $C^2R$ loss from the exciting current quite separately from that due to the useful current.

§ **26.** The dimensions and other particulars of the open transformer are collected in Table X, from which we can determine the efficiency on the usual load. This is worked out in Table XI.

**Table X.**—*No. 3 as an Open Transformer.*

| | | | |
|---|---|---|---|
| Full-load output ........................ | = | 22·4 | kilowatts |
| Frequency = F ........................ | = | 70 | |
| Total volume of iron in core ......... | = | 2,230 | c.c. |
| Sectional area of iron in core ......... | = | 29 | sq. cms. |
| Mean length of iron in core ............ | = | 76 | cms. |
| Width of core plates ...................... | = | 5·1 | cms. |
| Thickness of core plates ................ | = | ·048 | cms. |

* [H] is used here to signify the integral of H taken throughout the air path and iron path; in the latter it is equal to H × (length of core).

Digitized by Google

| —— | Primary. | Secondary. |
|---|---|---|
| Volts | 2,000 | 100 |
| Turns on coil | 2,240 | 112 |
| Resistance | 7·6 | ·0188 |

**Table XI.**—*No. 3 as an Open Transformer.*

Maximum B = 10,000 F = 70.

Load as in Table V.

| | | |
|---|---|---|
| Total output | 24,000 | watt hours |
| 24 hours' waste in core at 137 | 3,280 | ,, |
| 24 hours' waste in $C^2 R$ at $(7·6 \times 3·4^2)$ | 2,110 | ,, |
| 6 hours' waste in $C_p^2 R_p + C_s^2 R_s$ at 62 | 372 | ,, |
| | 29,762 | |

$$\text{Efficiency} = \frac{24}{29·8} = 81 \text{ per cent. (nearly enough).}$$

Full load drop 2·8 per cent.

Astounding as it may seem, the removal of about one-third of the core and re-arrangement of the coils and remainder of the core as an old-fashioned induction coil has made practically no difference whatever in the efficiency. But although considered merely by itself, this transformer is in every way as efficient and would be somewhat cheaper to build than the closed transformer from which it has been formed. The large exciting current required is sufficient to condemn it when we recollect that a transformer is only one item in a system of distribution, for in a central station running transformers like No. 3 (open), although the light load during the day would be small in *power*, yet large machines must be kept running at practically no load simply to provide the enormous exciting current, so that the plant efficiency of the generating machines would be very seriously reduced.

§ 27. Leaving the discussion of this question until we have explained the method of drawing transformer indicator diagrams, we will now describe the ingenious device adopted by Mr. Swinburne for reducing the exciting current in an open transformer to more reasonable, or, let us say, less unreasonable, dimensions.

Reverting for a moment to the result arrived at (by a process resembling guesswork, it must be confessed) for the value of the magnetic resistance of the air path, it is easily seen that the most obvious improvement consists in increasing the radius of the "equivalent" sphere. If we do this by putting a solid lump of laminated iron on each end of the core, we soon find we are using sufficient iron to make a closed circuit. Suppose we slit the core plates up at each end into very narrow ribbons, and spread these out radially in all directions, so that their ends lie approximately on the surface of a hemisphere. The outline of the transformer will now be something like Fig. 7 ; the radius of the spherical surface is roughly equal to the length of the slit portion of the core (that is to say, to the length of the core projecting outside the coils), plus the average distance from the axis of the core to its surface. In estimating the surface of the equivalent sphere we meet a new difficulty : the ends of the ribbons not forming a continuous surface it is impossible to say exactly what their effective surface really is. We shall probably err on the safe side if we count the hemispherical surface formed by the ribbon ends as being continuous, and leave the flat surface of each hemisphere next the coil cheeks entirely out of account. It is as well to mention here that although this apparently loose and utterly unjustifiable reasoning was used by the writer in the absence of any experimental evidence of its even approximate accuracy, yet the actual exciting current required by Hedgehog transformers agrees very closely with that calculated on such a slender basis of fact. The radius of the hemisphere of ribbon ends (Fig. 7) is about 13cms., so that its surface is 106 square cm., and the radius of the "equivalent" sphere will be 9·2cms., as against 5cms. in No. 3 (open), so that [H] spent on the air-path will be reduced in the ratio $\frac{5}{9}$, and becomes 7,200, to which [H] required for the core, viz., 500 roughly, must be added, making the total 7,700 as compared with 13,400 for No. 3 (open). The exciting current will, of course, be reduced in the same proportion, and will now be 1·95 amperes. This is better, and leads to a higher all-day efficiency, as will be seen from Table XII. :—

**Table XII.**—*No. 3 as an Open Transformer with "Hedgehog" ends.*

Maximum B = 10,000 F = 70.

Load as in Table V.

| | | |
|---|---|---|
| Total output | 24,000 | watt hours |
| 24 hours' waste in core at 137 | 3,280 | ,, |
| 24 hours' waste $C_p^2 R_p$ at $(7·5 \times 1·95^2)$ | 700 | ,, |
| 6 hours' waste $C_p^2 R_p \times C_s^2 R_s$ at 62 | 372 | ,, |
| | 28,352 | |

$$\text{Efficiency} \frac{24}{28·4} = 85 \text{ per cent.}$$

Full load drop = 2·8 per cent.

§ 28. The efficiency of No. 3 as a "Hedgehog" is, in fact, as high as that of the best of the three closed transformers (No. 2), and examination of the losses in Table XII. suggests that the core waste can be reduced by lowering the induction just as in the case of No. 2. In short, if we convert No. 2 into an open transformer by precisely the same modifications as we adopted in producing Fig. 7, we get the open transformer shown in Fig. 8. The width of the plates being 10·2cms., the projecting ends of the core are, of course, 20·4cms., so that when slit into ribbons and spread radially they form hemispheres twice the radius of those

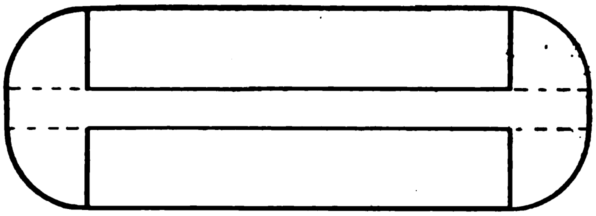


Fig. 7.—No. 3 Transformer ; open ; Hedgehog ends. One-tenth full size.

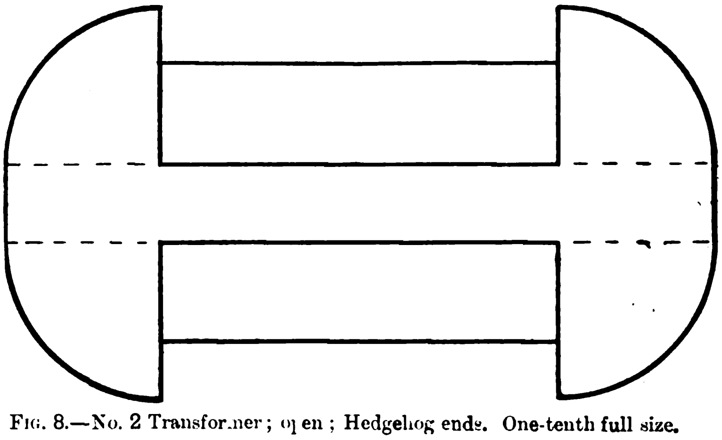


Fig. 8.—No. 2 Transformer ; open ; Hedgehog ends. One-tenth full size.

in Fig. 7, and the exciting current is reduced in nearly the same proportion, being actually 1 ampere. It will be remembered that when the original closed transformer, having 6,600 cub. cms. of iron in its core, was modified into No. 2, we were obliged to increase the volume in the core by 30 per cent., to make room for the new coils, so that it had 8,580 cub. cms. of iron in the core. Of this amount only 5,450 cub. cms. are required when it is converted into a "Hedgehog" so that the core waste is reduced in the ratio $\frac{545}{848}$, and becomes 103 watts. Its efficiency is given in the following table :—

**Table XIII.**—*No. 2 as an Open Transformer with "Hedgehog" ends.*

Maximum B = 5,000 F = 70.

Load as in Table V.

| | |
|---|---|
| Total output | 24,000 |
| 24 hours' waste in core at 103 | 2,470 |
| 24 hours' waste $C_p^2 R_p$ at $(7·6 \times 1^2)$ | 182 |
| 6 hours' waste $C_p^2 R_p + C_s^2 R_s$ at 62 | 372 |
| | 27,024 |

$$\text{Efficiency} = \frac{24}{27} = 89 \text{ per cent.}$$

Full load drop = 2·8 per cent.

Digitized by Google

§ 29. The full load efficiency of this transformer is very high, being just 96 per cent., so that by opening the magnetic circuit of No. 2, we have greatly improved it in efficiency at all loads, lessened the cost of materials, and probably also cost of construction. The one disadvantage introduced is the larger exciting current.

It will be noticed that when once the bold step is taken of reverting to an open magnetic circuit, Mr. Swinburne's "Hedgehog" suggests itself very naturally as an easy way of reducing the exciting current without increasing the volume of iron required for the core; only no one ever took that step.

§ 30. There are a few points that require notice, which we have hitherto neglected entirely in order to keep the comparison between open and closed transformers as free as possible from confusing details. In estimating the drop in volts at full load, an allowance must always be made in practice for the drop due to an independent back E.M.F. acting in the primary or secondary coil, or in both. In every practical transformer the primary and secondary coils are separately wound, and there is often a considerable space left between the coils. Each coil will then be threaded by induction due to its own current, only a portion of such induction threading both coils. The latter portion may be conveniently called "useful induction," the former being "stray induction." It is the stray induction which causes the independent back E.M.F. in each coil, and the quantity of stray induction being proportional to the currents in the primary and secondary coils (that is to say, proportional to the load), the back E.M.F. simply produces an extra drop in volts over the coils beyond that due to resistance. The amount of this extra drop being dependent on the shape and position of the coils is capable of being reduced to practically nothing; if the primary and secondary wires could with safety be wound side by side, the only stray induction would be that round and in each individual wire. Even in practice the effective stray induction may be made extremely small by a judicious arrangement of the two coils; but as we are not here concerned with transformer design, we need not discuss the matter. Any extra drop in the closed transformers we have described will be very nearly the same in all, and so does not affect the comparisons made. With the open transformers the case is rather different; the stray induction may easily bear a far larger proportion to the useful induction, and its direction varies slightly with the varying induction density in the core. It may be greatly reduced, however, by suitable windings.

§ 31. Another small detail in the case of open transformers has not yet been mentioned. We used exactly the same coils on the closed and open types. In practice, a few extra turns will have to be put on the secondary to keep the secondary E.M.F. at the proper value. It is readily seen that the whole induction due to the exciting current cannot be made to thread the secondary coil, so that its E.M.F. will be less than that calculated on the assumption that it is equal to the primary E.M.F. multiplied into the ratio of the turns on the two coils. As a matter of fact, the assumption is by no means necessarily true in the case of closed transformers. If the space occupied by the two coils is large compared with the area of the iron core, the secondary will require a few more turns than the calculated number. This is a point by no means generally understood by manufacturers, and the writer, by a curious accident, discovered that in the case of a well-known and largely used transformer the secondary and primary E.M.F.'s had been assumed to be proportional to the number of turns on the respective coils, with the result that the actual secondary E.M.F. was 10 per cent. below the calculated.

It will be remembered that in estimating the losses in closed circuit transformers, eddy current losses in the coils themselves were neglected as too insignificant to have any appreciable effect. In an open transformer a considerable fraction of the useful induction, in passing from pole to pole, traverses some of the windings near each end of the core, so that coils of copper tape, which are extremely convenient and perfectly admissible in a closed transformer, would probably lead to some energy waste in an open transformer.

§ 32. It will be convenient to pause at this point, and review the results arrived at so far, in this more or less theoretical investigation. For the sake of easy reference, the chief features of the six best modifications of the original transformer are collected in Table XIV.

**Table XIV.**—*Six Ten Horse-power Transformers. Full load drop = 2·8 per cent. in each.*

| Description of transformer. | Frequency (v per sec) | Maximum induction (gausses) | Exciting current (amperes) | Percentage efficiency | | Weight of materials. | |
|---|---|---|---|---|---|---|---|
| | | | | All day | Full load. | Iron. | Copper |
| CLOSED. | | | | | | | |
| No. 1 low frequency. | 35 | 10,000 | ·22 | 80 | 94·0 | 143 | 240 |
| No. 2 low induction. | 70 | 5,000 | ·11 | 85 | 95·0 | 143 | 240 |
| No. 3 small core ... | 70 | 10,000 | ·18 | 81 | 94·5 | 60 | 173 |
| OPEN. | | | | | | | |
| No. 3 small core (plain ends) ...... | 70 | 10,000 | 3·4 | 81 | 94·5 | 37 | 173 |
| No. 3 small core (hedgehog ends).. | 70 | 10,000 | 1·95 | 85 | 95·0 | 37 | 173 |
| No. 2 low induction (hedgehog ends).. | 70 | 5,000 | 1·00 | 89 | 96·0 | 91 | 240 |

The exciting currents are, of course, only approximate; the two last columns give the approximate weights of iron and copper used in pounds. Nos. 1 and Nos. 2, it should be remembered are identical so far as dimensions and disposition of core and coils are concerned, and No. 1 is not therefore inserted in the table as an open transformer at a low frequency. It is easily seen that its efficiency under these conditions would be raised by 4 or 5 per cent., but it would still compare unfavourably with No. 3 and No. 2.

§ 33. According, then, to the results condensed in Table XIV., the efficiency of any closed transformer, good, bad, or indifferent, is raised (both at full load and on a time load) when converted without any change in the windings into an open transformer with Hedgehog ends. The increased efficiency is due to diminution in the volume of the core, and is purchased at the expense of a largely increased exciting current, the total magnetising force for a 10-H.P. Hedgehog being roughly ten times that required by the same transformer with a closed magnetic circuit. We have just stated that these results apply to *any* transformer, and made no restriction as to size or output. It is not necessary to work out examples of larger or small transformers, in order to realise that this is true in a general sense; in fact, we can predict that the larger the transformer the greater the increase in efficiency when its magnetic circuit is opened. For removal of a large part of the core must raise the efficiency, even if the $C^2 R$ loss due to the exciting current increases at the same rate in large as in small transformers; but actually the ratio of extra loss in $C^2 R$, due to the large exciting current required by an open transformer, to the total waste becomes less and less as the transformer is increased in size, since the magnetic resistance of the air path practically depends only on the radius of the hedgehog ends, and only to a very minute extent on the distance from pole to pole. The same considerations apply with equal force (but in an opposite sense) to transformers of less than 10-H.P., so that if a 2-H.P. closed transformer, for example, were converted into a Hedgehog, we should find the $C^2 R$ loss for exciting current increased in a much larger ratio to the total waste than was the case in the 10-H.P. transformers. But a glance at Tables XII. and XIII. clearly shows that this loss might be very largely increased, indeed, before it balanced and neutralised the saving effected by throwing away a large portion of the iron core, so that there will still be a clear gain in efficiency on converting a small closed into an open transformer, although the smaller it is the less the gain on any given time load. However, a small diminution in the total daily waste is worth having in little transformers suitable for running single houses and therefore working for a very short time on anything like full load. A larger transformer, running a few hundred lights, would, in all probability, have one or two shops or offices in addition to houses on its secondary circuit and would feel the benefit of a more evenly distributed load.

*(To be continued.)*

Digitized by Google

## ON THE DETERMINATION OF THE CAPACITY OF LONG SUBMARINE CABLES.

BY ARTHUR DEARLOVE.

At the British Association meeting of last year Mr. Glazebrook presented a Paper, entitled, "On the Air Condensers of the British Association," with a Note by Dr. A. Muirhead, which dealt with a method of correcting the capacity of condensers for absorption and leakage. Dr. Muirhead also published in *The Electrician* (Vol. XXV., September 5, 1890, p. 487) some results obtained when determining the capacity of a short length of core by this method, using a formula to which the following is equivalent:—

$$C = K \frac{10000 - (R \mp P)}{R \mp P}.$$

where C is the total capacity of the cable,
K is the total capacity of the condenser used as standard,
R is the slide reading observed at balance,
and P is the correction found, and which is either substractive or additive as explained hereafter.

I have lately had an opportunity of applying this test and correction to a cable of over 1,300 miles in length, laid by the Telegraph Construction and Maintenance Company, for the Eastern Telegraph Company, while testing on behalf of Messrs. Clark, Forde and Taylor, engineers to the latter company.

The method of finding the capacity, long known as "Gott's method," was, I believe, first suggested by Sir William Thomson, in Vol. I. of the *Journal* of Society of Telegraph Engineers, pages 397 and 398. This test has been for some time employed by electricians, and possesses fewer disadvantages than any other of the well known methods of taking the capacity of long cables, and good results have been frequently obtained by it. The test, however, has had objections, in that the value obtained by it differed largely for various times of charge. The corrections suggested obviate to a large extent this difficulty, and moreover the necessary time of charge, in order to obtain a fairly correct value for the capacity of the cables, is easily determinable.

The following sketches (Figs. 1, 2, 3) show diagrammatically the varied conditions of things produced by the movements of the key when making the test. The key employed was the one specially designed by Mr. H. A. C. Saunders, of the Eastern Telegraph Company, and is described in *The Electrician*, Vol. XXV., June 20, 1890, p. 170.

The mode of procedure is as follows:—Join up the battery, slides, standard condenser, and cable as for an ordinary "Gott's test," charge the condenser with cable in "cascade" from the 10,000 end of the slides, and obtain by depressing the galvanometer or index key I. as good a balance as is possible; this is done by adjusting the slides until a point is found where the galvanometer deflection is *nil*, or at which the potential equals the potential of the junction of the standard condenser and the cable.

The galvanometer key should not be kept down for any considerable length of time, but very short contacts of the key should be made until an approximate balance is obtained; when near the balance, a longer contact is not objectionable. The balance having been obtained, the point K in Figure 1 is disconnected from the battery and slides, and is put direct to earth; the position of affairs is then represented by Figure 2, no circuit being made through the galvanometer. After the point K has been to earth for a period of, say, three to four seconds, for cables of from 1,000 to 1,500 knots length, the point J is discharged through the galvanometer to earth; the deflection so produced is noted in scale divisions, and called hereafter *d*. This diagram shows merely what is actually done to obtain the correction deflection, *i.e.*, *d*.

To ascertain the value of *d* in terms of the slide reading, or of potential difference, the index of the slides is run back towards zero, and the point J is charged from a position on the slides that gives approximately the same deflection as noted in the preceding operation (Fig. 3). Call this deflection *d'* and its equivalent in slide reading *p'*, then the value in slide readings of *d* is $p = p' \frac{d}{d'}$, and is either subtractive or additive, according to direction of throw.

If *d* and *d'* are in *opposite* directions the value *p* (in slide readings) must be *subtracted* from the original slide reading obtained on balance in the "Gott's test" (Fig. 1); if *d* and *d'* are in the *same* direction, *p* becomes *additive*.

The following series of tests was taken on laid cables of 1,331 knots and 100 knots in length, whose respective mean capacities were 0·352 microfarads and 0·354 microfarads per knot when tested at 75°f. in lengths of two knots. The absolute resistance of the 1,300 knots length was approximately one megohm, and that of the 100 knots length 6 megohms. The condensers used were compared step by step with a standard ⅓ microfarad, and had an insulation resistance of over 450 megohms per microfarad, or the 60 microfarads had an absolute resistance of over 7 megohms at 75°F.

A series of tests was taken with conditions as explained, using as a standard condenser 59·20 microfarads *versus* 1331·4

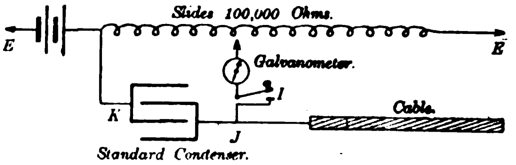


FIG. 1.

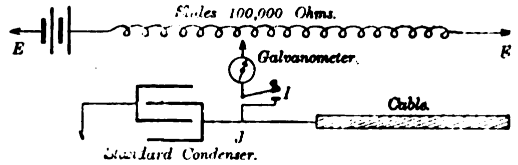


FIG 2.

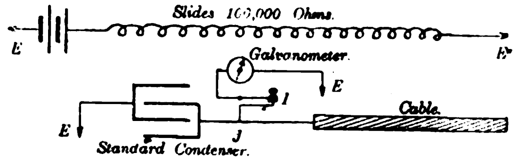


FIG. 3.

knots of cable and 10 Leclanché cells as a battery. The standard condensers, it may be understood throughout, were short circuited for a short time between each test.

*Series No 1.*

| Time of charge in seconds. | S.R. when balance obtained. | Earthing period. Seconds. | Discharge in scale divisions. | Equivalent value of scale, divs. in S. R.'s. | Corrected slide reading. |
|---|---|---|---|---|---|
| | | | *d* | *p* | |
| 6 | 1,148 | 2½ to 3 | 68 right | – 35 | 1,113 |
| 8 | 1,149 | " | 66 " | – 34 | 1,124 |
| 10 | 1,175 | " | 100 " | – 52 | 1,123 |
| 15 | 1,175 | " | 110 " | – 57 | 1,118 |
| 30 | 1,229 | " | 200 " | –117 | 1,112 |
| 30 | 1,224 | " | 185 " | –107 | 1,122 |
| 40 | 1,192 | " | 135 " | – 74 | 1,118 |
| 50 | 1,224 | " | 200 " | –117 | 1,107 |
| 60 | 1,243 | " | 225 " | –138 | 1,105 |
| Mean of ob. S. R.'s | 1,195.4 | | | Mean of cor S. R.'s | 1,115·8 |

Worked out, these results give the following values for capacity of cable.

Uncorrected S. R. = 1,195·4 = total capacity 436·4 = ·3,275 per knot.
Corrected " = 1,115·8 = " 471·35 = ·354 "
The capacity when tested in 2 knot lengths, which is here taken as the *true* capacity............ ............ 468·65 = ·352 "

Digitized by Google

In one case we have an error of 7·5 per cent., and in the other of about 0·5 per cent.

Some tests not included in the above series showed quite conclusively that the period allowed to elapse between the point K being put to earth and the deflection $d$ being noted had an important influence upon the accuracy of the correction. If the time allowed to earth is insufficient, the cable is not properly discharged, and the correction will be too large, the capacity, therefore, of the cable will apparently be much higher than it actually is.

To illustrate this, three or four tests are given below, in which the "earthing period" was about half that allowed previously, or about $1\frac{1}{4}$ to $1\frac{3}{4}$ seconds.

| Time of charge in seconds. | R. S. when balance obtained. | Discharge in scale divisions. | Equivalent value of scale divs. in S. R.'s | Corrected slide reading. |
|---|---|---|---|---|
| | | $d$ | $p$ | |
| 20 | 1,197 | 50 left, 250 right | - 117 | 1,080 |
| 30 | 1,200 | 250 „ | - 135 | 1,065 |
| 30 | 1,202 | 260 „ | - 158 | 1,044 |
| | | | Mean slide reading...... | 1,063 |

This corrected S. R. 1,063 gives a total capacity for the cable of 499 microfarads, or 0·375 per knot, which is 5·5 per cent. too high a value.

No. 2 Series was taken under the following conditions :—

*19·782 Microfarads versus Cable 1331·4 Knots.*

| Time of charge in seconds. | S. R. when balance obtained. | Earthing period. Seconds. | Discharge in scale. Divisions. | Equivalent value of scale divs. in S. R.'s. | Corrected slide reading. |
|---|---|---|---|---|---|
| | | | $d$ | $p$ | |
| 5 | 412 | $2\frac{1}{4}$ to $2\frac{1}{2}$ | 30 right | - 8 | 404 |
| 5 | 415 | „ | 38 „ | - 10 | 405 |
| 10 | 416 | „ | 45 „ | - 13 | 403 |
| 10 | 414 | „ | 38 „ | - 10 | 404 |
| 17 | 422 | „ | 70 „ | - 18 | 404 |
| 22 | 434 | „ | 112 „ | - 32 | 402 |
| 30 | 441 | „ | 133 „ | - 39 | 402 |
| 40 | 457 | „ | 200 „ | - 60 | 397 |
| 50 | 463 | „ | 220 „ | - 67 | 396 |
| 60 | 478 | „ | 280 „ | - 87 | 391 |
| Mean of ob. S. R's | 435·2 | | | Mean of cor. S. R.'s | 400·8 |

Mean S. R. for all times of charge up to 30 seconds equals 403·4 = 470·6 microfarads for cable, 0·353 microfarads per knot.

It will be observed that in the above test the "earthing period" is the same for all times of charge. The correction applied appears to answer perfectly up to 30 seconds charge, beyond this time it becomes too powerful. It is quite possible that when the cable is charged for so long a period as 60 seconds, a slight increase in the "earthing period" is required.

The following series of tests was made *varying* both the time of charge and the "earthing period" before noting the correction discharge from the point J, and the observations are entered exactly as taken. The cable current during operations was fairly steady, and about 10 divisions right.

The mean of the whole of these slide readings is 1,114·5, which gives a total capacity of 472· microfarads or 0·355 microfarads per knot for the cable, or assuming the 75° value per knot to be correct the result is 0·8% in excess.

An examination of the above figures shows that a less time to earth than three seconds complicates matters, as on discharging a throw is obtained first in one direction and then in the other; this, I think, may be used as a means of finding the proper amount of time necessary for the "earthing period" of any length of cable. The correction made above when these two throws occur is applied only to the *difference* of these readings.

*59·20 Microfarads versus Cable 1331·4 Knots.*

| Time of charge in seconds. | S. R. when balance obtained. | Earthing period. Seconds. | Discharge in scale divisions. | Equivalent value of scale divs. in S. R.'s | Corrected slide readings. |
|---|---|---|---|---|---|
| | | | $d$ | $p$ | |
| 5 | 1,100 | $3\frac{1}{2}$ | nil | ... | 1,100 |
| 5 | 1,100 | $3\frac{1}{2}$ | 12 right | + 10 | 1,110 |
| 5 | 1,110 | $3\frac{1}{2}$ | 9 left | - 7 | 1,103 |
| 10 | 1,117 | $3\frac{1}{2}$ | 15 right | + 10 | 1,127 |
| 10 | 1,130 | 5 | 28 left | - 19 | 1,111 |
| 15 | 1,138 | 2 | { 4 right then 32 left } | - 19 | 1,119 |
| 15 | 1,130 | $3\frac{1}{2}$ | 15 left | - 10 | 1,120 |
| 15 | 1,141 | 5 | 37 left | - 25 | 1,116 |
| 20 | 1,135 | 5 | 26 left | - 18 | 1,117 |
| 20 | 1,137 | 5 | 25 left | - 17 | 1,120 |
| 25 | 1,113 | 5 | 10 right | + 6 | 1,119 |
| 25 | 1,124 | 5 | 5 left | - 3 | 1,121 |
| 25 | 1,128 | $2\frac{1}{2}$ | { 7 right then 20 left } | - 4 | 1,124 |
| 30 | 1,145 | 3 | 78 left | - 24 | 1,121 |
| 30 | 1,152 | 5 | 130 „ | - 40 | 1,112 |
| 40 | 1,149 | 3 | 90 „ | - 28 | 1,121 |
| 40 | 1,150 | 5 | 115 „ | - 35 | 1,115 |
| 50 | 1,148 | 3 | 100 „ | - 30 | 1,118 |
| 50 | 1,149 | 5 | 108 „ | - 33 | 1,116 |
| 60 | 1,158 | 3 | 127 „ | - 39 | 1,119 |
| 60 | 1,171 | 5 | 204 „ | - 66 | 1,105 |
| 60 | 1,179 | 10 | 250 „ | - 81 | 1,098 |
| 120 | 1,194 | 8 | 127 „ | - 93 | 1,101 |
| Mean of observed S. R.'s | 1,139·0 | | | Mean cor. S. R.'s. | 1,114·5 |

The foregoing series of tests was taken upon the 1,331 knots length, whose mean temperature was 72°F. The *following* tests were taken on the 100 knots length of cable, whose mean temperature was 80°F. In the case of the long cable, the correction to be applied to the original slide reading observed was invariably substractive; this was reversed on the 100 knots length, and it becomes always additive. These tests are inserted to show with what accuracy the capacity of such lengths can be found.

*19·782 Microfarads versus 100 Knots of Cable.*

| Time of charge in seconds. | S.R. when balance obtained. | Earthing period. Seconds. | Discharge in scale divisions. | Equivalent value of scale, divs. in S. R.'s. | Corrected slide reading. |
|---|---|---|---|---|---|
| | | | $d$ | $p$ | |
| 5 | 3,557 | 2 to 3 | 20 left | + 9 | 3,566 |
| 7 | 3,530 | „ | 85 „ | + 36 | 3,566 |
| 10 | 3,558 | „ | 40 „ | + 16 | 3,568 |
| 18 | 3,547 | „ | 53 „ | + 22 | 3,569 |
| 20 | 3,531 | „ | 92 „ | + 38 | 3,567 |
| 30 | 3,539 | „ | 62 „ | + 29 | 3,568 |
| 40 | 3,526 | „ | 97 „ | + 42 | 3,568 |
| 50 | 3,528 | „ | 93 „ | + 38 | 3,565 |
| 60 | 3,517 | „ | 120 „ | + 52 | 3,569 |
| Mean of ob. S. R.'s | 3,537 | | | Mean of cor. S. R.'s | 3,568 |

Observed S.R. = 3537 = 36·15 mfds. total capacity, or 0·361 per knot.
Corrected „ = 3568 = 35·66 „ „ or 0·356 „
Mean capacity when tested in two-knot lengths = ... 0·354 „

By the use of the correction it is evident that a nearer value to the actual capacity is obtained.

As a further illustration of the usefulness of this method, I give the values of tests on the same length of cable (100 knots), using 59·20 microfarads as a standard capacity.

*59·20 Microfarads versus 100·14 Knots of Cable.*

| Time of charge in seconds. | S. R. when balance obtained. | Earthing period. Seconds. | Discharge in scale divisions. | Equivalent value of scale, divs. in S. R.'s. | Corrected slide reading. |
|---|---|---|---|---|---|
| | | | $d$ | $p$ | |
| 5 | 6,227 | $2\frac{1}{2}$ approx. | 92 left | + 34 | 6,261 |
| 10 | 6,220 | „ „ | 47 „ | + 35 | 6,255 |
| 30 | 6,144 | „ „ | 154 „ | + 114 | 6,258 |
| 40 | 6,129 | „ „ | 170 „ | + 126 | 6,255 |
| 52 | 6,045 | „ „ | 275 „ | + 207 | 6,252 |
| 60 | 6,070 | „ „ | 250 „ | + 187 | 6,257 |
| Mean of ob. S. R.'s | 6,139 | | | Mean of cor. S. R.'s | 6,256·3 |

Digitized by Google

These slide readings give the following results:—

Observed S. R.'s ... 6,136 = 37·23 mfds. total, or 0·372 mfds. per knot.
Corrected S. R.'s ... 6,256·3 = 35·425 mfds. total, or 0·354 „ „
Value of cable taken by
75° tests ............ = 35·460 total, or 0·354 „ „

The *corrected* S. R. when worked out gives for the cable identically the same capacity per knot as that *observed* in the factory tests on short lengths, the uncorrected S. R. giving too high a result by 5 per cent.

The values on long cables are of course affected by the earth currents existing at the time of observation, but the new correction adds nothing to the usual difficulties associated with strong earth-currents, and any error arising from them would be lessened, if not altogether eliminated, by a few readings taken with the poles of the charging battery reversed. It may be objected that there are few advantages in this test, and that it is of no practical use, but I consider that it gives an opportunity of verification of results afforded by no other method. Thus, whether the length of the circuit be known or unknown, and either the capacity of the cable, or the distance of a rupture in the conductor is required, the result may be considerably far from the truth, if the calculations are made from the uncorrected observations, whereas by employing this test and its correction intelligently, the capacity of the cable or the distance of the break can be obtained to within 0·5% of its true value.

The large number of tests taken and given here were made to get an idea of the capabilities of the method suggested.

The insulation resistance of the condensers and cable tested, has no doubt an influence upon the magnitude of the correction, but does not appear to seriously diminish its accuracy. Other things being alike, the magnitude of the correction no doubt depends on the relative rates of electrification of the dielectrics of the condenser and of the cable. Dr. Alexander Muirhead has lately shown me a curve of the electrification of a paraffin condenser at a temperature of about 78°F. This was plotted on the same sheet as the electrification curves of a cable whose mean temperature was 36°F. when tested, and they show a nearly identical electrification at their respective temperatures.

It should follow from this that when comparing condensers at say 75 deg. with a cable at a temperature of say 40°F. the correction would be found to be small. This is true only, I believe, when the insulation resistance of the two capacities compared are about the same per microfarad.

## REVIEWS.

**Electricity:** A Sketch for General Readers. E. M. CAILLARD. (London: John Murray, 1891.)

Of elementary books on electricity it would seem that we have far too many, and no subject seems so to tempt an author to display his ignorance, and sometimes his conceit. Yet the veriest trash runs into second and third editions, and the same old woodcuts are made to do duty again and again. Though it was not to be expected that the present publisher would bring out a book of this class, we turned over the pages with some doubts, and lighted on the words "by the term power engineers understand the rate of doing work." This was very reassuring, since most writers on popularised electricity do not appear to see any need for defining such a term, which would, as a rule, be used by them as a synonym for energy, force, and work. A glance at the preface revealed that the writer is a lady, and that the volume was therefore one of peculiar interest and meriting special attention. Having read it with care, we have great pleasure in coming to the conclusion that it is the only book of the kind (as far as we know) that can be thoroughly recommended, and one that may be safely relied upon for explaining the present state of electrical science and its applications, to the general reader. The writer does not give the applications a prominent position, as is done in "Electricity in Modern Life," and "Electricity in the Service of Man," and the pages are not, therefore, elaborately illustrated. The style is excellent, and the space devoted to the different branches of the subject are well proportioned, with the exception perhaps of the two chapters devoted to atmospheric electricity, but these are so interesting that little could be spared from them.

The book reveals a good many indications of the influence of the teaching of Profs. Ayrton and Perry, whose names and inventions are frequently alluded to. The authoress expresses her obligations to the former for his assistance in the revision of the proofs, and this being so we have less hesitation in pointing out a few slips which have escaped his notice. On p. 122 the favourite concept of the mathematician—a magnetic shell—is spoken of and described as though "a thin sheet of metal may be so magnetised that the whole of one face of it will possess north-seeking, and the whole of the opposite face south-seeking magnetism," although permanent magnetisation of thin steel plates at right angles to their planes has been shown, by Duole and others, to be impossible in practice. On p. 139 the two-fluid hypothesis of electricity is put forward under the guise of a two-current theory. "It must not be forgotten that there is always a negative current as well, whose course is exactly opposite." "No satisfactory theory can be propounded which does not take into account the double current." We do not count this as a slip, but as a rather rash assertion. The centimetre is said, on p. 198, to be "considerably less than two-thirds of an inch." Probably two-fifths is intended. "The main cause of the light" of an arc "appears to be the incandescence of minute particles of carbon, which are carried in two incessant streams between the carbon pencils." This is a careless, unverified statement, which has been common for years past in text-books and in the lecture room, and is the only one of its kind that we have found in the book. It is the surface of the carbons which emits the light, and the arc does not consist of particles of carbon but of carbon vapour, which emits a very small fraction of the light. Once only does the authoress get out of her depth. The proof reviser must have been nodding when he came to the foot of page 214, where there is a strange jumble about the self-induction in the core of a Gramme ring. The book is in a way unique, since on the one hand it is utterly unconnected with examination cram, and on the other hand is not a mere schoolboy's book, written up to a set of pretty illustrations, nor has it to do with advertising, like so many other popular publications on electric light.

**A Dictionary of Metric and other Useful Measures.** By LATIMER CLARK, F.R.S. (London: E. & F. N. Spon. 1891.)

Tables of weights and measures are among those matters which schoolboys are supposed to commit to memory. Many industrious schoolboys believe that their elders and betters carry about, at all events, the British measures firmly and clearly fixed in their minds, and that any well-educated person ought to be able to reckon in his head the number of firkins of water which would flood a field of 75 perches to the depth of three-seventeenths of a yard. But as he grows older, and becomes a second-year student at a technical college, he finds out that many well-educated persons, who have often to deal with weights and measures, carry about with them note-books or pocket-books, or slips pasted on the back of a slide rule; and as by that time he has to deal not only with our national system but with metric quantities and a host of electrical and physical units, he falls back on Molesworth or Munro and Jamieson, or Kempe, and if he needs to refer frequently to them, he must burden his pocket with information as to the minimum rounded projection of Prussian railway buffers, sundry tests of submarine cables, lists of jointers' tools, &c.

A reaction is taking place in this class of literature, and the whole body of tables are condensed into a few square inches or elaborated into a comprehensive form. Of the latter class, no more complete and handy a volume has ever appeared than the one before us. It is arranged in four columns. The first gives the name and definition of the unit or measure or the names of two measures, *e.g.*, "*Centimetres into feet.*" The second gives the multiplier for conversion; the third gives the reciprocal of the second for dividing; and the fourth contains the logarithms of the multipliers. The names are arranged in alphabetical order, and the system is manifestly much better than any attempt at classification. Such a collection of thoroughly practical and modern

Digitized by Google

weights and measures has surely never before been made. Obsolete and foreign terms are ranged with the latest and crudest suggestions. Thus we find *Barad* next to *Barley-corn*, and *Coulomb* next to a *Cran of herrings*, which is stated to consist of 37½ gallons. Imperial gallons are converted in some 20 different measurements, and as many more sundry gallons, such as the gallon of the United States and of Queen Anne, are enumerated and defined. Further on, we find together the *Kapp line*, *Kilderkin* and *Kilodyne*, the standard *Candle* and the *Carat*, besides numerous foreign measures and conversions, such as *Roubles per pood* into *Shillings per cwt.* The accuracy of the work is sufficiently guaranteed by the author's reputation. He has adopted the latest determination of the weight of a cubic inch of water (see *Electrician*, Vol. XXV., p. 633).

Since the author has given so large a number of different measures, we would venture to suggest that the ampere should be given in the weight of silver and copper deposited per minute and per second. We referred to this work for the purpose of checking the definition of ·000329 gramme of copper per second given in E. M. Caillard's "Electricity," and did not find it. Since the very object of the book is to save labour in conversion of measures, it might be well to give the weights also in pounds, to check statements about the commercial deposition of copper.

The abbreviated title on the cover, "Metric Measures," does not adequately describe the contents, since, as may be gathered from the items to which we have alluded, the whole ground is covered, including the metric system, which, though occupying but a portion, is dealt with in a more thorough, practical and convenient way than in any other work that we have seen.

**Histoire d'un Inventeur.** By G. Barral. (Paris: 1891.)

There is probably no man in this hemisphere who has produced so many electrical inventions as M. Gustave Trouvé. Whether Edison has outnumbered him by occasional attention to mechanical matters, or by concocting neuralgia cures, or whether M. Trouvé has occasionally designed a flying machine or two in which compressed air replaced the battery, they have made a profession of electrical invention, and these two men stand alone as the most prolific inventors of the century. The book before us, a large and copiously illustrated volume, consists of no less than 610 pages, on each of which M. Trouvé's name occurs at least once. M. Trouvé does not appear to strive after epoch-making discoveries. He devoted a great deal of attention to the making of small motors, and to supply current for these he experimented largely with bichromate batteries, which were also used for electric light. Unlike Edison, the subject of this volume appears to have done little towards the establishment of works on a large scale, but applied his motors in a diminutive form to the working of mechanical rabbits on scarf-pins, and provided batteries and glow lamps for the adornment of *danseuses de ballet*, of whom some nine or ten are portrayed with all the vigour of French wood engraving. Perhaps the most useful of the hundreds of ingenious inventions of M. Trouvé are the laryngoscopes, opthalmoscopes, and "polyscopes," with which a surgeon may examine the interior of the natural cavities of the human body, or may explore wounds and facilitate difficult operations. Telephones, electric launches, gyroscopes, and innumberable other devices are described and illustrated in this remarkable book.

**Laxton's Price Book, 1891.** (London: Kelly and Co. 1891.)

It is customary for members of any one particular trade to think lightly of any publication which purports to set forth particulars of the cost of the work with which they are familiar. If electrical engineers find, as usual, that this excellent annual may be relied on for information about the building trade generally, while they think that the short electrical section might be improved, it is certain that many other readers will appreciate the prices and other informatiom given. The chapter dealing with electrical engineering may be taken as substantially correct although the estimates for wiring are considerably lower than are generally to be found in practice.

## PHYSICAL SOCIETY.

At the meeting of this society, on February 27, 1891, the following Paper, by Prof. W. E. Ayrton and Mr. J. F. Taylor was read:—

**"Proof of the Generality of certain Formulæ, published for a Special Case, by Mr. Blakesley. Tests of a Transformer."**

In 1888 Mr. Blakesley published a number of formulæ relating to the measurement of power, &c., in alternating-current circuits by means of electro-dynamometers, one of which had its two coils independent, and placed in different circuits. These formulæ were deduced on certain assumptions, the chief ones being that the currents and magnetisations varied harmonically, and that the magnetic stress in the iron was proportional to the ampere-turns. The present Paper shows that the above assumptions are not necessary to the truth of the resu ting formulæ. To take the case of a transformer, let alternating current ammeters be placed in the primary and secondary circuits, and a direct reading, "split dynameter," have a coil in each circuit. Let $D_p$, $D_s$, and $D_{ps}$ be the respective readings, of these instruments, then whatever be the law of variation of the currents,

$$D_p = \sqrt{\frac{1}{T}\int_0^T A_p^2\,dt}, \qquad D_s = \sqrt{\frac{1}{T}\int_0^T A_s^2\,dt},$$

and

$$D_{ps} = \sqrt{\frac{1}{T}\int_0^T A_p\,A_s\,dt},$$

Where $A_p$ and $A_s$ are the values of the primary and secondary currents at any instant, and T the time of one complete alternation. If $i$ be the total induction in the core, P and S the numbers of turns of wire on the primary and secondary respectively, $V_p$ and $V_s$ the terminal pressures, $p$ the resistance of the primary coil, and $s$ the resistance of the whole secondary circuit, then the following equations hold at any instant:—

$$V_p = p\,A_p + P\frac{di}{dt}. \qquad \frac{di}{dt} = \frac{s}{S}A_s$$

Therefore,

$$V_p = p\,A_p + \frac{P}{S}\,s\,A_s.$$

Multiplying both sides by $A_p$ we get $A_p V_p = p\,A_p^2 + \frac{P}{S}s\,A_p\,A_s$ and integrating from $t = o$ to $t = T$ and taking the mean

$$\frac{1}{T}\int_0^T A_p\,V_p\,dt = \frac{p}{T}\int_0^T A_p^2\,dt + \frac{P}{S}\,\frac{s}{T}\int_0^T A_p\,A_s\,dt$$

or watts in primary $= p\,D_p^2 + \frac{P}{S}\,s\,D_{ps}$ quite independent of the laws of variation of A and V.

The power lost in heating the iron core was also shown to be

$$s\left(\frac{P}{S}D_{ps} - D_p^2\right).$$

Other formulæ, such as that given by Mr. Blakesley, expressing the primary volts in terms of the dynamometer readings, are shown to be true generally.

On the subject of transformer magnetisations, the authors state that it is desirable not to speak merely of the ampere-turns, but also of the self-induction, for they have reason to believe that the magnetising value of an ampere-turn varies. Defining the self-induction of the secondary by the equation $L_s = -\frac{dN}{dA_s}$, N being the total flux through the secondary, they show geometrically (assuming harmonic variations) that if $L_s$ diminishes the efficiency increases, and at the same time the phase angle $\theta$ between the primary and secondary currents and the magnetic lag $\phi$ decreases. On comparing this theoretical deduction with the results of experiment, they find a good agreement as will be seen from the following table:—

| Frequency. | Efficiency. | $L_s$ | $\theta$ | $\phi$ |
|---|---|---|---|---|
| 160 | 96·3% | ·0017 | 113° | 0° 24′ |
| 160 | 92·0 | ·0368 | 169 | 18° 24′ |
| 160 | 85·4 | ·1241 | 174·6 | 45° 36′ |

Similar results were obtained in different sets of experiments. It was also noticed that as the secondary current is increased the efficiency rises to a maximum and then diminishes, whilst $L_s$, $\theta$, and $\phi$ diminish and then rise again; the current which gives the maximum efficiency coinciding almost exactly with that which gives minimum values to $L_s$, $\theta$, and $\phi$.

Digitized by Google

The methods employed in making the tests are described in the Paper, and the formulæ used in working out the results are there demonstrated. Amongst the facts deducible from the experiments are the following :—

1. With constant frequency, the ratios $\frac{V_s}{V_p}$ and $\frac{D_s}{D_p}$ increases as the primary volts rise.

2. With frequency constant, and primary volts constant, $\frac{V_s}{V_p}$ decreases and $\frac{D_s}{D_p}$ increases as the secondary current increases.

3. With constant secondary current, $L_s$ decreases as the primary volts are increased.

4. With small constant secondary currents the efficiency diminishes as the frequency increases.

5. For large secondary currents the efficiency is approximately independent of the frequency.

6. Shunting the secondary with a condenser increases the efficiency.

---

Mr. T. H. BLAKESLEY then read a Paper :—

### "On Further Contributions to Dynamometry."

The object of Mr. Blakesley's Paper was, in the first place, to show what sort of physical quantities could be advantageously evaluated by using electro-dynamomoters of two coils of low resistance in circuits conveying electric currents. The meaning of a dynamometer reading was explained to be the mean value of the product of two currents, either steady or alternating, or one steady and the other alternating, undergoing any periodic variations with sufficient rapidity. In mathematical language such an instrument measured $\frac{1}{T}\int_0^T C_1 C_2 \, dt$, where $C_1$ and $C_2$ were the instantaneous values of the currents in the two coils, including, of course, the common case where these currents are identical.

Any physical quantity whose value was such a product, $C_1 C_2$, multiplied into something which was independent of the time, and which, therefore, on integration came outside the integrator, was well adapted to have its mean value given by such instruments. Power was such a quantity, being merely $(\text{current})^2 \times$ resistance. The square of an E.M.F. was another such quantity, but he did not wish to restrict the method to such evaluations.

It follows that any quantity whose instantaneous value can be expressed by terms each quadratic in current, and whose other factor was independent of time, could have its mean value expressed in dynamometer readings. In addition, the particular place and mode of coupling of the dynamometers was indicated by the instantaneous equation, as well as the factor to be applied to each reading. *Thus the equations are made to indicate the practical arrangements to be adopted, and the use to be made of the observations in each case.*

Examples were given for the cases of transformers in series and parallel, and special applications of the method were suggested in the measurement of the power employed in such diverse apparatus as, voltameters subject to direct or variable currents of any sort, welding machines, parallel generators, tuning-fork circuits, vacuum discharges and imperfect condensers. For parallel generators, the power of each could be separately estimated, and in the case of electric welders, the power employed in the welding circuit was shown to be measurable without introducing any resistance whatever into that circuit.

---

DISCUSSION.

Mr. J. SWINBURNE said that it had been impossible to follow the mathematical reasoning from hearing the paper read, and it would be necessary to see the calculations which had succeeded each other on the black-board in print, before discussion would be possible. The author's assumption that there is no back or forward E.M.F. in the primary and secondary circuits of tranformers except that due to $\frac{di}{dt}$, where $i$ is the total induction in the core, was unwarrantable, for in all real transformers there was a "drop" due to waste field, and this made the split dynamometer method useless. It makes the full load efficiencies too high, and this, he thought, accounted for the extraordinary results obtained by Prof. Ayrton and Mr. Taylor. If a dynamometer be used at all, it should, he said, be used as a wattmeter, the moving coil of one turn being joined in series with a non-inductive resistance, and put as a shunt to the primary. The power absorbed by the instrument itself should be then determined, and the power given out by the secondary measured by the same instrument, if the secondary be not non-inductive. Any errors due to self-induction in a wattmeter are, he said, equally present when it is called a split dynamometer; and, in addition to this, the wattmeter as a split dynamometer precludes the possibility of measuring power.

Mr. MORDEY said the results obtained by Prof. Ayrton and Mr. Taylor confirmed experiments he had made himself by an entirely different method, for he found that the losses in the iron decreased considerably as the secondary current increased, and this gave increased efficiency. In his experiments he kept the load constant until the transformer attained a steady temperature, and then substituted a direct current for the alternating one, varying its strength until the same steady temperature was maintained. The power thus supplied is a measure of the loss in the transformer under the working condition. A 6-kilowatt transformer, tested by this method gave a loss of 110 watts at no load, and at full load 205. Of this 205, 176 was accounted for by the loss in the copper coils, leaving only 29 watts as the iron losses at full load. Figures which he quoted from Prof. Ayrton and Mr. Taylor's Paper showed the same general result.

---

## BOOKS, &c., RECEIVED.

"Die Elektrischen Verbrauchsmesser." By Etienne de Fodor (Vienna: A. Hartleben.)

"Verzeichniss der innerhalb der letzten nahezu 30 Jahre in deutscher Sprache erschienen Literatur, auf dem Gebiete der Lehre von der Elektricitäts und Elektrotechnik." (Vienna: A. Hartleben.)

"The Electro-Platers' Handbook." By G. E. Bonney. (London: Whittaker and Co.)

"Transactions of the Canadian Institute." Vol. I., Part I. (Toronto: Le Copp, Clark Company, Limited.)

---

## MEETINGS OF SCIENTIFIC SOCIETIES, &c.

**FRIDAY, March 6th.**

SOCIETY OF ARTS.

*4.30 p.m.* Popular Afternoon Lecture: "The Science of Colour," by Capt. ABNEY, F.R.S.

ROYAL INSTITUTION.

*9 p.m.* Evening Discourse: "Electro-Magnetic Repulsion," by Prof. J. A. FLEMING, D.Sc.

PHYSICAL SOCIETY.

*5 p.m.* Ordinary Meeting. Papers to be read: (1) "Note on Electrostatic Wattmeters," by Mr. J. SWINBURNE. (2) "Interference with Alternating Currents," by Prof. W. E. AYRTON, F.R.S., and Dr. W. E. SUMPNER. (3) "The Theory of Dissociation into Ions and its Consequences," by Mr. S. N. PICKERING, F.R.S. (4) "Some Points in Electrolysis," by M. J. SWINBURNE.

**SATURDAY, March 7th.**

ROYAL INSTITUTION.

*3 p.m.* Afternoon Lecture: "The Forces of Cohesion," by Lord RAYLEIGH, F.R.S.

CITY AND GUILDS OLD STUDENTS' ASSOCIATION.

*8 p.m.* Smoking Concert at the Mason's Hall Tavern.

**MONDAY, March 9th.**

SOCIETY OF ARTS.

*8 p.m.* Cantor Lecture IV. 1. "Photographic Chemistry." by Prof. R. MELDOLA, F.R.S.

**TUESDAY, March 10th.**

INSTITUTION OF CIVIL ENGINEERS.

Ordinary Meeting. Paper to be discussed: "On the Subterranean Water in the Chalk Formation of the Upper Thames, and its Relation to the Supply of London," by JOHN THORNHILL HARRISON, M.I.C.E.

**WEDNESDAY, March 11th.**

SOCIETY OF ARTS.

*8 p.m.* Ordinary General Meeting. "Electricity in Relation to the Human Body," by H. NEWMAN LAWRENCE and ARTHUR HARRIES, M.D.

**THURSDAY, March 12th.**

ROYAL INSTITUTION.

*3 p.m.* Afternoon Lecture: "Modern Chemistry in Relation to Sanitation," by Prof. C. MEYMOTT TIDY.

INSTITUTION OF ELECTRICAL ENGINEERS.

*8. p.m.* Ordinary General Meeting. "Transformer Distribution," by J. SWINBURNE. Adjourned discussion.

**FRIDAY, March 13th.**

SOCIETY OF ARTS.

*4.30 p.m.* Popular Afternoon Lecture: "The Science of Colour," by Captain ABNEY, C.B., F.R.S.

INSTITUTION OF CIVIL ENGINEERS.

*7.30 p.m.* Students' Meeting. Paper to be read: "The Lanarkshire and Ayrshire Railways," by A. P. TAIT, B.Sc., Stud. Inst.C.E.

ROYAL INSTITUTION.

*9 p.m.* Evening Discourse: "The Culture of the Singing Voice," by FELIX SIMON, M.D.

**SATURDAY, March 14th.**

ROYAL INSTITUTION.

*3 p.m.* Afternoon Lecture: "The Forces of Cohesion," by LORD RAYLEIGH, F.R.S.

Digitized by Google

# The Electrician.

Published every Friday, Price Fourpence; Post Free, Fourpence Halfpenny
Editorial, Publishing, and Printing Offices:
SALISBURY COURT, FLEET ST., LONDON, E.C.
*Telephone No.* 2714. *Telegrams:* "ELECTRICIAN NEWSPAPER, LONDON."

*All Letters relating to Subscriptions, Advertisements and other business matters should be addressed to the Publisher,* "THE ELECTRICIAN," *Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to* "THE ELECTRICIAN" *Printing and Publishing Company, Limited, and be crossed* "*Coutts and Co.*" *All other letters to be addressed to the Editor.*

*All letters intended for insertion in* "THE ELECTRICIAN," *or containing questions, must be accompanied by the address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

"THE ELECTRICIAN" *is published every Friday morning, in time for the morning mails. Subscribers should receive their copies by the first post on Friday morning.*

"THE ELECTRICIAN" *is on sale at the railway bookstalls throughout the Kingdom on Friday morning, and can be obtained of all Booksellers and Newsvendors; or direct from the Publishing Offices as above.*

*New Volumes of* "THE ELECTRICIAN" *commence in May and November.*

## SUBSCRIPTION RATES

The rates for Subscriptions to "THE ELECTRICIAN" are as follows:—

| | 3 months s. d. | 6 months. s. d. | 12 months. s. d. |
|---|---|---|---|
| For the United Kingdom | 5 0 | 10 0 | 19 6 |
| For Foreign Parts and Colonies:— Within Postal Union | 6 6 | 12 6 | 24 0 |
| For Aden, Borneo, Ceylon, China, India, Japan, Java, Labuan, Mozambique, New Caledonia, Persia, Philippine Islands, Siam, Transvaal, and Zanzibar | 7 6 | 14 6 | 28 0 |

## TO ADVERTISERS.

"THE ELECTRICIAN" *offers exceptional advantages to Advertisers.*
**It has by far the largest circulation of any English Electrical paper, and circulates all over the World.**

*Particulars relating to Advertisements will be promptly forwarded on application to the Offices as above.*

TRADE ADVERTISEMENTS *intended for the current issue must reach the Offices not later than First Post on Thursday morning. Renewals of expiring advertisement orders and alterations to standing advertisements should be in the Publisher's hands by Wednesday at latest. No alteration can be made in Wrapper advertisements after Wednesday evening.*

SMALL PREPAID ADVERTISEMENTS *(for Rates see page xv.) are accepted up to 4 p.m. on Thursday.*

## TECHNICAL PRINTING.

"THE ELECTRICIAN" PRINTING AND PUBLISHING COMPANY (LIMITED) *inform Electricians, Electric Light Engineers, &c., that they make a specialty of Technical Printing, and have a large Staff thoroughly acquainted with Electro-Technology. They can, therefore, promise Accuracy and Despatch in the Printing of Electro-Technical Literature, &c.*

## "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. (Royal 8vo.)

*Early in each year is issued* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. *The* DIRECTORY *was established in 1883, and the 1891 Edition, published on the 23rd February, consists of 900 pages of printed matter. The names and addresses of all persons engaged in the Electrical Industries at home and abroad may be relied upon as accurate. Useful Tables and Electrical Formulæ, and information specially compiled for this work are given, together with popularly-written Biographical Notices of the leading Electricians, Electrical Engineers, &c., accompanied in many cases by Portraits.*

*The issue for 1891 is ready, and should be ordered at once. Price 5s., post free 5s. 9d. Abroad postage extra. Full particulars on application.*

## ELECTRICAL BOOKS AND PUBLICATIONS

*All Books, Newspapers, and other publications, dealing with Electrical and kindred subjects, can be ordered direct of* "THE ELECTRICIAN" *Printing and Publishing Company, who are proprietors of the well-known* "ELECTRICIAN" *Series of Standard Electrical Works, and are agents for all the leading publishing houses at home and abroad.*

## CONTENTS OF THE CURRENT NUMBER.

NOTES ... 529
The Magnetic Circuit of Transformers: Closed versus Open. By S. Evershed. Continued Illustrated ... 534
On the Determination of the Capacity of Long Submarine Cables. By Arthur Dearlove. Illustrated ... 537
Reviews ... 539
Physical Society ... 540
Meetings of Scientific Societies ... 541
THE SUPPLY OF ELECTRICITY ... 542
The Electric Current and its Laws. By John T. Sprague. Continued. Illustrated ... 543
The Ferranti Meter ... 544
Transformer Distribution. By J. Swinburne. Concluded. Illustrated ... 545
Phenomena of Alternating Currents of very High Frequency. By Nikola Tesla ... 549
Parliamentary Intelligence—
Central London Railway Bill 551
American Notes ... 553
CORRESPONDENCE—
Electrostatic Forces *versus* Gravitation—O. J. Lodge 553
CORRESPONDENCE—*Continued.*
Electric Theories—Ether—Oliver Heaviside and John T. Sprague ... 553
Magnets and Nomenclature—Sydney Evershed ... 554
The Callan Induction Coil—Francis Lennon ... 554
The Barking Road Cars—T. Frazer ... 554
Electric Lighting Statistics—Denny Lane ... 555
The Rentsch Incandescent Lamp Suspension. Illustrated ... 555
Trade Notes and Notices ... 556
COMPANIES' MEETINGS, &c.—
The Telegraph Construction and Maintenance Company (Limited) ... 556
The St. James' and Pall Mall Electric Light Company (Limited) ... 557
Taunton Electric Lighting Company (Limited) ... 558
Keswick Electric Light Company (Limited) ... 559
New Companies registered ... 559
City Notes, &c. ... 559
Companies' Share List ... 560

## STEEL-PLATE PORTRAITS

*Of W. H. Preece, F.R.S.; Michael Faraday; Sir John Pender, K.C.M.G.; Sir William Thomson, F.R.S. (Past-President of the Institution of Electrical Engineers); C. H. B. Patey, C.B. (Late Secretary of Telegraphs, G.P.O.); Dr. John Hopkinson, F.R.S. (Past-President of the Institution of Electrical Engineers); Dr. Oliver J. Lodge, F.R.S., and Prof. William Crookes, F.R.S. (President of the Institution of Electrical Engineers), have been issued as Supplements to* "THE ELECTRICIAN." *A few Copies of these admirably-executed Steel Engravings can be supplied, price 1s. each, post free on roller, 1s. 2d. Or framed in neat Black Pillar or Brown Ornamental Frames, price, post free, 4s. 6d.*

## THE SUPPLY OF ELECTRICITY.

It is a good thing that some quarter of a million glow lamps are now connected to upwards of 120 miles of mains laid under the streets of London, and that on an average several hundred thousand of these lamps are burning steadily and satisfactorily every night. It is a good thing that supply companies are beginning to hold their meetings, and to show their balance sheets. It is also a good thing that honestly-earned dividends are being paid, for in some quarters one is asked to believe that the whole thing is still tentative and experimental, that those who are making and using electrical machinery are quite mistaken as to the principles involved in its action, and wrong in their application of it to the supply of electrical energy. Fortunately, the public—the good public who pay the piper—are fairly content with the tunes, and will not give much attention to those who dispute about the definition of musical terms, object to the construction of the instrument, and throw doubts on the accuracy of the counterpoint. Some consumers of electric light mi hail with satisfaction the theory that the electrical energy purveyed to them by the supply company passes through general space to their lamps, and not through the wires, since they might imagine that they were getting something which did not necessarily pass through the meter; but other hesitating individuals, who cannot settle whether they shall admit the new light to their dwellings, may perchance hear that it is

Digitized by Google

averred by the leading authorities that the conductor does not conduct electricity as a pipe conveys water, and may imagine that streams of electric fluid are liable to trickle out and cause mischief. Then again, the advocates of low pressure distribution boldly accuse the users of alternating currents of burning half their coal and of incurring half the wear and tear of their machinery in magnetising their transformers throughout the day, and that these transformers are as costly to maintain as batteries, owing to frequent breakdowns. Well might an intending investor wait until some reply is offered, and some defence and refutation given. But it takes more than this to shake the confidence of the public when it has at length been won. This is a day of pessimism. Progress has been made at such a rate during the closing years of this century that there is a temptation to put oneself on the safe side and belittle the boldness of pioneers; for it is not difficult to follow if they succeed in opening up a new path, while yet more easy is it to jeer at them if they are impeded by difficulties, and to offer them advice if they go astray. But while pessimism is the fashion of a few, the public are not fooled by it; and while it is said that you may give a dog a bad name and hang him, it would need an exhaustive vocabulary of expletives to kill him with criticism.

We were once assured that the sides of Mr. CROMPTON'S conduits would give way, that they "would probably leak extensively," "insects would overrun the insulators," "the insulation would disappear," and "that these nice little roads under the footway would become a sort of Rotten Row for a large population of rats." It did not occur to the critic that the rats might eat the insects, and die in consequence, which we suppose accounts for the fact that no specimens of either species are to be found among the mains. In spite of all this prophecy we have heard of no trouble whatever, and the best proof is the fact that fresh conduits are being made to-day. But to all these forebodings about low pressure distribution it was retorted that transformers were hopelessly inefficient, and that the system of alternate currents demanded an extensive plant, and with no reserve there was liability to break down and extinction of the light; there would be great waste from continued running on light loads; that each electrical horsepower in the lamps would take about 18lb. of coal, and so on. But since that time several alternate-current supply stations have started, and no break-down at a London generating station at any rate has yet been heard of. We have recently been informed, in spite of the announcement that the critic does not think it well "to offer any criticisms lightly," that this system is all wrong, that the method of distribution is hardly likely to be permanent anywhere, that it has many disadvantages, that it is dangerous, and that the greatest drawback lies in the waste of power in the transformers themselves.

The latest panacea is the sub-station system. There is nothing very new about it. It has been discussed repeatedly. It is excellent on paper, and presents admirable features to any engineer who sits down to design the complete lighting of a town. But how often has he the chance of sallying forth with his plans under his arm and getting to work on the job? Until the contracts were given for the lighting of the City, all electric supply in this country, with the exception of some enterprising but small towns where series working sufficed, depended entirely on the supply to houses, shops, clubs and theatres. Street lighting is a very poor business compared with house work, even if the same price be paid for the current, on account of the comparatively great first cost of fittings and the length of conductors per lamp. The City of London schemes and that of Dublin are to provide primarily for street lighting, and the house follows as a matter of course. The street lighting settles the area over which the supply is to take place in a far more systematic manner than a schedule of compulsory streets. But even when street lighting is to form the skeleton of the system and to define the extent of the district, it indicates very slightly, if at all, how and where the bulk of the house lighting will come on. The engineer who is fond of calculating generally assumes that nearly everybody who wants the supply will take it as soon as he can get it, and neglects the period which must elapse before it is possible to tell where the heaviest demand will come from. The present system of distribution by transformers is eminently fitted for feeling one's way about a district, and permits of rapid extension. The choice of the size of a pipe for drawing in mains is a much less serious matter than the estimating of the dimensions of a conduit, while more difficult than either would be the selection of the sites of sub-stations. But after a district has arrived at an established condition, when all the streets of any importance have been served, and the rush of new consumers is over, an alternating supply company may consider the question of sub-stations. But in doing so, no brand new system is suggested, and there is not any reason whatever for supposing that the introduction of such a measure implies that the previous work was on wrong lines and was provisional, that electrical engineers do not know their own minds, and that the public should stand aside and wait for more perfected methods.

## THE ELECTRIC CURRENT AND ITS LAWS.

BY JOHN T. SPRAGUE.

(*Continued from p. 514.*)

§ 13. There are people so constituted that they flourish on a mental diet of $\frac{1}{2}$ V D ($L_1$ $N^2$) + $\sqrt{\mu}$ − $R^2$, and so on, and to whom scalars and vector potential act like hock or champagne; others find them useful as occasional stimulants only, while mortals of weaker digestion regard them as dangerous and apt to act emetically. Alas, I am one of them, and am compelled to use a simple diet easily cooked. I prefer to form concrete pictures of what I suppose really to occur in nature, or of the actions which a theory involves.

I have, therefore, endeavoured to put into a diagram the conception I can form of the theory described (p, 513), &c., so far as it is possible to represent motion, which I do by arrows.

§ 14. Fig. 1 represents an electric current by the middle arrow. S is the source which, in order to correspond with

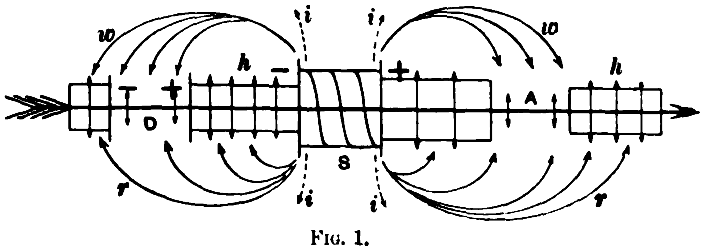



FIG. 1.

ideas to be developed later on, I show as a turbine, instead of as the usual pair of battery plates. The circuit consists of wires of different sections or conductance, in order to bring out the varying rates at which the heat which corresponds to $C^2$ R is radiated away, and which is shown by the cross-bars *h*; D is a decomposition cell, *i.e.*, a voltameter; and A is an arc lamp. These two are not often put in series practically, but for present purposes we can do what we like, as the horsepower expended is supplied gratis.

Digitized by Google

The upper arrows $w$ indicate the asserted energy streams in the outer medium, doing work; the lower lines $p$ show the similar streams, carrying the energy which overcomes the resistance and appears as heat in $h$.

I can in no way manage to include the actions which we know as the electric charge of the circuit, though I make a feeble attempt to do so in the arrows $i\ i$ issuing from the source S. Neither can I indicate the magnetic lines formed around the conductor; all this would make the diagram too confused, even if I could see my way to present them on this theory. I should be very glad if some one else would do so. No doubt, as suggested in p. 520, it may be better for my opponents not to attack my points in detail till I have stated my case, but in such matters as this it will save time if they supply information which I do not possess, or cannot give clearly.

§ **15.** I find it very much more easy to draw a picture of the other theory, the one which is unorthodox now, but was generally held until quite lately. I suspect it is still held by all electricians who belong to the ranks of the practical appliers of science. These men know that they must be careful to use enough iron and copper, and so much gutta percha as is necessary to insulate their conductors, and only regard its "medium" quality as an element of cheapness. They know they must provide a current conductor, but do not care how the energy travels, or make any provision for it.

§ **16.** Fig. 2 presents this, which for simplicity I will call my theory. It is just the same as Fig 1, as regards the current and the heat; but the energy is shown as a current inside the

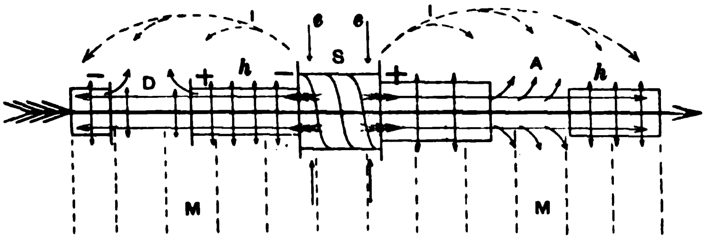



Fig. 2.

conductor, by arrows issuing from the poles of the source S. From these arrows or current (which is an integral part of the electric current, as will be shown by-and-bye) proceed the supplies of energy to carry on all the electrical actions—the heat of resistance $h$, the heat and light of the arc A, the chemical energy to give off, say, oxygen and hydrogen at the plates of the voltameter D, in fact all the accompaniments of the electric current. This internal stream also supplies the energy necessary for the actions which occur in the "variable period" on closing the circuit and previous to the forming of the true current. These are shown in dotted lines; I the static charge or lines of stress existing along the whole circuit and shown in what used to be called the "tension" between the various parts, now called slope of potential, &c. This is what is called also the self-induction, inductance, &c. The lines M M show the magnetic functions of the circuit, equal at every part, source, arc, voltmeter, as well as in the wires, but varying with the external conditions—that is, with the "permeance" or magnetic capacity of the substances near the conductor. These lines of energy then represent the magnetance of the circuit, and M and I are both storages of energy, which reappear in the circuit, and constitute the E.M.F. of the later "variable period," when the circuit is broken.

(*To be continued.*)

## THE FERRANTI METER.

This well-known meter has lately received considerable attention at the hands of the makers, who have introduced several improvements and have laid down special plant for turning them out in large numbers. The instrument, as is well known, depends upon the rotation of mercury in a magnetic field. The poles of the magnet are shown in Fig. 1, N S S. The current to be measured passes from the outside to the centre at right angles to the lines of force of the magnet, which are approximately axial. The rotation of the mercury sets in motion a fan, and this operates a counting train. To overcome the initial friction an auxiliary shunt coil is provided, and is shown in the figure over the letter

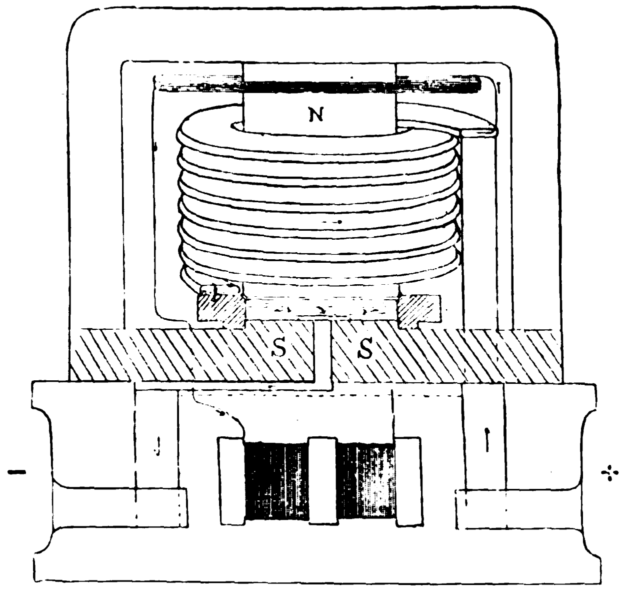



Fig. 1.—Section of Ferranti Meter, showing Direction of Current.

N. A resistance placed at the bottom of the case is in series with this. If the shunt current were strong enough, the meter would of course slowly revolve, but it is arranged so as to be just too weak to do this. A very small current through the main coils will therefore start the meter, whose readings are then proportional to the current. Figs. 2 and 3 are diagrams showing the method of ascertaining the constant of each instrument.

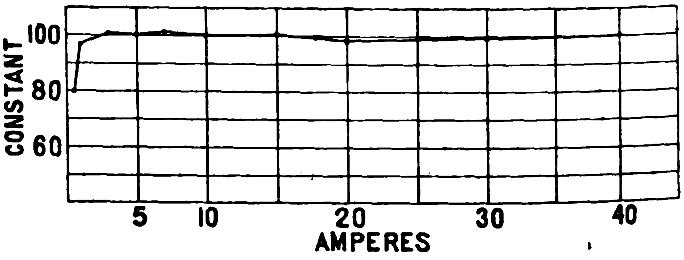



Fig 2.—Curve showing Performance of 40-ampere Meter.

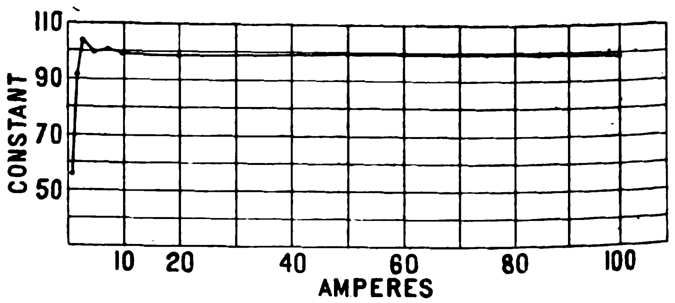



Fig. 3.—Curve showing Performance of 100 ampere Meter.

The following particulars give an idea of the performance of these meters:—Forty ampere alternate current mercury meter, shunted; started with three ampere; mean constant 7·56 over twenty-fold range; variation—above 1·85 per cent., below 2·12 per cent. 100 ampere direct current meter; starts with five amperes; mean constant 2·838 over fifty-range; variation—above 1·3 per cent., below ·99 per cent. Ten ampere continuous current mercury meter, unshunted; started with two amperes; mean constant 23·56 over twenty-fold range; variation—above 3·98 per cent., below 2·37 per cent.

Digitized by Google

## TRANSFORMER DISTRIBUTION.*

BY J. SWINBURNE.

*(Concluded from page 518.)*

It is thus possible by altering the field excitation of such dynamos to make them work well as generators or motors on supply circuits. Instead of depending on the reaction of the armature to strengthen or weaken the field, the field excitation may be automatically regulated, so that the current and electromotive force of the machine are always in step, or very nearly so.

Take first the case of a separately excited motor. The field magnets may have an additional set of coils, and these are put in series with the main armature current, which is redressed or rectified by a commutator. These coils are arranged so as to demagnetise or weaken the field as the current increases, so that it is not necessary for the machine to lag in order to take a large load.

The machine may be made to excite itself. In that case, special exciting coils on the main armature are provided. These are connected with the circuit for exciting the field-magnet. If a machine made in this way is used as a motor without a series demagnetising circuit round the field-magnets, it begins to lag as soon as load is put on, and the armature current then reacts on the fields and weakens them. As the exciting coils now pass through the same field, this will also lessen the field excitation directly; and as soon as the field is weakened by the armature reaction, the ampere-turns round are also reduced, because the electromotive force in the exciting circuit is lessened. A very small lag will thus weaken the field considerably, so that a large load may be put on without the lag being great enough to make the machine inefficient. A series demagnetising circuit may be used in addition. If the ampere-turns of the field magnet are not adjusted to the load with perfect accuracy, the machine adjusts itself by lagging or leading very slightly.

Machines with fields excited chiefly by special exciting circuits on the main armatures, and partly by series circuits, may be specially useful for working in parallel as generators. The series circuits are then arranged to magnetise instead of demagnetise. If power is applied to a motor instead of taken from it, it becomes a generator, and the direction of its main current is reversed, both in the armature and the series coils on the fields; so that a motor with a backward series circuit becomes a generator with a forward series-circuit. If one machine when used as a generator begins to lead because too much power is supplied to it by its engine, its field is strengthened by the series circuits, and this increases the armature electromotive force enough to make it give a large output corresponding to the power supplied to it. If machines excited from special armature circuits, without series circuits, are run in parallel, they will keep in step, because the least leading or lagging alters the field excitation.

The compound form is best, because the whole station will then supply the mains at constant pressure, if all the engines are mechanically governed for constant speed of one of them—that is to say, if the whole steam supply is regulated to keep the speed of all the engines constant, the engines taking the steam in proportion to their size. Instead of keeping the speed constant, an electric governor can keep the electromotive force of the whole station constant. With alternate machines as at present commonly used, it is necessary to alter the field excitation by hand or by automatic gear. Such machines as those described have advantages corresponding to those of compound direct-current dynamos, compared with shunt or separately excited machines. The analogy between these machines and compound or shunt direct-current machines must not be used too far. In direct-current machines, the electromotive force adapts itself by slight alterations of speed, and the armature reaction depends on the position of the brushes; in alternate machines, the speed is unalterable, and the armature reaction depends on lead and lag.

Prof. E. Thomson tells me that he has been accustomed to send out separate and series excited machines for working in parallel, and that they will work either with or without "equalising connections" such as are needed with direct compound machines. They also work well as motors, and so do the self-exciting machines with separate exciting armature circuits. He also finds the ordinary Thomson-Houston machines works efficiently as a motor.

In discussing such questions, however, we must always remember that the size of the machine is most important. A small dynamo has high resistance, small cross induction, and small armature reaction. A large machine has a small resistance and great armature reaction. Large machines may therefore easily run well in parallel or as motors, without automatically varied field excitations. A very small lagging current will reduce the field of a large machine 3 or 4 per cent., and the extra loss of power in the armature is small; for if C is the component of the current that is in step, and $c$ the lagging component, the power wasted in the armature is not $r\,(C+c)^2$, but $r\,C^2+r\,c^2$—a very different matter.

The case of motors, however, is not the same. A two-horse or one-horse motor is about the size that is most needed. There is no opening for 100-kilowatt motors on supply circuits just now. In these small sizes $c$ will be very large compared with C, so automatic regulation of the field may be of the highest consequence.

The subject of motors is of enormous importance, and is most interesting. I fear it cannot be pursued here, for want of time. It is to be hoped one of my hearers may be induced to write a Paper on this subject at an early date, unless, as is probable, it is exhausted in Mr. Kapp's Cantor Lectures.

According to the armature reaction theory, then, whether a machine will run in parallel with others depends on its armature resistance and armature reactions. It must be borne in mind that most machines have cast-iron fields, and though that may make no difference according to the orthodox theory, it does from the armature reaction point of view. If the field-magnets do not quickly respond to the armature reactions, it may be difficult or impossible to run machines in parallel.

Another important consideration is the government of the engines. If two engines are working two machines in parallel at 200 revolutions, and one governor is set for 200 and the other for 195 revolutions, if the governors are truly isochronous, one engine and dynamo will supply the whole of the power, and the other will be dragged round idle. The whole question of the government of central stations requires the most careful consideration. I have dealt with the matter at some length elsewhere,* but the subject should be very fully thought out in designing stations.

### *Arrangement of Station.*

Whatever system of distribution be used outside the station, the power leaves by high-pressure leads. In this country 2,000 volts is the pressure commonly employed; in America, 1,000. I cannot help thinking that the Americans are right. The use of 2,000 volts does not decrease the cost of copper so very much, and it increases the cost of insulation enormously. In addition to this,

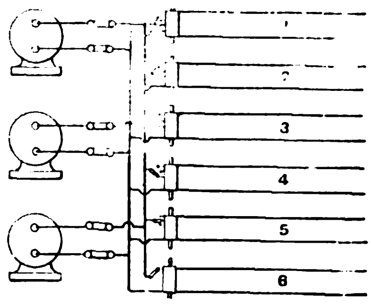



Fig. 8.

it increases the dangers of breakdowns, and the chance of danger to life. 2,000 volts seems to have been chosen in the early days, when people had very little idea of the commercial difficulties of high-pressure insulation. In addition to this, high pressure increases the cost of transformers as well as dynamos, and also lessens the output for a given size.

If the machines are employed in parallel, they may feed into common bars, as in the case of direct currents. If each district must have its own circuit—which seems to be generally assumed necessary—each circuit may be led away from the common bars with a transformer regulator in it. One objection that has been raised against parallel working is that, if each district has its own system, it may have an earth on one lead without disaster, while, if the station is in parallel, two leaks in the whole system cause a breakdown. This objection comes from America, where they have had a great deal of experience, but it seems to assume the leads to be in a very bad state. There is no need for such danger, however, for each district may be fed through a transformer, so that it has no metallic connection with the system of any other district. It is most difficult to understand why central station machines are made to give high pressures to begin with. In most forms of dynamos 2,000-volt insulation adds very materially to the cost of the machine, and lessens the output for a given size in addition. The difference of cost would more than cover the extra cost of transformers, as large converters can be made for considerably under £1 per 1,000 watts; and the efficiency, when very large, is very high, being above 99 per cent. at full load. So that the efficiency of a low-pressure dynamo and transformer is higher than that of a high-pressure dynamo working direct. It is also a great advantage to have all the switches, connections, and measuring instruments on the low-pressure side. The high-pressure circuits may then be arranged to have no metal exposed any-

* Paper read before the Institution of Electrical Engineers, February 19, 1891.

* *Industries*, September, 1890.

Digitized by Google

where. If each district must have its separate circuit, it has its own step-up transformer, with its regulator. If feeders are used on any system, each feeder has its step-up transformer, which is made adjustable; or it may have an unadjustable transformer and a feeder regu'ator, such as that designed by Mr. Kapp. If the district is large, it may have large transformers. Several feeders may then come off in parallel, each feeder having its own regulator. The regulators may have the adjustable parts connected with the low-pressure supply, so as to avoid high-pressure switches or other gear.

One arrangement is shown in Fig. 8. The dynamos are all in parallel, and wound for 100 volts, the immediate neighbourhood of the station being fed direct. Each feeder circuit has a transformer with a variable number of primary turns. A compensated voltmeter is placed on each, and all the attendant has to do is to alter the switches a little occasionally, so as to keep all the instruments' pointers vertical.

*Transformers.*

It is not my intention to go into the question of leads, as I am informed that a Paper specially devoted to that important subject is to be read here very shortly; I am therefore most happy to leave the very special question of high-pressure alternate-current mains in far abler hands.

Before discussing the relative merits of house transformers, low-pressure direct from the station, and various sub-station arrangements for distribution, it will be best to consider the vexed question of the transformers themselves.

In 1884 electrical engineers were surprised to learn from Dr. Hopkinson that the Gaulard and Gibbs transformers gave something like 90 per cent. full-load efficiency. Since then alternating work has developed enormously; but a complete change has come over the transformers: they are almost always made with the iron circuit closed on itself. The closed iron circuit has been regarded as an enormous advance on the old form; but it is difficult to find any definite statement as to where the advantage comes in. It was for a long time assumed that almost any closed-circuit transformer would give an efficiency of something like 98 per cent.—in fact, that the loss in transformers might be neglected.

In a discussion on the relative merits of direct and alternate current distribution, Mr. Crompton said that the efficiency of the ordinary commercial transformer in a station was about 50 per cent.; and I need hardly say he was not believed. He laid particular stress on the small proportion of the total number of lamps installed really used. The loss in the iron in transformers has till lately been very much overlooked; if it is even a small percentage of the full load of the transformer, it mounts up very seriously in station work when the transformers are in circuit all day and all night.

I had the honour of reading a Paper before the British Association in 1889, in which the question of design for all-day loads was, as far as I know, discussed fully for the first time; and the relative proportions of iron and copper for closed-circuit transformers which gave the best results were given. At the same time I pointed out that the loss in iron was really such a serious matter that by a special design not only can a very much higher efficiency be obtained at light loads, but that even at full load a new form is better in every way.

The principle of the "Hedgehog" transformer is this: By using an open circuit the iron can be reduced in volume with a given induction. The mean length of the iron part of the magnetic circuit is considerably less, and more copper turns can be wound on without increasing this length much. The additional turns admit of a smaller cross section of core, so that the iron is enormously reduced. The loss in copper is somewhat increased; but as the loss in copper is only serious at full load, this does not matter.

The old Gaulard and Gibbs form of transformer had the disadvantage of requiring a very large exciting current. Increased number of turns of copper reduces the exciting current; but, in addition, the ends of the core are spread out in a peculiar way, which again reduces the exciting current. The result is that the exciting current, though larger than in the case of closed-circuit transformers, is not a serious matter. The loss in copper is considerably smaller than the loss in iron in most closed-circuit transformers, and, as it varies as the square of the current, it is inappreciable except at full load, which very seldom occurs. The loss in iron is very small, so that the loss per day in ordinary working is very much smaller than in the case of closed-circuit transformers. Since my Paper at the British Association, many makers have altered the proportion of their transformers considerably; but still it is impossible to get as good results with closed circuits.

Perhaps the best way I can make this clear is by a comparison of actual transformers. I am here confronted by a difficulty. If I select any particular closed-circuit transformer of a particular maker, all the other makers of closed-circuit transformers would say that I had closen a bad example; while the maker himself would say that it was an old form, or that he now uses a quality of iron which wastes no power by hysteresis.

A great deal of unnecessary mystery has been made about the efficiency of transformers, and all sorts of roundabout ways of measuring or calculating it have been proposed, and sometimes tried. The matter is simple, however. The loss in the copper can be calculated if the resistance and current are known. The loss in iron in a given type of transformer depends on the quality of the sample used just as much as the loss in the copper depends on the quality of the copper used. I will therefore assume the ordinary "96 per cent." quality of copper, and I will assume that the iron is as good as the soft iron tested by Prof. Ewing. I have the best reasons for knowing that the iron used is generally much below this standard, so this assumption is considerably in favour of the closed circuits. Moreover, I am giving away the loss by Foucault currents, which is often considerable. Of course, anyone is at liberty to assume that he has some particularly good iron; but in discussing the relative value of the two types of transformer, he must allow me the same quality of iron. In fact, I might assume a special quality of copper equally unknown to the trade in mine.

As an average size of transformer, one taking 2,000 volts and a frequency of 100, and giving 15 amperes at 100 volts, may be taken, and the working compared.

Though the theory of the "Hedgehog" transformer was fully discussed in the British Association Paper referred to, it may not be out of place to describe the construction of the commercial article.

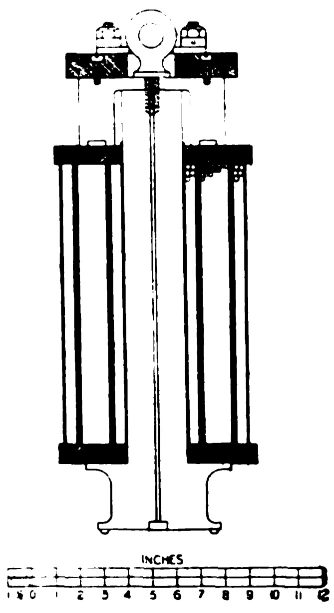



FIG. 9.

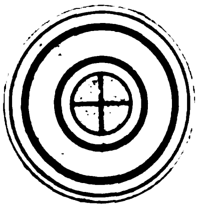


FIG. 10.

A gun-metal casting forms the backbone of the transformer. It is cross shape in section, and at one end is spread out to form four legs. It also supports the lower flange, or cheek, of the winding. The four spaces have bundles of soft iron wire put in, so that the core is practically cylindrical. The cross-shaped core has been criticised on the ground that there are Foucault currents in it. The least consideration will show that there is no change of induction in it, and therefore no Foucault currents. The iron wire is bound tightly, and the two flanges are slipped into place. A gun-metal "spider" is then screwed to the top. It is finally held on by the eye-belt, but temporarily a set screw is used. The core is then wound in a special lathe in the usual way. Both the terminal board and the coil flanges gave us a great deal of trouble till we found suitable materials. There is a great need of good insulating materials that will not warp, that will insulate perfectly, and that can be worked.

The electrical particulars of a 50 8-candle-power lamp transformer are as follows:—

Core, 13·5in. long, 2·5in. diameter. In taking the area of the core, allowance must be made for the space occupied by the backbone, and for the loss of room in using round wires. Maximum induction, 4,800. Loss of power in iron, assuming it to be of good quality, 13·5 watts. Primary, 3,920 turns of copper wire, 0·042in. diameter; resistance, 37 ohms (warm). Secondary, 200 turns, 19/0·042in.; resistance, 0·098 ohm. Loss of power in primary at full load, due to the transformed current, 21 watts; loss due to the exciting current—0·3 ampere—which is always on, 3·6 watts; loss in secondary at full load, 22 watts. Efficiency at full load, 96·15.

This transformer is shown to scale in Figs. 9 and 10.

Digitized by Google

Fig. 11. is a scale drawing of a closed-circuit transformer I have taken as representative. The primary is 400 turns of 0·042in. wire, and the secondary 20 turns of 0·176in. The loss in copper at full load is 11·3 watts, and the loss in the iron 120 watts. At full load the efficiency is 91·95, or nearly 92 per cent. The diagram (Fig. 12) shows the percentage loss at various loads of the two transformers. The ordinates are percentage loss, and the abscissæ fractions of full load. Curve II. is the "Hedgehog," and IV. is the closed circuit. It will be noticed that the "Hedgehog's" efficiency increases slightly at first, and keeps above 95 per cent. till the load is reduced to one-fifth, and above 90 down to one-tenth load, and it then begins to fall more rapidly. The efficiency of the closed form, however, begins to fall at once, and falls rapidly. In house work the full-load efficiency is a matter of little or no consequence; the loss at very light loads is really important. A house that has a 50-light transformer is wired for 50 lamps, and that is a maximum load.

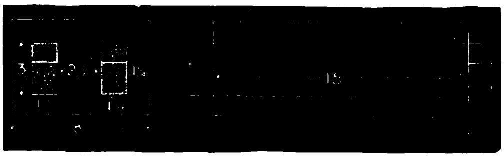
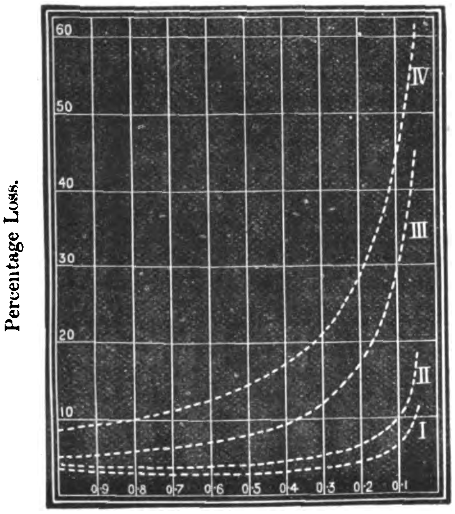


FIG. 11.

As a rule, there are seldom more than 25 lamps on at any one time, and these are on during the evening only. The average load varies with the time of year, and with the class of house. Shops, for instance, have full load for a short time each day; private houses have the lights in the hall and passages on the whole evening, with either the dining or drawing-room, and for some time both the dining and drawing-rooms are on. It will be a fair average if we take four hours of half-load per day as the output of house transformers. This means an efficiency of 83·3 per cent. for the "Hedgehog," and only 51 per cent. for the closed circuit. In other words, the waste in the closed circuit is between five and six times as great as in the open circuit.

It will, I have no doubt, be urged that various published tests have shown closed-circuit transformers to have efficiencies of, say, 95 per cent. I have elsewhere* examined some of these tests, and




Fractions of Full Load,

FIG. 12.

shown that, according to the figures given, the results can only be accounted for by the iron acting as freezing mixture, and supplying power to the transformer; the total loss given being in some cases less than the loss by copper resistance. In some other cases too few data are given, so that it is impossible to say how the figures are obtained. In order that an efficiency test can be taken as reliable it must contain full particulars of the transformer. It is then possible to see whether the supposed efficiency of 95 per cent. is due to the type of transformer, to inaccuracies in the measurements, or to phenomenal iron. Of course it is not impossible some one may discover phenomenal iron which will be the salvation of closed-circuit transformers, but it will have to be very good. In Fig. 12, Curve III. represents the loss in a closed-circuit transformer with phenomenal iron having a loss of only 60 watts, or half that taken in the example. The dotted curve (I.) belongs to the open-circuit transformer with the same quality of iron; for, of course, the phenomenal iron is available for both. It will be seen that the ratio of the percentage losses is sensibly the same, so that the open-circuit transformer is improved nearly as much as the closed. In the case taken of half-load for four hours a day, the loss in the closed circuit comes out more than four times that in the open, even without re-designing the "Hedgehog." There is thus no chance of iron being found good enough to allow the closed circuit-form to compete with the open. There is one objection to the "Hedgehog" which must not be passed over, and that is the exciting current. The exciting current in the 50-lighter is 0·31; in the closed circuit it is 0·2; so that it is quite half as much again. Moreover, if a better quality of iron is discovered it will lessen the exciting current in the closed circuit, but will make no perceptible difference in the open, unless it is re-designed. The exciting current does harm in two ways: it weakens the field of the dynamos at the central stations, and it gives rise to troubles in the station at light loads. For instance, if a station had 10 dynamos to run the full load, in the daytime three would be required to supply the exciting current, while in the closed circuit two would do. If the dynamos are direct-driven, this means three engines running light instead of two; and engines running light are very wasteful. These difficulties are, however, to a large extent imaginary. The weakening of the fields is, in ordinary working, counteracted by stronger excitation. Running three dynamos instead of two or one does not involve running three engines; the engine should be uncoupled and the dynamos run as idle motors, supplying the exciting current necessary for the transformers. In the future it is to be hoped that alternate motors will be used; and as they will be used chiefly during the times the load on the transformers is light, they will thus supply the exciting currents, and it will be unnecessary to run any idle dynamos. It must be remembered that the difference is only one of degree. Closed-circuit transformers have very considerable exciting currents; but it is most desirable to avoid any troubles, whichever kind is used. The solution of the difficulty lies in the employment of condensers. A condenser supplies the exciting current, so that the station dynamos supply a current sensibly proportional to the power used. Thus, in the daytime, with open-circuit transformers, a very small engine and dynamo will give all that is needed. More will be said about condensers presently.

*Distribution.*

Even with the most efficient transformers, the house system is a very poor method of distribution. Apart from the question of loss of power, consider the outlay involved in providing each consumer with a high-pressure double-pole fuse, a transformer, an automatic device for rendering the whole arrangement safe in case of insulation giving way, perhaps a double-pole main switch, a meter, and a fire-proof safe in which all these things have to be enclosed. In addition to this, it involves a complete high-pressure parallel system of distribution, and a network of 2,000-volt underground mains, involving a heavy outlay, and probably heavy depreciation. The adoption of sub-stations is generally regarded as the cure for all this. I believe no sub-station distribution is in use, or even in construction, in this country. The London Electric Supply Company are using sub-stations, but not in this way. These sub-stations merely transform from 10,000 to 2,500 volts, and the distribution itself is carried out by means of house transformers. The principle of sub-stations is that the town has a network of low-pressure mains, with low pressure feeders led to sub-stations. In each sub-station there are attendants who regulate the pressure in the network, as they have control of the feeders. The sub-station is supplied by high-pressure mains from the station, the power being transformed to low pressure at the sub-stations. There is, however, no need for sub-stations; the low-pressure network may be fed at various points by transformers and feeders coming direct from the station. These transformers need not be in houses or cellars; they can be placed conveniently in the ground in cases filled with insulating oil. The method of feeding into a low-pressure network was described in Mr. Kapp's Paper on transformers in 1888, and he referred to it as being in use on the Continent and in America. At the station each feeder can be regulated, and has a compound-wound voltmeter, so that an attendant can keep the pressure in the whole town constant. As Mr. Kapp pointed out, the advantage of such a system is enormous. In direct currents the low-pressure mains must be large. The great size needed for parallel distribution was pointed out at the time of the Electric Light Act of 1882, and Prof. Forbes afterwards went into the matter much more fully; but even now the enormous saving that can be effected by using small low-pressure mains fed at frequent intervals seems hardly to be realised.

In beginning in a new district it may be objected that the subscribers at first are so few that it does not pay to put down low-pressure mains. This would be true if alternate low-pressure had to be as large as direct-current mains. Without going into the cost of a particular case, it is probable that low-pressure mains large enough to supply any demand likely to arise for many years can be put down for little, if any, more than the high-pressure net

*"Induction, and other Things," *Electrical Review*, October, 1889.

Digitized by Google

work with its expensive insulation. Even in scattered districts it would generally pay to use small low-pressure mains and feeders. The alternate system has so many advantages over the direct in the matters of regulation and distribution, when worked on the low-pressure system, that it is astonishing that such arrangements are not utilised. For instance, with direct currents, it is most difficult to find a leak; and one leak on the positive at the west end, combined with one leak on the negative at the east, will cause serious trouble. With alternate currents, a number of small local networks may be used, each of them being complete in itself. It is not in metallic connection with any other part of the town, nor with the central station. Where it meets the network of the neighbouring district it is not metallically joined, as in the case of direct currents, but is connected through a one-to-one transformer sunk in the ground, in a case full of oil.

After the clear and able manner in which Mr. Kapp urged the advantages of low-pressure networks for alternating currents, it is most astonishing that engineers should go on with house transformers. With the low-pressure network system we have everything that can be wanted. Perfect regulation at every point throughout the town, small mains, inexpensive insulation, cheap and efficient plant, and—what is of importance in comparison with battery work—simple and inexpensive switch-boards. There is no trouble from general ground leak; and both arc and incandescent lighting can be done from same leads. The only thing wanting is storage; and to what extent is that really necessary, and what does it cost? It is significant that throughout America, where direct-current stations could have it for the asking, it is never used.

At present, however, we are using alternating currents in just about the worst way that could be possibly devised.

*Condensers.*

Condensers frequently figure in electric light literature, but they are only put forward as possible means for transforming currents. Direct currents and interrupters are generally discussed. Condensers may, however, have another very large opening in connection with ordinary alternate-current distribution. Take, for instance, the case of arc lamps. It is customary, whenever possible, to run arc lamps in long series with high pressures, generally with direct currents. In many cases such an arrangement is very convenient; but wherever there are incandescent lamps to be fed at the same places as the arcs, it is, of course, wasteful to run two sets of engines, dynamos, and leads. With direct currents this is sometimes necessary, for arc lamps in parallel do not burn well on 100-volt circuits, and must be used two at a time; and at 50 volts resistance is needed in series, which is wasteful. With alternate currents nothing is easier than to run lamps with choking coils. If the supply is high-pressure, each lamp can have its own transformer, and the transformer can be wound for nearly constant secondary current. Prof. E. Thomson has brought out several forms of constant-current transformer, and so has Mr. Tesla. The "Hedgehog" form, however, lends itself especially well; all that is necessary is winding the coils one at each end instead of one over the other. Whether the mains are high or low pressure, choking coils or constant-current transformers will give rise to large currents at the station, which will lower the output of the machines.

For instance, suppose a station supplies a 100-volt secondary circuit by means of transformers with 2,000 volts primary pressure; and suppose there are 200 arc lamps, each taking 33 volts and 10 amperes, arranged on the 100-volt circuit, with a choking coil in series with each. Suppose, for simplicity, that there are no incandescent lamps in use. The arc lamps then take 2,000 amperes and 100 volts; but this does not amount to more than 66,000 watts, as the current is not in step with the electromotive force. The dynamos thus have to supply 2,000 volts and 100 amperes; whereas the same power, if the current did not lag, would be supplied by 2,000 volts and 33 amperes. This gives rise to several troubles. Suppose each machine has an armature wound to give 2,000 volts and 33 amperes, or 66,000 watts, it takes three instead of one to work the lamps. In addition to this, the lagging of the current weakens the field of the dynamos, so that they need more excitation to give 2,000 volts than they would need even on full load on a non-inductive resistance. Moreover, running three engines and dynamos at a third load instead of one at full load is not economical. A condenser takes a current which leads relatively to the pressure, so that it counteracts the effect of the lagging current. The 100 amperes may be regarded as compounded of 33 amperes in step with the pressure, and 95 amperes lagging a quarter of a period. A condenser of about 85 microfarads will supply the 95-ampere component, while one dynamo supplies the 33 amperes really needed by the lamps. This reasoning holds good without the curve of sines assumption.

The use of condensers to overcome troubles arising from exciting or magnetising currents of closed or open circuit transformers has already been mentioned.

They may also be used to increase the output of dynamos. As already explained, even if a dynamo is worked on resistance, the cross induction causes the current to lag, and the back induction weakens the field. If a condenser is put in shunt to the terminals of the machine, its current strengthens the field again and increases the terminal pressure, and therefore the output. If the condenser is large enough, and if the armature actions are great enough, it might be possible to make a machine excite itself without any field winding at all. This action of a condenser on a dynamo may be equally easily explained on the self-induction theory. The difference between the two theories may be shown here, however. According to the self-induction theory, if the condenser is large enough to produce resonance—that is to say, when $(2\pi n)^2 LK = 1$ —the output increases till the current is as great as if the no-load pressure of the machine were short-circuited on the armature resistance. According to the armature reaction theory, the machine increases its field till the field-magnets become more saturated; in fact, the machine is like a direct-current shunt-wound dynamo which has a low-resistance shunt. I do not wish to go into this matter further here, for it might lead to a discussion of a rise in the Deptford mains—a subject which will be treated, I am informed, in a forthcoming Paper, and will certainly receive full justice at the hands of the authors.

The commercial manufacture of high-pressure condensers is not so easy as might be supposed. Knowing the difficulties there are in insulating leads and mains—in which thick insulation is permissible, and, in fact, advisable—it may be realised that to insulate many hundreds of square feet of metallic surface with the thinnest possible material is anything but an easy problem. In addition to being a good insulator, the dielectric must be free from "absorption." Some account of my work on condensers has lately been given.* Mr. W. F. Bourne, who has carried out all the experiments, has tried almost every conceivable kind of dielectric, and finds a kind of paper called "butter-skin," soaked in paraffin oil, the best material. It is curious that this particular kind of paper is specially made so as to be grease-proof. Some kinds of bank post paper worked nearly as well, but it is too expensive for commercial use. It seems as if the paper must be relied upon for insulation, not the paraffin. The condensers are simple cast-iron boxes containing numbers of sheets of paper and tinfoil. Lids are fitted on and made tight.

*Town Lighting.*

Alternate arc lamps have already been discussed to some extent. In some places, especially in small towns, it is usual to have special circuits for the town lighting, which are shut off during the day. It is needless to point out that if the low pressure network is used, condensers at the station allow arc lamps to be run with choking coils, and incandescent lamps can be run direct, and it is no more necessary to run special mains for the street lighting than it is needful to put down two sets of gas pipes in a town. Sometimes, however, high-pressure mains are used. Each arc lamp can then have its own constant-current transformer. If incandescent lamps are used, the plan generally adopted is using a transformer for every 10 or 20 lamps. If the wires are underground, this involves great expense; and if overhead, it means both expense and unsightliness. A small "Hedgehog" transformer has been designed to meet this particular want. It is so small that it can be worked into the design of the lamp-holder or shade, and one can be used for each lamp.

In America alternating arc lamps are run in series, with a series transformer for each. This arrangement is quite unnecessary for places where there is incandescent lighting too. It has the advantage of allowing series arcs without bringing high pressures into the lamps. It has no other advantage over direct series lighting. The dynamo used by the Westinghouse Company is made to give nearly constant current. This is a barbarous arrangement. It is a reversion to the old alternating machines of 10 years ago, which gave approximately constant current. All that is needed is great armature reaction, and hence a large machine for the output. The economical way of getting constant current is to use a good dynamo, and to take the governor off the engine, or to use it as a safeguard against racing only. If the Westinghouse machine has only quarter load on, it still goes at full speed, using nearly full steam, and wearing everything out. With a constant-pressure dynamo it would run at quarter speed, each cylinderful of steam being used economically and being expanded properly. To put a constant-speed governor on the engine, and then to design a special dynamo to get over the difficulties you have introduced, is a very common proceeding with direct-current arcs also.

Alternating constant currents have, however, one advantage over direct that I think is not realised. Synchronising motors will run perfectly on series constant-current circuits; and as they run at constant speed, there is no racing, or trouble about governing, as in the case of direct currents. Of course, constant speed of engine is here necessary to give constant frequency. Many people seem to have gathered from Dr. Hopkinson's Paper that series alternating motors will not run; but this is a false inference.

* *Phil. Mag.*, February, 1891.

Digitized by Google

## PHENOMENA OF ALTERNATING CURRENTS OF VERY HIGH FREQUENCY.*

BY NIKOLA TESLA.

Among his many experiments Prof. Crookes shows some performed with tubes devoid of internal electrodes, and from his remarks it must be inferred that the results obtained with these tubes are rather unusual. If this be so, then the writer must regret that Prof. Crookes, whose admirable work has been the delight of every investigator, should not have availed himself in his experiments of a properly constructed alternate-current machine—viz., one capable of giving say, 10,000 to 20,000 alternations per second. His researches on this difficult but fascinating subject would then have been even more complete. It is true that when using such a machine in connection with an induction coil the distinctive character of the electrodes—which is desirable, if not essential, in many experiments is lost, in most cases both the electrodes behaving alike ; but, on the other hand, the advantage is gained that the effects may be exalted at will. It is possible to obtain excessively high electromotive forces in the secondary circuit with a comparatively small primary current ; moreover, the perfect regularity in the working of the apparatus may be relied upon.

The writer will incidentally mention that anyone who attempts for the first time to construct such a machine will have a tale of woe to tell. He will first start out, as a matter of course, by making an armature with the required number of polar projections. He will then get the satisfaction of having produced an apparatus which is fit to accompany a thoroughly Wagnerian opera. It may, besides, possess the virtue of converting mechanical energy into heat in a nearly perfect manner. If there is a reversal in the polarity of the projections, he will get heat out of the machine ; if there is no reversal, the heating will be less, but the output will be next to nothing. He will then abandon the iron in the armature, and he will get from the Scylla to the Charybdis. He will look for one difficulty and will find another, but, after a few trials, he may get nearly what he wanted.

Among the many experiments which may be performed with such a machine, of not the least interest are those performed with a high-tension induction coil. The character of the discharge is completely changed. The arc is established at much greater distances, and it is so easily affected by the slightest current of air that it often wriggles around in the most singular manner. It usually emits the rhythmical sound peculiar to the alternate current arcs, but the curious point is that the sound may be heard with a number of alternations far above 10,000 per second, which by many is considered to be about the limit of audition. In many respects the coil behaves like a static machine. Points impair considerably the sparking interval, electricity escaping from them freely, and from a wire attached to one of the terminals streams of light issue, as though it were connected to a pole of a powerful Toepler machine. All these phenomena are, of course, mostly due to the enormous differences of potential obtained. As a consequence of the self-induction of the coil and the high frequency, the current is minute, while there is a corresponding rise of pressure. A current impulse of some strength started in such a coil should persist to flow no less than four ten-thousandths of a second. As this time is greater than half the period it occurs that an opposing electromotive force begins to act while the current is still flowing. As a consequence, the pressure rises as in a tube filled with liquid and vibrated rapidly around its axis. The writer's experiences tend to show that the higher the frequency the greater the amount of electrical energy which may be passed through the body without serious discomfort ; whence it seems certain that human tissues act as condensers.

Experiments with Geissler tubes are of special interest. An exhausted tube, devoid of electrodes of any kind, will light up at some distance from the coil. If a tube from a vacuum pump is near the coil the whole of the pump is brilliantly lighted. An incandescent lamp approached to the coil lights up and gets perceptibly hot. If a lamp have the terminals connected to one of the binding posts of the coil and the hand is approached to the bulb, a very curious and rather unpleasant discharge from the glass to the hand takes place, and the filament may become incandescent. The discharge resembles to some extent the stream issuing from the plates of a powerful Toepler machine, but is of incomparably greater quantity. The lamp in this case acts as a condenser, the rarefied gas being one coating, the operator's hand the other. By taking the globe of a lamp in the hand, and by bringing the metallic terminals near to or in contact with a conductor connected to the coil, the carbon is brought to bright incandescence and the glass is rapidly heated. With a 100-volt 10 candle-power lamp one may without great discomfort stand as much current as will bring the lamp to a considerable brilliancy ; but it can be held in the hand only for a few minutes, as the glass is heated in an incredibly short time. When a tube is lighted by bringing it near to the coil, it may be made to go out by interposing a metal plate or the hand between the coil and tube ; but if the metal plate be fastened to a glass rod or otherwise insulated, the tube may remain lighted if the plate be interposed, or may even increase in luminosity. The effect depends on the position of the plate and tube relatively to the coil, and may be always easily foretold by *assuming* that conduction takes place from one terminal of the coil to the other. According to the position of the plate, it may either divert from or direct the current to the tube.

In another line of work the writer has in frequent experiments maintained incandescent lamps of 50 or 100 volts burning at any desired candle-power with both the terminals of each lamp connected to a stout copper wire of no more than a few feet in length. These experiments seem interesting enough, but they are not more so than the queer experiment of Faraday, which has been revived and made much of by recent investigators, and in which a discharge is made to jump between two points of a bent copper wire. An experiment may be cited here which may seem equally interesting. If a Geissler tube, the terminals of which are joined by a copper wire, be approached to the coil, certainly no one would be prepared to see the tube light up. Curiously enough it does light up, and, what is more, the wire does not seem to make much difference. Now one is apt to think in the first moment that the impedance of the wire might have something to do with the phenomenon. But this is of course immediately rejected, as for this an enormous frequency would be required. The result, however, seems puzzling only at first ; for upon reflection it is quite clear than the wire can make but little difference. It may be explained in more than one way, but it agrees perhaps best with observation to assume that conduction takes place from the terminals of the coil through the space. On this assumption, if the tube with the wire be held in any position, the wire can divert little more than the current which passes through the space occupied by the wire and the metallic terminals of the tube ; through the adjacent space the current passes practically undisturbed. For this reason, if the tube be held in any position at right angles to the line join the binding posts of the coil, the wire makes hardly any difference, but in a position more or less parallel with that line, it impairs to a certain extent the brilliancy of the tube and its facility to light up.

It is well to take certain precautions when operating a Ruhmkorff coil with very rapidly alternating currents. The primary current should not be turned on too long, else the core may get so hot as to melt the gutta-percha or paraffin, or otherwise injure the insulation, and this may occur in a surprisingly short time, the current's strength considered. The primary current being turned on, the fine wire terminals may be joined without great risk, the impedence being so great that it is difficult to force enough current through the fine wire so as to injure it, and in fact the coil may be on the whole much safer when the terminals of the fine wire are connected than when they are insulated ; but special care should be taken when the terminals are connected to the coating of a Leyden jar with anywhere near the critical capacity.

The limit of audition of an arc depends on its size. The greater the surface by a given heating effect in the arc the higher the limit of audition. The highest notes are emitted by the high tension discharges of an induction coil in which the arc is, so to speak, all surface. If R be the resistance of an arc, and C the current, and the linear dimensions be $n$ times increased, then the resistance is $\frac{R}{n}$, and with the same current density the current would be $n^2C$; hence the heating effect is $n^3$ times greater, while the surface is only $n^2$ times as great. For this reason very large arcs would not emit any rhythmical sound even with a very low frequency. It must be observed, however, that the sound emitted depends to some extent also on the composition of the carbon. If the carbon contain highly refractory material, this when heated tends to maintain the temperature of the arc uniform, and the sound is lessened ; for this reason it would seem that an alternating arc requires such carbons. With currents of such high frequencies it is possible to obtain noiseless arcs, but the regulation of the lamp is rendered extremely difficult on account of the excessively small attractions or repulsions between conductors conveying these currents. An interesting feature of the arc produced by these rapidly alternating currents is its persistency. There are two causes for it, one of which is always present, the other sometimes only. One is due to the character of the current, and the other to a property of the machine. The first cause is the more important one, and is due directly to the rapidity of the alternations. The heating effect is practically continuous and the arc behaves like one produced by a continual current, with the exception, however, that it may not be quite as easily started, and that the electrodes are equally consumed, though the writer has observed some irregularities in this respect.

The second cause alluded to, which possibly may not be present, is due to the tendency of a machine of such high frequency to maintain a practically constant current. When the arc is lengthened the electromotive force rises in proportion, and the arc appears

* Abstract from the *Electrical World* of New York.

Digitized by Google

to be more peristent. Such a machine is eminently adapted to maintain a constant current, but it is very unfit for a constant potential. As a matter of fact, in certain types of such machines a nearly constant current is an almost unavoidable result. As the number of poles or polar projections is greatly increased, the clearance becomes of great importance. One has really to do with a great number of very small machines. Then there is the impedence in the armature, enormously augmented by the high frequency. Then, again, the magnetic leakage is facilitated. If there are three or four hundred alternate poles the leakage is so great that it is virtually the same as connecting in a two-pole machine the poles by a piece of iron. This disadvantage, it is true, may be obviated more or less by using a field throughout of the same polarity, but then one encounters difficulties of a different nature. All these things tend to maintain a constant current in the armature circuit.

In this connection it is interesting to notice that even to-day engineers are astonished at the performance of a constant-current machine, just, as some years ago, they used to consider it an extraordinary performance if a machine was capable of maintaining a constant potential difference between the terminals. Yet one result is just as easily secured as the other. It must only be remembered that in an inductive apparatus of any kind, if constant potential isrequired, the inductive relation between the primary or exciting and secondary or armature circuit must be the closest possible; whereas, in an apparatus for constant current just the opposite is required. Furthermore, the opposition to the current's flow in the induced circuit must be as small as possible in the former and as great as possible in the latter case. But opposition to a current's flow may be caused in more than one way. It may be caused by ohmic resistance or self-induction. One may make the induced circuit of a dynamo machine or transformer of such high resistance than when operating devices of considerably smaller resistance within very wide limits a nearly constant current is maintained. But such high resistance involves a great loss in power, hence it is not practicable. Not so self-induction. Self-induction does not necessarily mean loss of power. The moral is, use self-induction instead of resistance. There is, however, a circumstance which favours the adoption of this plan, and this is, that a very high self-induction may be obtained cheaply by surrounding a comparatively small length of wire more or less completely with iron, and furthermore, the effect may be exalted at will by causing a rapid undulation of the current. To sum up, the requirements for constant current are:—Weak magnetic connection between the induced and inducing circuits, greatest possible self-induction with the least resistance, greatest practicable rate of change of the current. Constant potential, on the other hand, requires: Closest magnetic connection between the circuits, steady induced current, and, if possible, no reaction. If the latter conditions could be fully satisfied in a constant potential machine, its output would surpass many times that of a machine primarily designed to give constant current. Unfortunately, the type of machine in which these conditions may be satisfied is of little practical value, owing to the small electromotive force obtainable and the difficulties in taking off the current.

With their keen inventor's instinct, the now successful arc-light men have early recognised the desiderata of a constant current machine. Their arc-light machines have weak fields, large armatures, with a great length of copper wire and few commutator segments to produce great variations in the current's strength and to bring self-induction into play. Such machines may maintain within considerable limits of variation in the resistance of the circuit a practically constant current. Their output is of course correspondingly diminished, and, perhaps, with the object in view not to cut down the output too much, a simple device compensating exceptional variations is employed. The undulation of the current is almost essential to the commercial success of an arc-light system. It introduces in the circuit a steadying element taking the place of a large ohmic resistance, without involving a great loss in power, and, what is more important, it allows the use of simple clutch lamps, which, with a current of a certain number of impulses per second, best suitable for each particular lamp, will, if properly attended to, regulate even better than the finest clockwork lamps. This discovery has been made by the writer—several years too late.

It has been asserted by competent English electricians that in a constant-current machine or transformer the regulation is effected by varying the phase of the secondary current. That this view is erroneous may be easily proved by using, instead of lamps, devices each possessing self-induction and capacity or self-induction and resistance—that is, retarding and accelerating components—in such proportions as to not affect materially the phase of the secondary current. Any number of such devices may be inserted or cut out, still it will be found that the regulation occurs, a constant current being maintained, while the electromotive force is varied with the number of the devices. The change of phase of the secondary current is simply a result following from the changes in resistance, and, though secondary reaction is always of more or less importance, yet the real cause of the regulation lies in the existence of the conditions above enumerated. It should be stated, however, that in the case of a machine the above remarks are to be restricted to the cases in which the machine is independently excited. If the excitation be effected by commutating the armature current, then the fixed position of the brushes makes any shifting of the neutral line of the utmost importance, and it may not be thought immodest of the writer to mention that, as far as records go, he seems to have been the first who has successfully regulated machines in providing a bridge connection between a point in the external circuit and the commutator by means of a third brush. Tht armature and field being properly proportioned and the brushes placed in their determined positions, a constant current or constant potential resulted from the shifting of the diameter of commutation by the varying loads.

In connection with machines of such high frequencies, the condenser affords an especially interesting study. One experiment performed three or four months ago with such a machine and a condenser may serve as illustration. A machine was used giving about 20,000 alternations per second. Two bare wires of about 20ft. long and two millimetres diameter, in close proximity to each other, were connected to the terminals of the machine on the one end, and to a condenser on the other. A small transformer without an iron core, of course, was used to bring the reading within the range of a Cardew voltmeter by connecting the voltmeter to the secondary. On the terminals of the condenser the electromotive force was about 120 volts, and from there inch by inch it gradually fell until on the terminals of the machine it was about 65 volts. It was virtually as though the condenser were a generator, and the line and armature circuit simply a resistance connected to it. The writer looked for a case of resonance, but he was unable to augment the effect by varying the capacity very carefully and gradually or by changing the speed of the machine. A case of pure resonance he was unable to obtain. When a condenser was connected to the terminals of the machine—the self-induction of the armature being first determined in the maximum and minimum position and the mean value taken—the capacity which gave the highest electromotive force corresponded most nearly to that which just counteracted the self-induction with the existing frequency. If the capacity was increased or diminished the electromotive force fell as expected. With frequencies as high as the above-mentioned, the condenser effects are of enormous importance. The condenser becomes a highly efficient apparatus capable of transferring considerable energy.

The writer has thought that machines of high frequencies may find use at least in cases when transmission at great distances is not contemplated. The increase of the resistance may be reduced in the conductors and exalted in the devices when heating effects are wanted, transformers may be made of higher efficiency and greater outputs and valuable results may be secured by means of condensers. In using machines of high frequency, the writer has been able to observe condenser effects which would have otherwise escaped his notice. He has been very much interested in the phenomenon observed on the Ferranti main which has been so much spoken of. Opinions have been expressed by competent electricians, but up to the present all still seems to be conjecture. Undoubtedly in the views expressed the truth must be contained, but as the opinions differ some must be erroneous. Upon seeing the diagram of M. Ferranti in *The Electrician* of December 19th the writer has formed his opinion of the effect. In the absence of all the necessary data, he must content himself to express in words the process which, in his opinion, must undoubtedly occur. The condenser brings about two effects. (1) It changes the phases of the currents in the branches; (2) it changes the strength of the currents. As regards the change in phase, the effect of the condenser is to accelerate the current in the secondary at Deptford and to retard it in the primary at London. The former has the effect of diminishing the self-induction in the Deptford primary, and this means lower electromotive force on the dynamo. The retardation of the primary at London, as far as merely the phase is concerned, has little or no effect, since the phase of the current in the secondary in London is not arbitrarily kept. Now, the second effect of the condenser is to increase the current in both the branches. It is immaterial whether there is equality between the currents or not; but it is necessary to point out, in order to see the importance of the Deptford step-up transformer, that an increase of the current in both the branches produces opposite effects. At Deptford it means further lowering of the electromotive force at the primary, and at London it means increase of the electromotive force at the secondary. Therefore, all the things co-act to bring about the phenomenon observed. Such actions, at least, have been formed to take place under similar conditions. When the dynamo is connected directly to the main, one can see that no such action can happen.

The writer cannot believe in the armature-reaction theory as expressed in *Industries*, though undoubtedly there is some truth in it. Mr. Swinburne's interpretation, however, is so broad that it may mean anything. Mr. Swinburne seems to have been the first who has called attention to the heating of the condensers. In the

Digitized by Google

opinion of the writer, the heating of the condensers is due to three distinct causes: first, leakage or conduction; second, imperfect elasticity in the dielectric, and, third, surging of the charges in the conductor.

In many experiments he has been confronted with the problem of transferring the greatest possible amount of energy across a dielectric. For instance, he has made incandescent lamps, the ends of the filaments being completely sealed in glass, but attached to interior condenser coatings, so that all the energy required had to be transferred across the glass with a condenser surface of no more than a few centimetres square. Such lamps would be a practical success with sufficiently high frequencies. With alternations as high as 15,000 per second it was easy to bring the filaments to incandescence. With lower frequencies this could also be effected, but the potential difference had, of course, to be increased. The writer has then found that the glass gets, after a while, perforated and the vacuum is impaired. The higher the frequency the longer the lamp can withstand. Such a deterioration of the dielectric always takes place when the amount of energy transferred across a dielectric of definite dimensions and by a given frequency is too great. Glass withstands best, but even glass is deteriorated. In this case the potential difference on the plates is of course too great, and losses by conduction and imperfect elasticity result. If it is desirable to produce condensers capable to stand great differences of potential, then the only dielectric which will involve no losses is a gas under pressure. The writer has worked with air under enormous pressures, but there are a great many practical difficulties in that direction. He thinks that, in order to make the condensers of considerable practical utility, higher frequencies should be used, though such a plan has besides others the great disadvantage that the system would become very unfit for the operation of motors.

## PARLIAMENTARY INTELLIGENCE.

### Central London Railway Bill.

BILL BEFORE THE HOUSE OF COMMONS SELECT COMMITTEE.

On Tuesday the Central London Railway Bill, which provides for the construction of an electric railway from Shepherd's Bush to Cornhill, E.C., came before a Select Committee of the House of Commons, consisting of Mr. Hanbury (Chairman), Mr. Barran, Mr. Gane and Mr. F. Parker. There were 27 petitions against the Bill.

The counsel for the promoters were Mr. Pember, Q.C., Mr. Saunders, Q.C., Mr. Freeman and Mr. Munro. The leading opponents with their counsel were as follows:—The Corporation of London, Mr. Littler, Q.C., and Mr. Rigg; the Commissioners of Sewers for the City of London, Mr. Russell Griffiths; the Ecclesiastical Commissioners, the London County Council, Mr. Pope, Q.C.; owners, &c., in Cornhill and Cheapside, and various local authorities, lessees and occupiers on the line of the proposed railway.

Mr. PEMBER, in opening the case for the promoters, said this was a very important measure which now came before Parliament for a second time. Last year it passed the House of Commons, but was lost in the House of Lords, and it was no secret that the ground upon which it was thrown out was that their lordships thought it was a year too soon. At that time they had had no experimental working of the City and South London Railway, and their lordships thought that under all the circumstances the Bill might very well stand over for another year. The object of the Bill was to enable the construction of an electric railway from Shepherd's Bush via Lansdown-road, Notting Hill Gate, Queen's-road, Westbourne, Marble Arch, Davies-street, Oxford Circus, Tottenham Court-road, Bloomsbury, Chancery-lane, Newgate-street, to Cornhill. At the terminus at Shepherd's Bush the promoters proposed to purchase a piece of land for the erection thereon of what was known as the generating plant. Last year the Bill proposed that the line should stop at Queen's-road, and that the generating plant should be put up there. No doubt the generating station in that case would have been erected in the midst of some largely valuable property, and certain members of the Committee by which the Bill was considered were a little anxious as to the effect of the erection of the plant in such a neighbourhood. That difficulty was got rid of under the present Bill by the proposal to erect the plant at Shepherd's Bush. The line last year was 4½ miles in length, but now it was 6 miles. The line would be, on an average, about 50ft. below surface. It rose to a higher level at one or two places, while at others it would be between 70 and 80ft. down in the London clay. The capital of the Bill was £3,600,000, being £2,700,000 in shares and £900,000 by borrowing powers. The proposed railway did precisely that which neither of the underground railways did, it tapped a great business thoroughfares. In addition to that there would be no such nuisance as that which arose from the smoke and noise on the underground lines during working hours. The deep level of the line would avoid any disfigurement of the streets. The sites for the 13 different stations, which would be erected at intervals of something less than half a mile, would be excavated first. Then the boring operations would begin at all the 13 stations, and the soil removed by those operations would be brought to the surface and carried away. There would be no noise or vibration, and there would be no blow-holes, because the railway would be worked by electricity. There would be two tunnels, one containing the up and the other the down line. The tunnels would be perfectly distinct, and consequently each train, as it passed through, would make its ventilation. Each tunnel would be 11ft. 6in. in diameter internally. Access to the platforms would be obtained by means of stairs and hydraulic lifts. They would be able to attain a maximum speed of 25 miles an hour, but including stoppages they would be able to do the journey at the rate of 15 miles an hour, or about 25 per cent. quicker than the speed of the trains on the Inner Circle Railway. The journey from the Marble Arch to the Bank—the best portion of the distance—would be performed in about a quarter of an hour. There was no doubt that this Bill was needed. In 1867 the London General Omnibus Company carried 42,000,000 passengers and the Metropolitan Railway Company 11,000,000; but in 1889 the former carried 104,000,000 and the latter 82,000,000. In the same year the District Railway Company carried 34,000,000, the London Road Car Company 15,000,000, and the tramways 169,000,000, bringing up the total number of passengers carried in 1889 to no less than 407,000,000, as against 53,000,000 carried 25 years ago. Last year there were 37 petitions against the Bill, but this year that number has been reduced to 27. Amongst the petitioners were the Westminster Electric Supply Company, who alleged that their generating works would be injured by the operations of the promoters in the neighbourhood of Oxford-street. The railway was undoubtedly one for Londoners. It would be similar to that which was recently opened in South London—the motive power, the tunnels and the stations would be precisely similar. The City and South London Railway at present ran only from the City to Stockwell. It was three miles in length, and at present it had only a six minutes' service with three cars. It had no middle-day traffic worth the name, and yet from December 18th to about the same date in February it carried over 900,000 passengers. That showed, at all events, that the system of electrical traction was an undoubted success. While no doubt there had been small hitches, nothing had occurred to wreck the confidence which the promoters of the Bill had last year in the success of electrical traction. One of the results of the success was that the City and South London had found that their rolling stock was insufficient, and that they ought to have a three minutes' instead of a six minutes' service. People could not get in at intermediate stations because the trains from Stockwell to the City, and *vice versa*, were full when they arrived. There was no doubt that the City and South London Company would double their traffic as soon as they could get sufficient rolling stock. The promoters intended to construct larger tunnels and stations than those on the City and South London line, and to make their carriages more commodious, and they would probably have a two minutes' service. He (the learned counsel) intended to call evidence to show that the cost of electrical traction would be at least as cheap, if not cheaper, than steam, and that the promoters were financially able to carry out their scheme. With regard to the claim that the promoters ought to pay compensation for the subsoil, he maintained that they ought not to be called upon to pay more than a public authority whose duty it was to lay down sewers. If such a clause were introduced into the Bill, the scheme would not go on.

Mr. J. H. GREATHEAD, M.I.C.E., consulting engineer of the City and South London Railway Company, stated that jointly with Sir John Fowler and Sir Benjamin Baker he was engineer of the proposed railway. He had given great attention to a system of boring underground for many years. The main object of the Bill was to afford better facilities for travelling between the western portion of London and the City. The main line of railway was from Shepherd's Bush to Cornhill, but there was a short line from Shepherd's Bush down Caxton-street to the depôt. The short line consisted of a single tunnel, which would not be used by the public. The proposed line was nearly straight, and its worst curve was at the junction of Cheapside and Newgate-street. The worst gradient against the load was 1 in 100. Last year the worst gradient was 1 in 58, and that on the City and South London was 1 in 30. From Notting Hill Gate to Tottenham Court-road the line was absolutely level. Cornhill station was between Cornhill and Lombard-street, and access to that station would be obtained from Change Alley. He was confident that the depths shown on the plans would enable the tunnels to be fixed down in the London clay. He had made a number of borings from time to time along the route of the proposed line, and he had come to the conclusion that the line would be well down in the London clay. The witness then proceeded to explain to the Committee by means of a model how the clay would be cut out and the tunnels fixed. He said the method of boring would be the same as was adopted in constructing the tunnels from the City to Stockwell. After a piece of clay had been cut out an iron ring would be at once placed in the aperture, and in that way a continuous tube was formed.

Mr. BARRAN: What prevents corrosion?—The iron is dipped into a composition of tar while it is hot, and that forms a sort of black varnish over the top.

WITNESS, continuing, said the iron would be protected from any action of the atmosphere both inside and out. The experience he acquired during the construction of the City and South London Railway would be of great value to him in constructing the proposed new line. Some little damage had been done on the City and South London Railway near the stations, and therefore the promoters had resolved to construct their stations in tunnels. There was a great advantage in having two separate tunnels. They secured perfect ventilation by the mere movement of the train, the carriage acting as a kind of piston in a cylinder. The tunnels would be entirely free from soil evaporation, and, therefore, dry. That was his experience on the City and South London Railway. The carriages would be constructed in the same manner as those on the City and South London Railway, the doors being at the end instead of at the side of the carriage. It was estimated that a train would seat about 336 passengers, whilst on the City and South London line they only carried 96 passengers per train. On the proposed line it was intended to have two classes of passengers. The motive power was to be electricity,

Digitized by Google

which would be generated at the depôt at Shepherd's Bush, and carried by a main conductor throughout the entire length of the two tunnels.

The CHAIRMAN: Is the depôt above or under ground?—Above.

WITNESS, continuing, said that in addition to the main conductor there was what was called the working conductor, or naked conductor, from which the locomotives could obtain the current.

Have you any doubt whatever that electricity will prove at least as efficient a motive power on this line as it has on the City and South London line?—I have no doubt whatever that electricity will work very well indeed.

Are you satisfied with your experience in South London?—Yes, it has worked very satisfactorily.

WITNESS, continuing, said that access to the platforms would be obtained by means of stairs and by hydraulic lifts. The hydraulic power would be generated at Shepherd's Bush. On the City and South London line the lifts had worked extremely well. The total costs of the works, including the purchase of land, was estimated at £2,173,515. To that amount must be added £600,000 for equipment, such as carriages and electrical and hydraulic plant. It would be possible to run a two minutes' service on the proposed line. The average speed of the trains would be between 14 and 15 miles an hour, including stoppages. The rate of speed would be from 20 to 25 per cent. better than that on the Inner Circle Railway. The whole distance between Shepherd's Bush and the Exchange would be covered in 25 minutes. The figures given by Mr. Pember with reference to the traffic in London were correct. On the City and South London line there had been about twenty stoppages in two months, and the longest stoppage was for an hour and a half. As a rule, stoppages had been for a few minutes.

The CHAIRMAN: Have stoppages arisen through a defect in the system which can be got over? Yes, and they have been overcome. I am satisfied with the system, which is perfectly workable, and will go on working satisfactorily.—Were there more stoppages during the first month than in the second? There were. There is nothing in the system to prevent it from becoming a complete success.

By Mr. POPE: He had not heard that the main of the South Metropolitan Gas Company had sunk near Kennington Church. It was not intended to have any brick tunnels. The line was no doubt a purely metropolitan scheme. If this railway failed as an electric railway it would be useless for anything else. It could not be used by another railway company.

Mr. BARRAN: May it not be used as a rope railway if it failed as an electric railway?—Certainly.

Mr. POPE: Why did you abandon the rope railway in South London?—Because we thought that an electric railway would be better. I do not think the County Council ought to have the right to purchase the railway.

By Mr. BIDDER: The length of the proposed line was double that of the City and South London Railway, and therefore it would be necessary to have a more expensive conductor to convey the electricity. In two months 900,000 passengers were carried on the City and South London line. Does that number include those who went over the line to see the system?—I believe the number was made up from the amount received. Then the gross takings have been about £900 a week?—No; between £700 to £800. On the City and South London line they have the turnstile system without tickets. If you have two classes of passengers what becomes of that system?—There must be a modification of it.

By the CHAIRMAN: The estimate of £600,000 for equipment was for a three minutes' service.

By Mr. RUSSELL GRIFFITHS: On the City and South London line the hydraulic lifts were more than sufficient to take down the passengers; but the train service on that line was not sufficient to carry the traffic. On the proposed line there would be more accommodation for passengers.

Re-examined by Mr. SAUNDERS: You cannot tell us what portion of the cost of equipment is for electricity?—No; not without making an elaborate calculation. I am perfectly satisfied that we have ascertained the efficiency of the different machines. How much do you lose by leakage on the City and South London Railway?—One horse power. On that line have the original calculations been fulfilled as regards power?—The power is ample. The amount of power required is less than we reckoned for. Do you think that your calculations as to the amount of power required for the proposed line are also likely to be verified?—Yes. Is it a fact that in consequence of the crowd coming from Stockwell in the morning you cannot, on the South London Railway, take up passengers at the other stations?—Yes; and the same thing occurs in the evening when the people return from the City.

The CHAIRMAN: Why don't you run oftener?—We have not sufficient equipment yet. We desired to see how the experiment worked before we ordered more stock.

Mr. SAUNDERS: Have you ordered new carriages?—Yes, and new locomotives as well. The stoppages or hitches on the South London Railway have not been sufficient to deter people from using the railway?—No.

The further hearing was adjourned till the following day.

### WEDNESDAY, MARCH 4TH.

SIR BENJAMIN BAKER, one of the engineers of the proposed railway, and consulting engineer to the City and South London Railway Company, said that he had not the slightest doubt that the proposed railway would work advantageously. After a great deal of consideration the engineers decided that the only way of carrying an underground railway through the heart of London was to take it entirely clear of all the sewers, and to construct it without interfering with the road traffic. He was convinced that the proposed railway could be constructed without any damage to the surrounding buildings.

After a careful consideration of the line do you say it can be safely and well worked by electricity as proposed?—Yes. Last year it was said by our opponents that experience was adverse to us; therefore when I went to America last autumn I took care to satisfy myself as to what really was American experience. I found that experience in America was entirely in our favour, and I challenge our opponents to repeat what they said last year with regard to American experience.

Have you found that experience confirmed by the working of the City and South London line?—I have. After taking into consideration what the train service should be—a three minutes' service; what the speed should be—an average of 14 miles per hour; and what the traffic is likely to be, I calculated what electrical horse-power would be required to work the line satisfactorily. I came to the conclusion that to perform the journey from Shepherd's Bush to the City and back again in an hour, including stoppages, we should require one electrical horse-power for each ton weight of trains on the line. As we shall require 18 trains on the line to perform the three minutes' service, and each train will be 120 tons weight, we shall require 2,160 electrical horse-power. I find that Dr. Hopkinson has made a similar calculation on the basis of the actual results obtained on the City and South London Railway, and has arrived at the conclusion that 1,800 electrical horse-power only will be required. The fact is that the experience on the City and South London Railway showed that we are 10 per cent. better than the evidence we gave last year. The experience in America is confirmatory of that also.

Allowing for the extra weight of trains to be drawn on this line, the extra length of the line and other circumstances, have you the smallest doubt that electricity will work the system proposed by the Bill?—No one can entertain any doubt about it. At present there are nearly 2,000 miles of electrical railway in the United States, and I have often travelled upon some of the lines. I have travelled on some of the fastest lines, such as that on the outskirts of Boston, and on some of the steepest, such as that at Richmond, Virginia. The gradients on the proposed line are easy, and the curves are not so severe as they are on the City and South London. That is a reason why we can travel 25 per cent. quicker than the Inner Circle Railway.

Do you think there will be any difficulty in working a two-minutes' service if required?—No.

Have you any doubt that this line will not only be able to take the passengers, but to obtain them?—I have no doubt at all about that.

Have you considered the question whether this will be a remunerative line?—Yes, I have no doubt about that.

Mr. CRIPPS said the complaints of the Westminster Electric Light Company would probably be arranged, and therefore he did not propose to cross-examine the witness.

Mr. SAUNDERS, in reply to the Chairman, said that while the promoters would not be liable for damage arising from working the railway, they would be liable for any injury caused by the construction.

Dr. JOHN HOPKINSON stated he knew last year precisely what the results of the London Railway would be, and the working of the line has confirmed his then views.

Have you been using the full pressure on that line?—Occasionally. The pressure has varied from 400 to 500 volts. The average has been about 400.

There have been a certain number of hitches in working the line. Have they been due to the electrical portion of the system?—Some of them have.

Have the hitches been reduced in number?—Yes. The hitches in connection with the electrical plant have been small. One stoppage, for instance, was due to a nut of one of the motors becoming loose, and jamming the machine. We have had some hitches due to the inexperience of the drivers. We have had to educate nearly 40 drivers, who had never been on an electrical locomotive before.

Nothing has occurred to check your confidence in the practical use of electricity as a motive power?—Absolutely nothing.

Can you give us the total cost of working?—No.

Have you heard of anything to shake your confidence that the railway can be worked as cheaply as you supposed it could be?—No; everything confirms that view.

Are the circumstances of the proposed new railway in some respects more advantageous than those of the City and South London Railway for electrical work?—Yes. It is a longer line, the trains are more frequent, and the trains are heavier, the gradients are less severe, and the curves are not so sharp. All these points are in favour of the proposed line.

You propose to work the line at 500 volts as a maximum pressure?—Yes.

Have you made an estimate of the total cost of the plant, the generating engines, and other machinery?—Yes.

Have you also made an estimate of the cost of working the trains?—Yes.

What is your estimate?—According to my estimate the working will cost 8$\frac{1}{10}$ths of a penny per train mile. Ninepence per mile would be a superior limit of the cost of running these trains.

Cross-examined by Mr. POPE: How is it that you have not been able to apply electric power to locomotive engines?—Do you mean for ordinary traffic?

Yes.—There the case is not so advantageous as it is here. It could be done, but the costs in comparison with the ordinary locomotive would be considerable. The trains do not run so frequently.

Cross-examined by Mr. MOON: Mr. Mather proposed to guarantee the working of the City and South London Railway at ninepence per train mile?—Yes.

This line will be a little more expensive to work than that of last year because it is longer?—It will involve a little extra, but not a great deal.

Last year, if I remember rightly, you agreed with the estimate of ninepence per mile, for a line 4½ miles in length?—That was not an estimate but a guarantee offered by a contractor, and you may suppose he allowed himself a good margin.

Digitized by Google

You thought it was a fair time?—I thought it was a sum at which it could be done.

What would you say would be the additional cost of prolonging the circuit by a mile and a-half, assuming ninepence to be a fair sum for $4\frac{1}{2}$ miles? - I should think something like three halfpence.

Mr. R. E. FARRANTI and others gave evidence to the effect that the proposed railway would be of great advantage to the working classes.

Mr. HAMILTON, Managing-Director of the Exploration Company of London, said the shareholders of this Company were very influential men in London, New York, and Paris. He was a member of the syndicate for promoting the Bill, and he had no doubt that the necessary capital would be raised. If, however, a clause were inserted in the Bill giving the County Council the right to purchase, the capital would not be raised.

Sir J. FOWLER, Consulting-Engineer to the City and South London Railway, said he was one of the engineers responsible for the present scheme. He had carefully considered the route and details of the proposed scheme, and he agreed with the evidence of Mr. Greathead and Sir Benjamin Baker. The strong objection to the scheme of last year was that the generating station was at Queen's-road. That objection could not be raised now, as the generating station would be at Shepherd's Bush. The construction of the railway would do no harm to adjacent buildings, and in no way interfere with the use of the roads. The mode of construction would secure perfectly pure atmosphere to the passengers using the line.

Mr. PEMBER informed the Committee that the promoters had arrived at an understanding with the Gas Light and Coke Company and also with the owners and frontagers in Cheapside and Cornhill.

This concluded the case for the promoters, and the further consideration of the Bill was adjourned till Thursday.

## AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *February* 20, 1891.

**Meeting of the National Electric Light Association at Providence.**—The event of the past week was the meeting of the National Electric Light Association at Providence, R I. The semi-annual conventions of this Association are events in the electrical world; but the present one was, from the size of the attendance, and the enthusiasm displayed, more than usually interesting. About 400 delegates were present, representing not only central station managers and those directly connected with the production of electric light, but every department of electrical industry. The meeting extended over three days. By Monday, February 16th, the head-quarters of the Association were already crowded. The neighbouring hall, furnished with light and power circuits, was set apart for exhibition purposes, and a very large number of electrical devices of various sorts were there displayed in operation. The citizens of Providence proved most hospitable, and two large receptions were tendered to the delegates during the continuance of their stay, besides numerous less ostentatious courtesies. The Papers were of a very high order of merit, and prominent among them was a discussion on the electric arc by Prof. Elihu Thomson. Another very practical and valuable Paper was on the distribution and care of alternating currents, by Mr. T. C. Smith. This is a topic not often discussed, and hence was of very peculiar interest to members of the Association who have to do with alternating circuits. An occasional fault of Papers read at these conventions is a lack of useful detailed information. Mr. Smith, however, did not fall into this error, and his practical hints were of extreme value. Wednesday, February 18th, was set apart as pioneers' day to celebrate the close of the first decade of commercial electric lighting. The morning session of the convention was taken up by interesting reminiscences on the part of the early workers in the field of electric lighting and power. Among the number were Prof. Thomson, Mr. F. J. Sprague, Mr. E. W. Rice, and other well-known electricians. One interesting fact brought to light was that some of the original Thomson-Houston 10-light arc dynamos made under Prof. Thomson's personal direction were still in use and doing excellent service in a central station at Kansas City, Mo. On Wednesday evening Mr. M. J. Perry, the president of the Association, gave a large reception to the delegates, and on Thursday evening a most unique festival was held, on the invitation of Mr. E. F. Phillips, president of the American Electrical Company, in the just completed factory of that organisation decorated expressly for the occasion with a profusion of bunting and electric lights. The annual election of officers occurred on Thursday afternoon, and resulted in giving to the Association a progressive and active set of officers, who will make their enthusiasm felt in all work of the Association. The president elected was Mr. C. R. Huntley, a central station manager of long experience and high reputation, while the office of first president was filled by Mr. J. I. Ayre, the enterprising young engineer who is at the head of the largest arc light station in the world at St. Louis, Mo. The next meeting will be held, in response to a most cordial invitation, at Montreal, and the time will probably be late in the coming August.

## CORRESPONDENCE.

### ELECTROSTATIC FORCES *VERSUS* GRAVITATION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. Sprague might satisfy himself what chance electrostatic forces have of coping or interfering with gravitation by doing the following little sum:—Let the earth be charged till its potential is a million million volts, and suppose the sun to be charged with an equal quantity of electricity, what force will they exert on each other? If I make no mistake it comes out about 22 tons weight.

Now the gravitative pull between earth and sun exceeds the weight of seven trillion tons.

The force which the sun's *light* exerts upon the earth is, I reckon, something not far short of a hundred thousand tons weight, and even that is altogether too insignificant to appreciably affect gravitation.—Yours, &c.,

OLIVER J. LODGE.

### ELECTRIC THEORIES.—ETHER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: There are a few misconceptions in Mr. Sprague's article on p. 513. I do not, however, write to dilate upon them now, but merely to say that I shall endeavour to profit by Mr. Sprague's criticisms, and try to remove them in my present articles as occasion presents itself. Perhaps, in the meantime, other writers may be able to assist him; and this would, I think, be facilitated by a receptive state of mind. Some of his questions will be found to be already answered in §§ 15, 16 of "Electromagnetic Theory."—Yours, &c.,

March 1, 1889. OLIVER HEAVISIDE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to Mr. Gray (p. 520), I did not say anything about Sir W. Thomson's use of a "massless fluid," and certainly I do not pretend to use it myself. All I meant to use was the statement that "massless" means devoid of inertia: mass being defined by gravitation force and resistance to motion of matter. There is a metaphysical meaning sometimes given to mass, to which Sir William alludes and ignores. I say, as he said, "in the strictest dynamical language 'mass' is taken as the measure of inertia." Therefore, I went on to say, no inertia, no momentum; no momentum, no basis for the application of dynamics. And I will ask Prof. S. P. Thompson how he can conceive a structure in a substance devoid of friction? Can parts hold together (when in motion) without adhesion, and is not adhesion a form of friction—at all events when exposed to shearing actions, as all moving parts must be?

I may as well add that I see a little uncertainty left in Prof. Thompson's fourth definition, "transfer of energy *through* the medium." I had not noticed this. I consider the lines of force of the magnet are formed in the medium. I do not consider that when a wire cuts those lines they transmit any energy with it; they oppose its passage. The energy comes from the motor which forces the wire into the lines, not from, or in any true sense by, the agency even of the medium, though indirectly by the agency of the magnet. But I shall meet this in my articles. I only need mention the point to avoid misunderstanding. I purpose showing that in every form of source, the energy is *in* the conductive form the first, as the source is a definite part of the conductor.—Yours, &c.

JOHN T. SPRAGUE.

Digitized by Google

## MAGNETICS AND NOMENCLATURE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Cannot something be done to check Mr. Oliver Heaviside's prolific invention of new words? I do not complain of "resistivity" or "permittivity." I do not even know what they mean. But to use the name of a well-known unit in a new sense is quite contrary to the permittivity of, and is likely to lead to considerable resistivity from, the general body of physicists. Mr. Heaviside proposes to call the unit magnetomotive force the gauss. Is he aware that the "powers that be" have already christened the unit of magnetic induction (unit B) the gauss? And although unit B and unit H are numerically equal in free ether, it is just as well to give them different names, because free ether is very rarely found outside text books.

There is one unfortunate unit which has never been christened, namely, "one line of force." I have been in the habit of calling this a Thom. Why not? Also why not call the whole flux *the* induction, and when we wish to speak of induction per unit area let us call it induction *density*. If Maxwell had been living now he would have agreed to this at once. It is a long time since he wrote his book, and the world has not stood still. Here is a list of my suggestions:—

| Physical quantity. | Unit: either C.G.S. or a convenient multiple. | Convenient symbol. |
|---|---|---|
| Electric current | Ampere | C |
| Current density | Amps per cm. | $\gamma$ |
| Electric resistance | Ohm | R |
| Specific resistance | Ohms per c.c. | $\rho$ |
| Magnetic induction | Thom. | B |
| Induction density | Gauss, or ohms per cm. | $\beta$ |

Of course, being only a practician, one has to use the orthodox B and B x area. Like Pooh-Bah, "It revolts me—but I do it."—Yours, &c., SYDNEY EVERSHED.

## THE CALLAN INDUCTION COIL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Allow me to supplement in a few points the admirable historical sketch of the induction coil from the pen of Dr. Fleming, which has recently appeared in *The Electrician* (pp. 396—416). It escaped my notice until a few days ago.

The large electro-magnet constructed by Dr. Callan in the year 1836, "with two separate insulated wires, one thick, the other thin, wound on the iron core," which was the immediate predecessor of his induction coil, is still preserved here. It is horse-shoe in shape, measures 13ft. in length, and weighs, with its armature, 210lb. A somewhat smaller one, constructed on the same principle, was presented to Mr. Sturgeon, and exhibited by him the following year at a meeting of the Electrical Society in London.

In Sturgeon's "Annals of Electricity" for April, 1837, there is described by Dr. Callan an instrument devised for producing a rapid succession of electrical currents in the coil by making and breaking connection with the battery. In some of his subsequent Papers he calls it a "repeater." This was the first form of contact breaker ever made (*Philosophical Magazine*, April, 1858). This simple piece of apparatus, forming, as it did, an essential element in the development of the induction coil, I have also carefully preserved.

But the most valuable relic I found here on succeeding Dr. Callan as Professor of Natural Philosophy was a large induction coil, which may be regarded as the completion of his labours. Although constructed by him nearly thirty years ago, it has still, for the same battery power, few rivals. A brief description of it may be of interest to some of your readers.

The core is a cylindrical bundle of annealed iron wires, 42in. in length and 3·5in. in thickness. The thickness of each wire is $\frac{3}{16}$in. The primary coil is a copper wire, ·25in. thick, covered with cotton thread and wound in three layers of spirals. For insulation the primary coil is covered with several layers of thin sheet gutta-percha, cemented together by a paste formed by dissolving gutta-percha, resin, and wax in boiling oil. The secondary coil, which is of iron wire ·01in. thick, consists of three separate rings. The inner diameter of each ring is 5·75in., the outer diameter is 21in. Two of the rings are 3in. in thickness, one is 4in. The rings are so arranged on the primary coil as to divide its entire length into four equal parts, the planes of the rings being perpendicular to the axis of the core. In each ring both ends of the wire are left projecting, so that the rings can be connected together either in series or in parallel. The contact breaker is an automatic mercurial one, which is worked by one extremity of the core. Two condensers of different dimensions, so arranged that they can be used together or separately, serve to reduce the spark at the break to a minimum with varying battery power. With six cells of the Maynooth or cast iron battery, I have frequently got sparks 15in. long in air, with the barometer at 30in., the rings being joined in series and the negative terminal connected with an insulated plate, the positive with a pointed wire placed opposite. Three cells of any of the nitric acid batteries are sufficient for all the ordinary experiments.

Let me add, in conclusion, that students of electricity owe a debt of gratitude to Dr. Fleming for the first true history of the induction coil that has appeared in our language. Most of our text-books would lead one to believe that we are indebted to our continental neighbours for this very useful invention. And considering the Frenchman's proclivity to appropriate the inventions and discoveries of other nationalities, such misstatements might be overlooked in books which are professedly translations. But text-books written by English authors for English-speaking students should be free from such blunders. Let us hope that Dr. Fleming's exhaustive narrative will prevent their recurrence.—Yours, &c.. FRANCIS LENNON.

Maynooth College, February 27, 1891.

## THE BARKING ROAD CARS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your last issue, the Secretary of the General Electric Power and Traction Company (Limited), at the request of his managing director, publishes a correspondence in which it is stated that the Tables 4 and 5 of Cantor Lecture, given by Mr. Kapp at the Society of Arts on Monday, the 16th ult., are entirely misleading, &c. Now, Table 4 shows the cost of the equipment of the Barking-road line with half a-dozen 52-passenger accumulator tramcars carried out by the writer in the spring of 1889 for the Electric Traction Company (Limited), every item of which is accurate, and their details can be furnished, the amount being £6,191. 16s. (see *The Electrician*, February 20th). The cars proper are not included in the table, as only those items connected with the running expenses are dealt with. To include the cars would add £1,200 to the total, making it £7,391. 16s., which is perhaps not what is desired. Table 5 gives the running expenses for the full mileage of the line, *i.e.*, five cars in service running a total of 100,844 miles per annum, being 8·068d. per car mile. This corresponds to the year ended June 30, 1890. It is accurate. It must also be very nearly true, indeed, for the present time, since the five most important items, namely, batteries, wages at depôt, drivers, steam plant, remain unchanged, and these five items represent 88 per cent. of the total. The life of the batteries is 10 months or 300 discharges up to present time. The cars have now been on the road 21 months, and are working with their second renewals. It is to be hoped that the K type plates may prove more durable. The end of the present year will show their merits or demerits as compared with the ordinary type.

It is to be observed that the 8d. per car mile corresponds to the full mileage of 100,844 miles per annum, and that the wages at depôt are a fixed charge of £677. 6s. a year.

The mileage run during the first half-year of 1890, under the charge of the writer, was 44,047 car miles, the mileage run during the second half-year (the installation now becoming the property of the General Electric Power and Traction Company, Limited), was 33,794 car miles, or a decrease in miles run, period for period, of 10,252. Is this a measure of the improvement? This low mileage runs up the proportion of

Digitized by Google

shed wages from 1·612d. to 2·40d., and making the car mile run 8·361d., which is unpleasantly near to 9d.

I must remind Mr. Mackenzie that I left the Electric Traction Company (Limited) at the time of its liquidation, and was in no way connected with the company to which he is secretary.—Yours, &c., T. FRAZER.

114, Broadway, Plaistow, E.

## ELECTRIC LIGHTING STATISTICS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR :—As on a former occasion you were good enough to publish some correspondence of mine in reference to the hours of lighting that may be calculated on, exclusive of public lamps, I would wish to call your attention to the following figures, taken from Mr. Manville's estimate for the private supply in Dublin, the total number of lamps to be supplied being 3,000. Of these Mr. Manville assumes that 300 will be lighting *day and night*, and he estimates the hours of burning as 300 × 24, or 7,200 hours per annum for each lamp. By taking 300, instead of 365 days, I presume he excludes Sundays and holidays.

The remaining 2,700 lamps he calculates will burn each for 1,000 hours. We thus have—

300 lamps × 300 days × 24 hours = 2,160,000
2,700 lamps × 1,000 hours......... = 2,700,000

Total ..................... 4,860,000 hours.

It would therefore appear that about 45 per cent. of the whole consumption would be appropriated by these 300 "day-and-night" lamps. Again, this raises the average over all the lamps to 1,620 hours.

When I wrote to you on a former occasion you estimated, from some data before you, the hours of lighting at about 800 or 20 per cent under that of the 2,700 lamps given above. But what strikes me most is this. Where in Dublin could there be 45 per cent. of the whole consumption used by lights burning *night and day?* The only establishments there that work at night are flour mills, of which there are very few; distilleries and breweries, which would require very few lights at night, and bakeries. None of these require artificial light by day, with the exception of a few used in brewers' cellars. It may be remarked that as land is cheap in Dublin, the inhabitants are not driven to that system of burrowing under ground which becomes necessary where land is very valuable.

We have in Dublin only one railway tunnel, and that far distant from the proposed central station. I should like to know if any provider of gas or electric light has an "all round the clock" consumption, equal to 82 per cent. of the light supplied to ordinary consumers who go to bed at reasonable hours?

In the Paris notes of your correspondent, it is stated that the low-tension supply leaves a net profit of £1,720 in a rental of £11,840, being nine months' working. This equals 14½ per cent. of the rental, and is said to be 10 per cent. on the capital sunk in the undertaking. This last figure cannot be checked, as there is no statement given of the *portion* of capital allotted to the low-tension system. But what is a most important omission is this: No mention is made of the *price* which is charged to the consumer, which I have been informed is very high in Paris. It would be desirable that the number of units paid for should also be given. This would enable us to compare French with English rates.

The Taunton Electric Lighting Company was the model small central station, and for some time was unique in showing a profit. Captious critics averred that the profit was made by the sale of fittings, &c., and not by the supply of light. This seems to be confirmed by the last report, which shows a deficit of £438, or 3½ per cent. on a capital 12,780, without making any allowance for ordinary depreciation, or the necessary loss incurred in abandoning old for new works. I may have misread the report, but if I have done so, I will be glad to be corrected.
—Yours, &c., DENNY LANE.

72, South Mall, Cork, Feb. 28, 1891.

P.S.—Since writing the above, I find the following statement made by Profs. Colombo and Ferrini of the Technical Institute Milan, which may be interesting.

*Number of Lamp-hours of Electric Lights in Milan (per annum).*

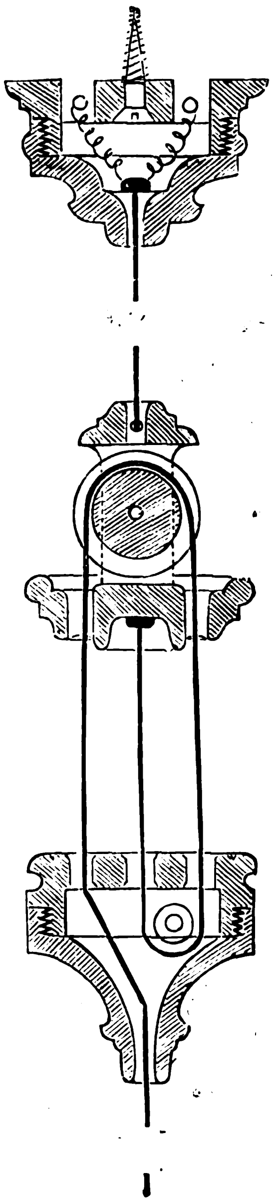
| | | | |
|---|---|---|---|
| Theatres, Cafés | 1,800 hours | Shops | 750 hours |
| Clubs | 1,300 „ | Offices, Banks, &c. | 400 „ |
| Hotels | 950 „ | Private consumers | 320 „ |

Average 750 hours. Gas jets: Average 650 hours.

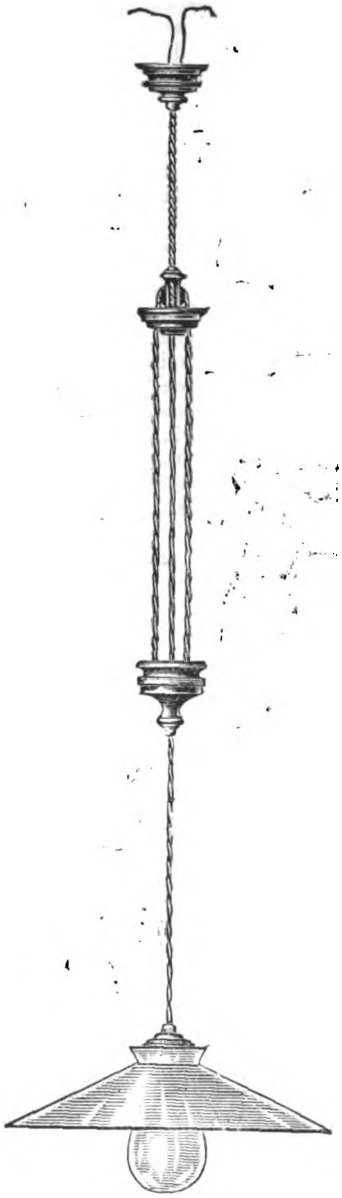
I take the statement from the *Gas World* of this date.—D. L.

## THE RENTSCH INCANDESCENT LAMP SUSPENSION.

The movable suspension device shown in the annexed figures is due to Mr. Rentsch, of Cölln-Meissen. Two collars are secured to the ceiling-rose by means of a twin flexible well-insulated conductor. This conductor is knotted at the top as shown, and long



Section.



General appearance, with Lamp fitted.

Rentsch Incandescent Lamp Suspension.

ends are carried to the terminals, so that the weight of the lamp, etc., shall come upon the knot instead of upon the separate wires attached to the terminals. Another knot prevents the upper collar from sliding further down. The wire passes round the little pulleys on its way to the lamp. When the lamp is pulled down the lower collar rises, (the lamp descending through three times the distance traversed by it.) Pulling the collar down causes the lamp to rise.

Digitized by Google

# TRADE NOTES AND NOTICES.

"THE ELECTRICIAN"

**ELECTRICAL TRADES' DIRECTORY & HANDBOOK for 1891**

The new edition of our well-known Directory and Handbook is now ready, price 5s., postage extra. The book consists of over 900 pages, and has entailed this year a heavy amount of work. The HANDBOOK DIVISION contains a mass of most useful information. The DIRECTORY DIVISION consists of 430 pages, and contains a very carefully compiled Alphabetical and Classified List of Firms and Persons engaged in the Electrical and Allied Trades in all parts of the world. This Division has been corrected up to date, and the book is thoroughly reliable, the very numerous changes which take place at the beginning of the year being incorporated. By the aid of this Directory, makers of Electrical Machinery, Apparatus, Instruments, Fittings, Sundries, Novelties, and other goods, may safely communicate direct with probable customers without the annoyance and great expense consequent upon using books which are mere lists of Members of Scientific Societies repeated again and again. A large number of copies have been already subscribed for from the Colonies, the Continent, the United States, and other Foreign Countries, whilst at Home orders have been received from Local Authorities, Railway, Tramway, Mining, and other large Industrial Corporations, as well as from those for whom the Directory and Handbook is primarily compiled. The Colonial and Foreign Division will be found extensive and reliable. *Orders should be forwarded at once.*

ELECTRICIANS', ENGINEERS', BUILDERS', AND IRONMONGERS' EXHIBITION.—This, the third annual exhibition of the kind, is announced to take place at the Agricultural Hall, Islington, N., from April the 23rd to May 2nd next. We are asked to state that the space is being taken up rapidly, and that the success of the Exhibition is assured.

REMOVAL.—We are asked to announce that Mr. E. M. Evans, electrical engineer, has removed from the Corn Exchange, Manchester, to 18B, Fountain-street, where more extensive and convenient premises are secured.

REGENERATIVE ELECTRIC LIGHT COMPANY (LIMITED) (IN LIQUIDATION).—A meeting is to be held at 13, Victoria-street, on April 2nd, at 2 o'clock, for an account of the winding-up.

NORTHERN DISTRICT TELEPHONE COMPANY (LIMITED) (IN LIQUIDATION).—A meeting is to be held at 5, Moorgate-street, on April 6th, at 3 o'clock, to receive the report as to the winding-up of the Company.

# PATENT RECORD.

## APPLICATIONS FOR PATENTS.

**NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.***

February 12, 1891.

2,518. W. GIBBINGS. Garston. An improved method of depositing copper or other metals by electrolysis with the object of refining it or them, or of recovering the precious and other metals contained in or alloyed with the metal under treatment.

2,522. W. R. LANE and J. HALL. Birmingham. Improvements in metallic bedsteads and other articles of a like manufacture.

February 13, 1891.

2,654. Sir C. S. FORBES, Bart. London. Improvements in primary batteries.

2,664. L. B. ATKINSON and C. W. ATKINSON. London. Improvements in machinery for cutting coal and other minerals driven by electricity.

February 14, 1891.

2,677. C. A. PARSONS. Birmingham. Improvements in meters for measuring, registering and recording electrical currents in part applicable to other measuring and recording instruments.

2,689. E. W. LANCASTER. Birmingham. An improved ceiling rose or connector for electrical circuits and for the suspension of electrical fittings and similar purposes.

2,706. A. W. HEAVISIDE and R. C. JACKSON. Whitley. Making joints and connections in concentric cables, or mains for conveying electric currents.

2,714. R. J. RAY. London. Improvements in electric lighting and for other like purposes.

2,732. W. WHITE. London. Improvements in flexible supports for electric lamps.

February 16, 1891.

2,798. H. J. ALTMAN. London. Improvements in solutions and salts for electro-deposition and other purposes.

## SPECIFICATIONS PUBLISHED.

1890.

180. EDWARDS (Casalette and another). Automatic telegraphs. (Price 1s. 1d.)
1,897. FAHRIG. Composition for electrical insulating. (Price 6d.)
1,939. BOUGAULT. Electric temperature alarm. (Price 8d.)
2,219. RUDOLPH. Telegraph printing apparatus. (Price 11d.)
2,297. RICHARDSON and HOLLAND. Electrolytic apparatus. (Price 8d.)
2,298. GARDINER. Electric calls, &c. (Price 8d.)
2,337. POSTLETHWAITE. Electro-magnetic motors. (Price 8d.)
2,876. WALTER. Safety devices for electric currents, &c. (Price 8d.)
2,945. LAURENT (Cely and Timmis). Electric secondary cells. (Price 11d.)
3,778. HART. Telegraph printing instruments. (Price 4d.)
3,839. DELANY. Cable telegraphy. (Price 8d.)
3,960. WOOD. Galvanic medical appliance. (Price 6d.)
3,967. STEVENSON. Secondary battery elements. (Price 6d.)
4,242. SIEMENS. Electric railway signals. (Price 8d.)
4,384. PITKIN and HOLDEN. Secondary batteries. (Price 6d.)
4,699. KELLOGG. Telephony. (Price 11d.)
4,767. SHERRIN. Electro-motors and dynamos. (Price 8d.)
4,821. OBACH. Insulated electric conductors. (Price 4d.)
4,858. KAPP. Dynamo-electric machines. (Price 8d.)
4,991. GAY and HAMMOND. Electric arc lamps. (Price 8d.)
14,197. LAKE (The Thomson-Houston International Electric Company). Electric motors. (Price 11d.)
15,455. THOMPSON (Coffin). Welding metals electrically. (Price 6d.)
17,560. ILIFFE and BARTON. Electric switches. (Price 8d.)
18,190. GISBORNE (Keeley). Multiplex telegraphy. (Price 8d.)
18,409. DAVIES. Electrical switches, &c. (Price 6d.)
18,993. PROKHOROFF and FAHLBERG. Electric clocks. (Price 8d.)
19,272. CARPENTER. Electric soldering irons. (Price 8d.)
20,099. KINGSBURY (Western Electric Company). Telephone exchange apparatus. (Price 8d.)
20,111. LAKE (Roberts and another). Electrolytic decomposition of metallic salts. (Price 8d.)
20,134. FAWCUS and COWAN. Suspending electric light, &c., cables. (Price 6d.)
20,289. BOTTOME. Insulating compositions. (Price 4d.)
20,307. DAHLGREN and SVENSSON. Electrical switches. (Price 6d.)
20,424. VON DOLIVO (Doprowolsky and others). Alternating current motors. (Price 6d.)
20,425. VON DOLIVO (Doprowolsky and others). Alternating current motors. (Price 6d.)

# COMPANIES' MEETINGS & REPORTS.

## Telegraph Construction and Maintenance Company (Limited).

The twenty-seventh ordinary general meeting of the shareholders in this Company was held at the offices, 38, Old Broad-street, on the 3rd inst., under the presidency of Sir George Elliot, Bart., M.P.

Mr. SHUTER (Managing Director) read the notice calling the meeting and the minutes of the last ordinary meeting and of the half-yearly general meeting held last July. These minutes were approved by the present meeting and signed by the Chairman as correct.

The CHAIRMAN: Gentlemen, I have great pleasure in coming before you to make a very brief statement regarding the results of the working of the Company during the past year. I suppose that each of you will have read with much interest the report which has been placed in your hands, which I assume we may take as having been read. The past year has been, I must say, a very successful year for our Company. We have done a great deal of most interesting and useful work in every sense of the word, and more particularly useful and interesting to the Company, because it has been done so well. There has been an entire freedom from the slightest accident in the execution of the enormous amount of work which was done by the Company during the year 1890. The effect of this has been to yield us a fair and good profit. That our enterprise has not been in any degree impaired by any misadventure in all the precarious and interesting work which we have done in the past year is due to our staff. We have laid—I suppose nearly all of it in deep sea, or the great bulk of it—4,000 miles of submarine cable during the past year, and we have manufactured a considerably larger quantity, part of the contracts remaining unexecuted. That work is going on in the present year, for which it augurs well. I am glad to say, therefore, that our prospects for this year seem very encouraging. We are at the present moment laying a cable from Madras across the Bay of Bengal, and loading another cable at our works for the Indian Ocean. I have been here since the formation of the Company, and I was connected with this business, as you know, for many years before the formation of the Company, and we have never made boasts about anything that we have done. We have been a silent Company, doing our work quietly and well, and generally having plenty of work to do. I

Digitized by Google

hope you will continue to be satisfied with the 20 per cent. dividend which we are enabled to give you, leaving something as a nest-egg for next year. By this means I trust we shall always—at any rate for many years to come—provide a safe guarantee for carrying on the Company in the way we have hitherto done, not dividing everything you earn, and in the next year having little or nothing. We try and steady our dividend. When we have one bad year we have something in hand to equalise our dividend, and we trust that this way of transacting our business will have your approval. The resolution which I have now to propose is as follows :—

"RESOLVED,—*That the report and accounts of the Directors to the 31st December, 1890, submitted to this meeting be, and the same are hereby received and adopted, and that a dividend of 36s. per share (in addition to the 12s. per share interest or interim dividend paid to June 30th, 1890), be paid upon all shares of the Company for the year ending December 31st, 1890, and that such dividend be paid free of income-tax.*"

Mr. PHILIP RAWSON, J.P.: I have much pleasure in seconding that.

The CHAIRMAN: Before putting this resolution to the meeting, I shall be very glad to answer any questions which may be asked.

Mr. WHISH thought that the proprietors had every reason to be most thankful for the exceedingly prosperous year which the Company had had. Its prosperity was most remarkable in the amount carried forward. This was so very noticeable that he desired to ask why such a large amount should be carried forward instead of some of it being added to the reserve fund. He did not propose that a larger dividend should be paid, but that, instead of the entire sum of £61,500 being carried forward, a portion of the amount should be added to the reserve fund.

The CHAIRMAN: I thought the observations I had made would have sufficed to explain that. Our work is of a very precarious character, and if you had had that which you might have had more than once in the course of last year, you might have lost half of that £60,000. It is the excellent manner in which the business of the Company has been executed that has enabled us to make these large profits, as there has been absolutely no inconvenience or accident in all the work that we have done. Our business is large, and it is of a special character, and the way in which it is done by the Directors and the staff—and especially the staff—is security for your position. We are enabled by doing our work with so much precision and regularity, and in such a very short space of time, to secure you a large business; and our position is safer and better by our always being well supported by a good reserve. You must be good enough to let us judge of this matter.

Mr. WHISH observed that he had merely thought that part of the amount carried forward might be added to the reserve fund.

The CHAIRMAN: I hope that my answer is regarded as sufficient.

The motion was then put and carried unanimously.

Mr. GEORGE W. CAMPBELL next proposed the re-election of the retiring Directors, Sir George Elliot, Bart., and Mr. P. Rawson.

Admiral Sir GEORGE H. RICHARDS, K.C.B., F.R.S., seconded the motion, which was unanimously adopted.

Mr. HEWAT afterwards proposed :—

"RESOLVED.—*That Mr. John Gane, F.C.A., and Mr. Patrick A. Glegg be and are hereby re-elected Auditors of the Company for the year 1891 at the usual remuneration.*"

Mr. BRYDEN seconded the motion, which was carried unanimously.

The CHAIRMAN: That is the end of our business, gentlemen.

Mr. CROFT: We ought not to separate without passing a vote of thanks to the Chairman and the Directors for the very excellent way in which they have conducted the business of the Company.

Mr. WHISH seconded the resolution, which was carried unanimously.

The CHAIRMAN: On behalf of my colleagues and myself I have to thank you very much. So long as we have your confidence we shall do our best for you.

The proceedings then terminated.

## The St. James' and Pall Mall Electric Light Company (Limited).

An extraordinary meeting of the shareholders of this Company was held on Monday last, at Winchester House, Old Broad-street, E.C., under the presidency of Mr. Eustace J. A. Balfour.

The GENERAL MANAGER and SECRETARY (Mr. James Strick) read the notice convening the meeting.

The CHAIRMAN: Gentlemen, I have to propose the first resolution, which is as follows :—

"*That the capital of the Company be increased to £200,000 by the creation of 20,000 shares of £5 each, to be called Preference Shares, and to be entitled to a Preferential Dividend at the rate of 7 per cent. per annum on the amount for the time being paid up on such shares, payable out of the net profits of the Company for each year.*"

In moving this resolution, I need scarcely dwell on the necessity for the increase in our capital as the terms of the Provisional Order, under which the St. James' Company exists, oblige us to extend our operations over the whole area of the parish of St. James. The chief questions which the Directors had to consider were—firstly, the amount of the increase; and, secondly, the form in which that increase should be made. To state with any certainty the exact amount of money we shall ultimately require would involve a gift of prophecy which none of us pretend to possess, but as nearly as we can estimate we consider that the original capital ought to be doubled. There are on the face of this matter three ways in which the capital might have been raised, namely, by the creation of ordinary shares, or Preference shares bearing a lower rate of interest than 7 per cent., or 7 per cent. Preference shares. I will give you the reasons which weighed with the Board in recommending the last of these three. You are aware that the founders' shares of this Company receive half the net profits after a dividend of 7 per cent. has been paid on the capital to the ordinary shareholders. Thus, supposing that ordinary shares were created, the present shareholders instead of receiving half the net profits after 7 per cent. had been paid would only receive one-fourth of that sum. The Seven per Cent. Preference shares, on the other hand, would receive their complete moiety. In order to place the present shareholders in a still better position, the Directors have intimated that they intend, should the resolution be adopted, to offer 10,000 of these Preference shares to the holders of ordinary shares in the proportion of one to two. And here I must call your attention to an error in Clause 14 of the report, in the fourth line of which the word "now" should have been written "then." It will read thus :—"It is the intention of the Directors to offer 10,000 of such shares to shareholders then on the register," &c.

Sir JOHN H. MORRIS seconded the motion.

Mr. MUIRHEAD said he wished to ask whether the Board was unanimous in recommending these 7 per cent. shares. He had a reason for asking the question.

The CHAIRMAN: That is a question which no shareholder has any right to ask.

Mr. MUIRHEAD said he had always understood that 7 per cent. meant bad security, and he did not think that theirs was a bad security. On the contrary, it was very good; and, therefore, he did not see why such a high rate of interest should be offered. He could not see the advisability of raising money at 7 per cent. to pay off Debentures which bore 6 per cent.

The CHAIRMAN: The Debentures are practically paid off.

Mr. MUIRHEAD thought it would be perfectly possible to raise the money at 5 per cent.

The CHAIRMAN: We are not borrowing at all. We are only creating new shares, and, of course, the creation of these shares gives us fresh borrowing powers. It is a matter of policy.

A SHAREHOLDER asked if the Board had any estimate from the engineer as to the cost of the proposed works.

The CHAIRMAN: We have not yet.

The SHAREHOLDER asked whether they proposed to work by tender.

The CHAIRMAN: There are details which the Board will have to consider.

The resolution, which was seconded by Mr. LATIMER CLARK, was carried unanimously.

The CHAIRMAN then said: The next resolution is :—

"*That the Articles of Association before the meeting be adopted as the Articles of Association of the Company in lieu of those at present in use as such.*"

The primary object of our wish to alter the Articles of Association is to enable the shares of the Company to be quoted on the Stock Exchange, which under the present Articles would not be the case. There is one alteration which specially affects the Directors, and to which I wish to call your attention, and that is the remodelling of the £1,500 limit under the remuneration of the Directors. It is conceded that they are entitled to the 10 per cent. in respect of the profits, and there is no doubt that the shareholders wish the Directors to participate in an industrial business of this nature. It has not been brought to its present state of prosperity without an enormous amount of very anxious work, as you may well understand, and I think we may fairly claim that our labours, while they have met the reward of success, have not met with any very tangible reward in any other direction. In this matter, of course, we are in your hands.

Mr. LATIMER CLARK seconded the motion, which was agreed to *nem. con.*

The ordinary meeting of the Company was afterwards held.

The SECRETARY and MANAGER having read the notice,

The CHAIRMAN said, in moving the adoption of the report, there are a few matters which I am sure will be of interest to you, matters connected both with the past and the present condition of the Company. You may recollect that it was at one time the intention of the Directors to propose a scheme for the reconstruction of the Company. Owing to the enormous improvement in our position this has now become unnecessary. The original contract with Latimer, Clark, Muirhead, and Co., we practically completed, and as a result of placing our claim against them for decision by arbitration we have received an award of over £1,800. I wish to take this opportunity of placing the credit of this fact where it is due, namely, to Colonel Francis. At the same time even, arbitration is a risky and possibly expensive resource. And, although in this case we have been successful, I am still of opinion that to agree to a reasonable compromise would have been a sounder course to adopt. Owing to expressions of opinion at last year's General Meeting, the Directors offered £7,000 (the unissued debentures) to the shareholders. This course was against their better judgment, they considering that it would be better if these debentures could all be held in one hand. Experience has justified their view, for, had this been done, these £7,000 of debentures would have been converted with the remainder. The Directors hope that the three shareholders who hold these debentures will see their way to converting them into ordinary shares, and it is for the purpose of inducing them to do so that we wish to substitute the word "then" for the word "now" in the last clause of the report. With respect to the issue of shares in July last, the Directors found themselves, owing to the want of the support of the shareholders, in the position of guaranteeing to subscribe £2,000 each. I merely mention this as an interesting practical comment on a somewhat violent attack that was made on them last year by a small body of the shareholders. By a perusal of the accounts it will be seen that the whole of the profit last year was made in six months, the greater part of it during the last quarter, from October to December inclusive. The true profit for the last six months of last

Digitized by Google

year represents for that period a dividend at the rate of 10 per cent. on £100,000, which is an amount largely in excess of the capital at the disposal of the Directors at any time during that period. I do not wish to prophesy, but I can put before you some figures which will, I hope, satisfy you as to our prospects in the future. The output of current during the last two months is considerably in excess of half the output for the whole of last year. The number of lamps wired at this moment is nearly seven times as many as on January 1, 1890, and we have application for over 10,000. The average daily revenue during the last week is not far off six times as large as the average daily revenue during January 1890, and that although the days are longer. I think that if you will put these figures together in your minds, recollecting that this increase of business is on our original capital, and that it implies but a small increase of staff, that you will agree with us in thinking that you possess a most valuable property, and one likely to be remunerative; and the Directors feel that the results of the year's working have completely justified the course of this Company's business as foreshadowed by them. As negotiations for the purchase of a site on the northern part of the parish of St. James are proceeding, it is undesirable to enter into details on this subject. The experience gained in the erection of the present station places us in a position of great comparative advantage with respect to the erection of new works, both from the point of view of economy and efficiency. We shall continue to follow the principle of the sub-division of engine power, the adoption of which principle has been one of the causes of our steady success, and we shall further develop this principle by connecting the new station with the old in such a way that in case of necessity each can afford the other support. In conclusion, I shall again thank the members of our staff for the admirable and energetic way in which they have worked, and I wish specially to mention our Secretary and Manager, Mr. Strick, and our Chief Engineer, Mr. Dobson. If any of you had been acquainted with the details of the work that they had gone through, I am sure you would feel, as we do, that these gentlemen greatly deserve our thanks. I now move:—

"*That the report and accounts of the Directors for 1890 be and the same are received, approved and adopted, subject to the alteration that the word 'then' be substituted for the word 'now' in the fourth line of clause 14 of the report, and that a dividend of 5s. per share, free of income tax, be declared and paid forthwith on the 9,000 ordinary shares in existence on December 30, 1890.*"

Mr. LATIMER CLARK seconded the motion, which was carried unanimously.

On the motion of Mr. HODGSON, seconded by Mr. HOWARD, the retiring Directors were re-elected, as were also the auditors, Messrs. Deloitte, Devers, Griffiths, and Co., on the motion of Mr. HODGSON, seconded by Mr. MUIRHEAD.

A vote of thanks to the Chairman and Directors terminated the proceedings.

## Taunton Electric Lighting Company (Limited).

The fourth annual meeting of this Company was held at the Castle Hotel, Taunton, on Wednesday, the 25th ult., under the presidency of Mr. W. H. Fowler, J.P., the Chairman of the Company.

In moving the adoption of the Directors' report, which appeared in our last issue, the CHAIRMAN said the past year had not been so satisfactory as former ones, but the report fully set out the difficulties they had met with, and which to some extent had been unforeseen. He had made an estimate for next year of their probable income and expenditure, as it struck him that their whole position hung on this question. He then referred to the estimate in detail, and made the probable total expenditure £1,895, and the income as £100 less. This was allowing the sum of £300 for payment of five per cent. interest on £6,000 debentures. There were two things they might do. First, they might increase the rentals. The light was supplied at a loss at the present time. The price of coal had gone up, and consequently the price of gas had been raised in most places, and he thought the electric light ought to go up. Then they could easily pay 5 per cent. on the Debentures, and have something left in hand. A 10 per cent. rise would make all the difference between paying 3½ per cent. and 5 per cent. They were overloaded with capital at the present time. They in Taunton were pioneers, and pioneers always had great difficulties; gas companies experienced great difficulties in starting, but the longer the Electric Light Company could keep going with its own money, the more likely they were in the future to have a prosperous concern. At present they had to raise £5,000 on Debentures. He did not think the Directors themselves were prepared to finance the concern at the present time, but next year they would see how the concern was going on, and would be in a better position to consider what should be really done. If they could keep the whole of the machinery running at full power the thing would pay in itself, and what they had to face was the difficulty in getting people to come to the front and take the light. He hoped every shareholder would see the necessity of getting additional people to take the light. The light must be had: it was in Taunton, and it must stop there. Every shareholder who obtained new customers was doing the best possible thing for the interests of the Company. He begged to move the adoption of the report.

Mr. MASSINGHAM seconded the motion. He regretted that there was no dividend this year, but he was not disappointed, because all the working members of the Board had realised that they would be quite unable to pay anything. The past year has been an abnormal one. They had to work two concerns at the beginning of the year, and great delay was caused by the Board of Trade, who were bringing out new rules at the time. They had to pay a year's expenses, and only got returns for three months. Their expenses had thus been very abnormal. At the same time he took a more hopeful view than the Chairman did, for he thought there was a very bright future before the Company. There was a time when gas companies could not make things meet anyhow, and it took them a great number of years to attain to the prosperity they now enjoyed. He thought that in course of time the electric light would prove even more successful financially than gas. Their coal bill for the past year had been very large, and he hoped that this year it would be considerably smaller. He felt sure that additional customers would be forthcoming, and he hoped they would be forthcoming during the present year. The Company possessed a large and efficient plant, but at present they were only using it to about a quarter of its capacity. The Company had paid 16 per cent. in four years, and that was 4 per cent. on the whole of the shares and 5 per cent. on the debentures.

The report having been adopted, and the retiring Directors (Messrs. Alfred Lewis and H. G. Massingham) having been re-elected,

Mr. MASSINGHAM, in returning thanks, said it had been suggested that during the year, and probably in the month of August, an exhibition of the electric light industry should be held in Taunton. Taunton was the pioneer town in electric lighting, and the light was a success there before it was in any other place. It had been suggested that such an exhibition might assist the Company very materially in popularising the light. The exhibition might include electric light appliances and electricity in every form, such as the telephone, the telegraph, and electricity as a motive power. He did not know whether the expenses of the exhibition would be guaranteed, or whether the Great Western Railway Company would be disposed to assist by running excursions on the main line between Plymouth and Bristol, and also on the branches. If the railway company were willing to co-operate, and the expenses of the exhibition could be guaranteed, it was probable they might have the pleasure of carrying the suggestion into effect.

The auditor (Mr. A. Goodman) was re-elected, and the meeting terminated.

PATENT
SILICIUM BRONZE AND SILICIUM COPPER WIRE.
The best for overhead Telephone and Telegraph Lines,
AND ALL ELECTRICAL PURPOSES.
Hard Drawn High Conductivity Copper Wire.
ROLLED AND DRAWN PHOSPHOR BRONZE.
PHOSPHOR BRONZE — VULCAN — PHOSPHOR — DURO METAL
PHOSPHOR BRONZE BEARINGS, BUSHES, AND OTHER PARTS OF ELECTRICAL MACHINERY
SOLE PROPRIETORS of the British, Indian and Colonial Patents,
THE PHOSPHOR BRONZE COMPANY (Limited),
87, Sumner Street, Southwark, London, S.E.
WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

Digitized by Google

## Keswick Electric Light Company (Limited).

The adjourned annual general meeting of this Company was held at the Court Buildings, Keswick, on Saturday afternoon. R. D. Marshall, Esq., J.P., presided.

The CHAIRMAN moved the adoption of the report and statement of accounts, which were taken as read. The Company, he said, was in a growing state; the Directors found that business was increasing, and to meet the increase they required additional power at the station. Already they had made some preparation, and an appeal had been made to the shareholders; but the response had only been partial, and, therefore, they were not in so good a position as he had hoped they would have been to supply even the present demand. It was very important that the work should be done, and he hoped the shareholders would think fit to put a little more money into the business to enable the Directors to carry out the intended enlargement. The works have been dependent chiefly on the water supply, which had been very precarious during the winter owing to exceptional frost, and there had been great difficulty in keeping the turbine clear and supplied with water. The engine had not been of the help expected, but their engineer assured them it would be in the future. The Directors were anxious to carry out the alterations as soon as possible. Referring to the profits, he said the balance was small, but the concern was young and could not jump into profits at once. New businesses had their ups and downs, yet, considering the bad weather and the delay that had occurred in some of the work, he thought the balance-sheet was satisfactory. Next year he hoped they would be able to show a much better result.

Colonel SPEDDING seconded the motion, and it was carried unanimously.

Mr. WILSON remarked that the position of the Company was better really than it appeared. Certain things had been paid for out of revenue which might have been charged to capital, and so have permitted a dividend.

The CHAIRMAN said that they might have paid 2 per cent.

Mr. THOMPSON said the balance would have been about £50. The whole period of the receipts extended only over eleven months, and some of them for only seven, eight or nine months. He estimated that the twelve months' takings of the company, as wired at present, and as their arrangements are made, would amount to about £460.

A resolution passed at a meeting on February 3, 1890, was rescinded, and it was now resolved that the accounts be made up to December 31st of each year, and that the Company meet annually in general meeting not later than the end of February.

Major CROSTHWAITE intimated his willingness to take another £100 worth of shares, and he said he thought there were plenty of people who would be glad to subscribe.

The SECRETARY said that now there remained but £1,545 worth of shares to dipose of.

Colonel SPEDDING suggested that immediate attention should be paid to the securing of way-leaves, so that the Company could be in a position to supply their customers.

The meeting closed with a vote of thanks to the Charman.

## NEW COMPANIES REGISTERED.

**JOSEPH RICHMOND AND CO. (LIMITED).**—Registered by Thomsons, Brooks and Danby, 63, Cornhill, E.C., with a capital of £25,000 in £10 shares. Object: To acquire the business carried on at 30, Kirby-street, Hatton-garden, and the New Sun Iron Works, Burdett-road, E., by Joseph Richmond and Walter Whiting, under the style of Joseph Richmond and Co., to carry on business as engineers, machinists, boiler makers, brass founders, metal workers, steel converters, &c.

**RUBBER TRUST SYNDICATE (LIMITED).**—Registered by Parker, Garrett and Parker, St. Michael's Rectory, Cornhill, with a capital of £10,000 in £100 shares. Object: To acquire the whole or any part of the founders' shares, or the other shares, of the New York Belting and Packing Company (Limited), or of any other company carrying on the business of indiarubber manufacturers.

## CITY NOTES, &c.

**BRAZILIAN SUBMARINE TELEGRAPH COMPANY.**—The traffic receipts of this Company for the week ended February 27th amounted to £5,998.

**CITY AND SOUTH LONDON RAILWAY COMPANY.**—The receipts of this Company for the week ended February 28th amounted to £753.

**CUBA SUBMARINE TELEGRAPH COMPANY.**—The estimated traffic receipts of this Company for the month of February were £3,400, as compared with £3,391 in the corresponding month of last year.

**DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).**—The Board of Directors of this Company decided on Tuesday to recommend the payment of the dividend at the rate of 10 per cent. on the Preference shares and a dividend at the rate of 6 per cent. per annum, together with a bonus of 1 per cent. (both free of income-tax) on the ordinary shares, making, with the previous half-year's dividend, a total distribution of 7 per cent. for the year on the ordinary shares. The traffic receipts of this Company for the month of February show a decrease of £272 as compared with the corresponding period.

**EASTERN EXTENSION TELEGRAPH COMPANY.**—The receipts of this Company for February amounted to £43,833, as against £38,466 in the corresponding period of last year, showing an increase of £5,367.

**EASTERN TELEGRAPH COMPANY (LIMITED).**—The traffic receipts for the month of February, 1891, amounted to £59,155, as against £53,347 in the corresponding period of 1890, or an increase of £5,808.

**ELECTRIC CONSTRUCTION CORPORATION (LIMITED).**—Provisional certificates for the Six per Cent. First Mortgage Debentures are now ready at the offices of the Corporation to be exchanged for bankers' receipts.

**NATIONAL TELEPHONE COMPANY (LIMITED).**—This Company have this week invited subscription for £350,000 Four and a-Half per Cent. Debenture Stock, forming part of a total amount of New Debenture Stock which is limited to one-half of the subscribed share capital of the Company for the time being. The payments are 5 per cent. on application, 20 per cent. on allotment, 25 per cent. on April 30, 1891, 25 per cent. on June 30, 1891, 25 per cent. on September 30, 1891. The present will make £3,044,920 issued out of a total authorised capital of £4,000,000. Notice has been given to pay off the existing Debenture Stock and Bonds. The new Debenture Stock will then be constituted a first charge on the entire undertaking and property of the Company. The net revenue of the Company for the year ending April 30th last was £185,754. The Debenture Stock is redeemable at the option of the Company on six months' notice at 110. The first payment of interest on the new stock will be made on July 1st next. The subscription lists were opened on Saturday, and closed on Tuesday.

**SANITAS COMPANY (LIMITED).**—At the fourteenth ordinary meeting held on Friday last a resolution was passed declaring a dividend of 5 per cent. for the half-year ended December 31, 1890, free of income-tax, making, with the interim dividend paid on June 30th, a distribution of 10 per cent. for the year. Mr. F. H. L. R. Moll, the chairman, and Mr. Kingzett, the managing-director, alluded to the disinclination of the Stock Exchange Committee to grant an official quotation of the shares of the Company, but they hoped that the Committee would favourably reconsider the application.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY.**—The traffic receipts of this Company for the week ending February 27, 1891, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £4,895.

**WEST INDIA AND PANAMA TELEGRAPH COMPANY.**—The traffic receipts of this Company for the half-month ended February 28th show a decrease of £625 as compared with the corresponding period.

THE NON-CONDUCTOR OF ELECTRICITY.

WAREHOUSE.

VULCANISED FIBRE,

PATENTED.

This new material is supplied in two qualities, Flexible and Hard.

The FLEXIBLE is a substitute for Leather, Rubber, Gutta Percha, &c., and is extensively used by Brass Founders, Axle Makers, Hydraulic, Sanitary, and other Engineers, Pump Makers, Carriage Builders, &c.

It makes the best Hot and Cold Water Packings, and for Axle Washers of all kinds it is unequalled.

The HARD is a substitute for Metals, Hard Wood, Ivory, Vulcanite, Ebonite, &c., and is a good Insulator.

Sold in sheets, 5ft. 6in. by 3ft. 6in., varying in thickness from 1-50in. to 1in.

FLEXIBLE, 2/- per lb.; HARD, 2/8 per lb.

FACTORY.

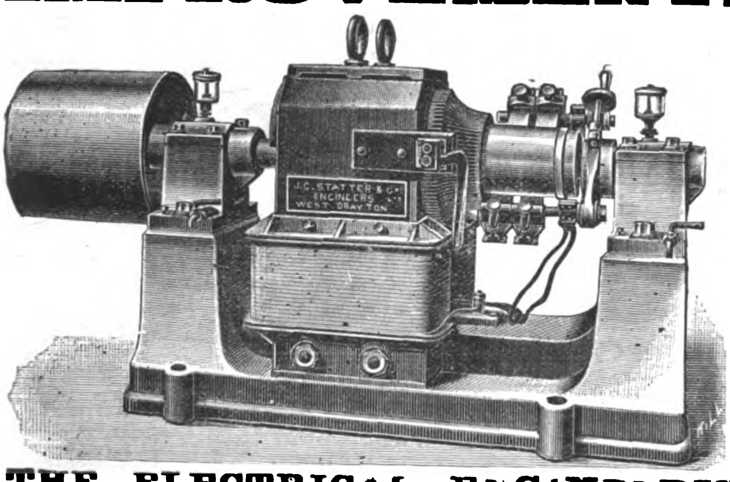
MOSSES & MITCHELL, 70, Chiswell-st., London, E.C.

Digitized by Google

# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name. | Previous Week's Price, Feb. 25. | | Price Wednesday, March 4. | | Rate per Cent. Yielded. £ s. d. | Dividend Due. | Business Done During Week Ending Feb. 25. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **TELEGRAPHS.** | | | | | | | | |
| £1,381,380 | Stock | 15/0 | Anglo-American | 47 | 48 | 47 | 48 | 5 19 9 | Jan., Apr., July, Oct. | 48 | 47½ |
| £2,809,310 | Stock | 30/0 | Do. Preferred | 84 | 85 | 84 | 85 | 6 15 4 | " " | 85 | 84½ |
| £2,809,310 | Stock | .. | Do. Deferred | 11½ | 12 | 11½ | 12 | .. | .. | 12 | 11⅝ |
| £250,000 | 100 | 4% | African Direct, Telegraph 4% Debentures | 99 | 102 | 99 | 102 | 3 18 5 | January and July .. | 99¾ | .. |
| 130,000 | £10 | 3/0 | Brazilian Submarine | 11¾ | 12¼ | 11¾ | 12¼ | 6 2 5 | Mar., June, Oct., Dec. | 11⅛ | .. |
| £84,500 | £100 | 5% | Do. 5 per Cent. Bonds | 100 | 103 | 100 | 103 | 4 17 1 | January and July .. | .. | .. |
| £75,000 | £100 | 5% | Do. 5 per Cent. Bonds (2nd Series, 1906) | 103 | 107 | 103 | 107 | 4 13 6 | June and December | .. | .. |
| $7,216,000 | $100 | 7% | Commercial Cable Capital Stock | 107 | 109 | 108 | 110 | 5 18 2 | April and October .. | 109¾ | 108¾ |
| 16,000 | 10 | 8/0 | Cuba Submarine | 10½ | 11½ | 10½ | 11½ | 6 19 2 | February and August | 11 | .. |
| 6,000 | 10 | 10% | Do. Preference 10% | 16 | 17 | 16 | 17 | 5 17 8 | " " | .. | .. |
| 12,931 | 5 | 7% for '90 | Direct Spanish (£4 paid) | 3¾ | 4¼ | 3¾ | 4¼ | 6 11 9 | April and October.. | 4⅛ | .. |
| 6,000 | 5 | 10% | Do. Preference 10% | 9 | 10 | 9 | 10 | 5 0 0 | " " | 9¾ | .. |
| 60,710 | 20 | 3/6 | Direct United States | 10⅛ | 10⅜ | 10⅛ | 10⅜ | 6 15 0 | Jan., Apr., July, Oct. | .. | .. |
| 400,000 | 10 | 2/6 | Eastern | 14 | 14¼ | 14 | 14¼ | 4 11 3 | " " | 14¼ | 14 |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference | 15 | 15½ | 15 | 15½ | 3 17 5 | " " | 15 | .. |
| £1,200,000 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock | 107 | 110 | 107 | 110 | 3 12 9 | May and November | 109 | 107½ |
| £200,000 | 100 | 5% | Do. 5 per Cent Debentures, 1899 | 107 | 110 | 107 | 110 | 4 10 11 | February & August | .. | .. |
| 250,000 | 10 | 2/6 | Eastern Extension | 14¾ | 15¼ | 14¾ | 15¼ | 4 11 10 | Jan., Apr., July, Oct. | 15 | 14¾ |
| .. | £100 | 4% | Do. 4 per Cent. Debentures Stock | 104 | 107 | 104 | 107 | 3 14 9 | .. | 106 | 105½ |
| £91,800 | 100 | 5% | Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900 | 103 | 106 | 103 | 106 | 4 14 4 | January and July .. | .. | .. |
| £145,300 | 100 | 5% | Eastern & S. African 5 per Cent. Mor. Deb., 1900 | 103 | 106 | 103 | 106 | 4 14 4 | " " | 103½ | .. |
| 180,227 | 10 | 1/9 | Globe Telegraph and Trust | 9 | 9¼ | 9 | 9¼ | 5 5 6 | Jan., Apr., July, Oct. | 9¼ | 9 7/16 |
| 180,042 | 10 | 6% | Do. 6 per Cent. Preference | 15 | 15¼ | 15 | 15¼ | 3 18 8 | " " | 15¼ | 15 |
| 150,000 | 10 | 5/0 | Great Northern | 16¾ | 17¼ | 17 | 17½ | 4 5 9 | Jan., April, and July | 17¼ | 17 |
| £230,000 | 100 | 5% | Do. 5 per Cent. Debentures, 1883 ... xd | 105 | 108 | 103 | 106 | 5 13 2 | March & September | .. | .. |
| 17,000 | 25 | 12/6 | Indo-European | 36 | 38 | 36 | 38 | 6 11 7 | May and November | 37⅝ | 37⅜ |
| 38,348 | 10 | 4/0 | London Platino-Brazilian | 6½ | 7½ | 6½ | 7½ | 5 14 4 | " " | .. | .. |
| £100,000 | 100 | 6% | Do. 6 per Cent. Debentures ... xd | 108 | 111 | 105 | 108 | 5 11 1 | March & September | .. | .. |
| 9,000 | 8 | 4/0 | Reuter's | 8½ | 9 | 8½ | 9 | 5 11 1 | April and October.. | .. | .. |
| 3,381 | £100 Cert. | 6% | Submarine Cables Trust 6% | 115 | 120 | 115 | 120 | 5 0 0 | " " | .. | .. |
| 15,609 | 10 | 4/0 | West African Telegraph | 8 | 9 | 8 | 9 | 5 11 1 | January and July .. | .. | .. |
| £290,900 | 100 | 5% | Do. 5 per Cent. Debentures ... xd | 100 | 103 | 97 | 100 | 5 0 0 | March & September | 101½ | .. |
| 30,000 | 10 | 3/0 | West Coast of America | 2 | 4 | 2 | 4 | .. | January and July .. | 2¼ | .. |
| £150,000 | 100 | 8% | Do. Debentures 8% 1902 | 94 | 99 | 94 | 99 | 8 1 7 | June and December | .. | .. |
| 88,321 | 10 | .. | West India and Panama | 2⅞ | 3⅛ | 2⅞ | 3⅛ | .. | .. | 3 1/16 | 3 |
| 34,563 | 10 | 6/0 | Do. 1st Preference 6% | 11½ | 12 | 11½ | 12 | 5 0 0 | May and November | 11 13/16 | 11½ |
| 4,669 | 10 | £3 | Do. 6 p. c. 2nd Pref. | 11 | 12 | 11 | 12 | 5 0 0 | " " | .. | .. |
| 64,174 | 15 | 6/0 | Western and Brazilian | 12 | 12½ | 12 | 12½ | 4 16 1 | " " | 12 5/16 | 12 |
| 27,873 | 7½ | 6/0 | Do. 5 per Cent. Cumulative Preferred | 6¾ | 7¼ | 6¾ | 7¼ | .. | — | 6⅛ | .. |
| 27,873 | 7½ | 4/6 | Do. 5 per Cent. Deferred | 5 | 5½ | 5¼ | 5¾ | .. | .. | 5 9/16 | 5⅜ |
| £200,000 | 100 | 6% | Do. 6 per Cent. Debs., Series "A" 1910 | 103 | 106 | 103 | 106 | 5 13 2 | February & August | .. | .. |
| £250,000 | 100 | 6% | Do. 6 per Cent. Mort. Debs., Series "B" 1910 | 103 | 106 | 103 | 106 | 5 13 2 | " " | .. | .. |
| $1,336,000 | $1,000 | 7% | Western Union 7 per Cent. 1st Mortgage | 120 | 125 | 120 | 125 | 5 12 0 | May and November | .. | .. |
| £175,100 | £100 | 6% | Do, 6 per Cent. Sterling Bonds ... xd | 101 | 105 | 100 | 104 | 5 15 5 | March & September | .. | .. |
| | | | **TELEPHONES.** | | | | | | | | |
| 224,850 | 14/0 | 0/4½ | Consolidated Telephone Const. & Maintenance. .. | 7/16 | 9/16 | 7/16 | 9/16 | .. | May and November | .. | .. |
| 220,000 | £1 | 3% | Oriental (11s. paid) | ¼ | ⅜ | ¼ | ⅜ | .. | Yearly ........... | .. | .. |
| 438,984 | 5 | 2/6 | National | 4¾ | 5 | 4⅝ | 4⅞ | 5 12 10 | June and December | 4 15/16 | 4 11/16 |
| 15,000 | 10 | 6/0 | Do. 6 per Cent. Cumulative 1st Pref. | 12¾ | 13¼ | 12¾ | 13¼ | 4 10 7 | " " | .. | .. |
| 15,000 | 10 | 4/9⅗ | Do. 6 per Cent. Cumulative 2nd Pref (£8 pd) .. | 10¼ | 10¾ | 10¼ | 10¾ | 4 9 7 | " " | .. | .. |
| 209,750 | 1 | ½% | South of England, Ordinary | ⅛ | ⅜ | ⅛ | ⅜ | .. | — | .. | .. |
| 20,000 | 5 | 2/1 | Do. 6 per Cent. Cumulative Pf. (£3 10s. pd) .. | 2¾ | 3¼ | 2¾ | 3¼ | 6 9 0 | .. | .. | .. |
| 58,000 | 5 | 1/0 | United River Plate | 3 | 4 | .. | 4 | .. | January and July .. | .. | .. |
| £146,128 | Stock | 5% | Do. 5 per Cent. Debenture Stock | 90 | 95 | 90 | 95 | 5 5 3 | .. | .. | .. |
| £3,200 | 100 | 7% | Do. 7 per Cent. Debentures | .. | | .. | | .. | — | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | | | |
| 111,000 | 5 | .. | London Electric Supply | 1¼ | 1¾ | 2 | 2¼ | .. | — | .. | .. |
| 43,900 | 10 | .. | Metropolitan Electric Supply (£9 paid) | 7¾ | 8¼ | 8¾ | 9¼ | .. | — | 8 1/16 | .. |
| 42,853 | 5 | .. | Westminster Electric Supply (£4 paid) | 3¾ | 4¼ | 3¾ | 4 | .. | — | 3⅛ | .. |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | | | |
| 63,416 | 3 | .. | Brush Electrical Engineering | 2⅛ | 2⅜ | 2⅛ | 2⅜ | .. | .. | 2½ | 2 5/16 |
| 63,416 | 2 | 1/1 | Do. 6 per Cent. Preference ... xd | 1½ | 2 | 1½ | 2 | 6 0 0 | June and December | 1⅞ | 1¾ |
| 20,000 | 5 | 3/6 | Crompton and Co., 7 per Cent. Pref. Shares | 5 | 5½ | 5 | 5½ | 6 7 3 | January and July .. | .. | .. |
| 17,139 | 5 | .. | Edison and Swan United | .. | | .. | | .. | .. | .. | .. |
| 45,000 | 10 | 6% | Electric Construction | 5½ | 6½ | 5½ | 6½ | .. | .. | 6½ | .. |
| 70,000 | 2 | 10/0 | Elmore's Patent Copper Depositing | 3 | 3½ | 2¾ | 3¼ | .. | .. | 3¼ | 2⅝ |
| 20,060 | 5 | .. | Fowler-Waring Cables (£4 paid) | 2½ | 3½ | 2½ | 3½ | .. | .. | .. | .. |
| 41,600 | 10 | 10/0 | India Rubber, Gutta Percha & Telegraph Works. xd | 19 | 20 | 18½ | 19½ | 5 2 7 | February & August | 19¼ | 18¾ |
| £200,000 | 100 | 4½% | Do. 4½ per Cent. Debentures, 1896 | 104 | 106 | 104 | 106 | 4 4 11 | March & September | .. | .. |
| 11,334 | £10 | 6/4 | International Okonite Limited Ordinary | 9¼ | 9¾ | 9 | 9½ | .. | .. | .. | .. |
| 11,382 | £10 | 5/0 | Do. Preference | 9¼ | 9¾ | 9¼ | 9¾ | 8 4 1 | .. | .. | .. |
| 78,949 | 5 | 4/10½ | Swan United (£3. 10s. paid) | 4½ | 5 | 4½ | 5 | 6 19 10 | May and November | .. | .. |
| 37,350 | 12 | 12/0 | Telegraph Construction and Maintenance | 46 | 48 | 46 | 48 | 5 0 0 | March and July..... | 48 | 47 |
| £150,000 | 100 | 5% | Do. 5 per Cent. Bonds, red. 1894 | 102 | 105 | 102 | 105 | 4 15 3 | January and July . | .. | .. |
| | | | **RAILWAYS.** | | | | | | | | |
| 50,000 | £10 | .. | City and South London Railway | 5½ | 6½ | 5½ | 6½ | .. | .. | .. | .. |


# IMPROVEMENTS IN DYNAMOS




## STATTER-BRUNTON DYNAMO.

**The latest design in the market, made with all the advantages of the latest scientific knowledge and the highest mechanical skill.**

The woodcut represents our B TYPE DYNAMO. A most efficient machine, working noiselessly, and without sparking or overheating; is highly finished and well proportioned. The output is so rated in our Catalogue that the machines may be worked very much in excess of their stated full output for short periods.

**STOCK SIZES UP TO 77 KILOWATTS.**

**MACHINES BUILT TO 500 KILOWATTS.**

**THE (STATTER'S) ELECTRICAL ENGINEERING CORPORATION, LIMITED, (UNITED**

68. Victoria Street, London, S.W. WORKS:—ALLIANCE ENGINEERING WORKS, WEST DRAYTON, NEAR LONDON.


Digitized by Google

# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 669.—Vol. XXVI. FRIDAY, MARCH 13, 1891. Price Fourpence.

## NOTES.

The "Monarch" having been waiting at Calais for fair weather to lay the new telephone cable, as we informed our readers last week, we were rather surprised to find on Tuesday, when a considerable gale was blowing, that the greater part of the work had been accomplished. We learn, however, that Monday morning was clear at Calais, and the shore end was accordingly laid, and paying out began. But before half the distance had been covered, a very strong easterly gale and snowstorm swept down the Channel. The "Monarch" found herself in a very awkward position, and was obliged to pay out the whole of the cable, and to slip the end and buoy it. She was sighted from the English coast during a lull in the storm at about 5 o'clock, and then went into the Downs. About five miles will have to be relaid; of these two miles were picked up yesterday afternoon, and connection will probably be completed to-day.

We had an opportunity of testing the land line between London and Dover on Wednesday last. The circuit is of course looped, and ordinary Gower-Bell instruments are used. We conversed with an officer in the hut at St. Margaret's Bay, a distance of about 83 miles, and found the articulation to be of extraordinary clearness, while the volume of sound was, if anything, too loud for agreeable conversation.

The Central London Railway Bill, after having been five days under consideration by the Select Committee of the House of Commons, passed successfully through that ordeal on Wednesday. Last year twelve days were spent on the Committee stage. The attempt of the County Council to be allowed to purchase the line on favourable terms after 42 years, the determination of the Committee that workmen shall be carried six miles for a penny, and the persistent demand that the rates shall be relieved at the expense of the Company, all tend to show that its opponents do not really believe that the line will never be used and cannot possibly prove remunerative, as was so ably argued both last year and this.

At the last meeting of the Physical Society Mr. Swinburne gave a brief description of a method of using an electrometer for measuring power, and there are several advantages in this arrangement. It is to be hoped that electrometers will soon come into fashion for engineering purposes, for while they are most troublesome in the laboratory, they offer great advantages where large forces are to be dealt with, and if made throughout of one kind of metal they entirely dispense with any corrections, and have no errors due to temperature, self-induction, or magnetism. For the testing of transformers electrostatic methods seem to be peculiarly valuable.

In our last issue we alluded to the error which is introduced in Mr. Blakesley's method of measuring power, by the presence of magnetic leakage. Dr. Fleming's discourse at the Royal Institution contained many references to the peculiarities of the stray field of magnets when excited by alternating currents and throttled with coils of copper wire or "shaded" with copper plates. The majority of his brilliant experiments depended upon such a stray field. The effects were altogether different from those of continuously excited magnets, and as a transformer is essentially a magnet with a throttling coil, it would be worth considering to what extent the stray field is affected, and how the leakage differs from that of ordinary electromagnets.

The second Paper at the Physical Society's meeting was a record of a very great number of experimental results obtained at the Central Institution; and although some of them are not new, they were then published for the first time in a collected form. The thanks which the mathematician gets come, as a rule, long after his work has been published, since his readers have, for the most part, to study his arguments with care, and to realise his deductions with deliberation. But experimentalists who carry out researches and practical examinations of the phenomena which are of daily increasing interest, attract the immediate attention of those who, having no opportunities for laboratory investigations, can apply the results directly to their daily work. This is particularly true in electrical science, especially in its modern developments, and such work as is done at the Central Institution, is extremely valuable in explaining those facts which are essential to a proper understanding of alternating currents. The Paper is marked by an implicit reliance on experiment, and, as a bird in the hand is worth two in the bush, we venture to congratulate the authors on this characteristic, though in no sense under-estimating the future value of such Papers as those which were presented to the previous meeting.

The interference effects described in the Paper by Prof. Ayrton and Dr. Sumpner will possibly throw considerable light upon the vexed question about the so-called back-electromotive force in the electric arc, to which we alluded below. The investigation of the "Ferranti effect" by experiment

Digitized by Google

will probably put that question upon a more satisfactory basis than it was left by the discussion which recently took place in these columns. A very strange peculiarity about the "Ferranti effect" is that no two persons seem to have heard the same account. In the discussion Mr. SWINBURNE introduced contentions about a difference of pressure between the London and the Deptford end of the mains. It is true that as the mains gradually grew in length, as mile after mile was laid, the observed pressure at the end remote from Deptford increased. But we have always understood that had the mains been tapped at intervals, all the way back to the Deptford transformer, the pressure would have been found to rise slightly on account of the ohmic resistance of the copper. In his reply, Prof. Ayrton speaks of pilot transformers. They have no doubt been used on the Deptford mains, or we should not have heard about them on more than one occasion from him, but we have no reason to suppose that the information given in our leading article of December 19 (page 205) was inaccurate in any particular. The very sensible method of using five lamps in series was there described. They were used by the workmen "in order to be quite sure that the pressure was on the mains," and evidently no pilot transformer was used when the effect was first noticed. The "London transformer" mentioned in the discussion probably referred to some later experiments.

THE recent meeting of the Electric Light Convention at Providence is noteworthy chiefly for the interesting paper by Prof. ELIHU THOMSON on the electric arc. The communication, of which an abstract will be found in another column, deals with a subject that has received but little attention. Prof. SILVANUS THOMPSON, in his Society of Arts Paper two years ago, broke fresh ground, and in the first section of that communication he placed the physics of the arc upon a sound basis. He showed that the temperature of the light emitting surface was the temperature of volatilization of carbon, and was therefore constant. No rush of current can ever raise carbon above this temperature under ordinary pressure, precisely as water cannot be raised above boiling point by any amount of firing.

ANOTHER point in connection with the physics of the arc was emphasised by Dr. FLEMING in his Royal Society paper of January 9, 1889, namely, that "the rise of potential along the arc takes place very suddenly just in the neighbourhood of the crater," and he had arrived at this conclusion by experimenting with a third carbon. He attributed this phenomenon to the fact that "the molecules are loosened from the mass by heat, and then move away by electric repulsion from the surface in virtue of the electric charge which they retain." It is probable that all chemical actions are due to electric charges, and Prof. SILVANUS THOMPSON, in his Society of Arts paper gave an explanation from the chemical point of view, describing the effect as one of evaporation, and as that takes place at the positive pole it is here, in fact on the very glowing surface, that we should look for the great change of potential. Nor is this theory shaken in any way by the experiments of H. LUGGIN, described in our "Notes."

THESE and other matters are alluded to by Prof. ELIHU THOMSON, but in describing the mushroom growth on a short arc, he does not give the interesting scientific suggestion of his English namesake, for the great difference in the counter-electromotive force, viz., the condensation of the volatilised carbon on the negative pole. Prof. ELIHU THOMSON says that he is not aware that any others have experimented with three or more carbons. We cannot recall any great success in this direction, but Mr. KILLINGWORTH HEDGES certainly exhibited some triple carbon lamps at Paris in 1881, and RAPIEFF has used four carbons. Little or no advantage has as yet resulted, and the usual practice in search light work seems preferable to the plan suggested and illustrated in Prof. THOMSON'S paper.

THE information given by Mr. KING in our correspondence columns does not go far towards removing the reproach which has recently been cast upon the economy of traction by secondary batteries. We now learn that the positive plates will last for 400 discharges if they are handled with sufficient care, and the negative plates (750 discharges); he further informs us that he has not seen a plate actually broken down from fair wear and tear. But do the exigencies of tramway work allow a more merciful treatment for accumulators than for horses? Do not the lives of tramway horses vary "according to the degree of care in handling," and is not the wear and tear such that they frequently *do* break down? In short, is not tram work the most trying duty that either a battery or a horse can be called upon to perform? We fail to appreciate the value of the "crucial experiments" to which Mr. KING refers, since he fails to give the conditions under which they were made. If they were carried out under any other conditions than those of the daily working of tramcars for public service, they must partake of the character of laboratory experiments. From these we can deduce facts of scientific interest, but not arguments in support of statements as to the cost of maintenance under every-day commercial conditions, which the amended figures in connection with the Barking-road cars can alone supply.

FROM a *précis* which appeared in *The Times* of yesterday of some correspondence which has recently taken place between the Postmaster-General and the Boy Messengers' Company, we gather that the powerful department over which Mr. RAIKES presides is threatening the Boy Messengers' Company with all manner of pains and penalties. We do not question for one instant the correctness of the contention of the Postmaster-General that to carry messages and to use an electric call system without his licence is illegal; but if we read this correspondence aright he refuses to grant the necessary licence. Now, the Boy Messengers' Company performs a most useful function, and meets a decided public want, and we trust that in his dealings with the Company the Postmaster-General has borne in mind the fact that after all the Post Office is made for the public, and not the public for the Post Office.

IN making an abstract of the final report to the Electrical Committee of the Bristol Town Council, we have omitted the oft recurring expression "bot" which does not appear to

Digitized by Google

be very useful, and which is certainly anything but graceful. When the Board of Trade first took electric lighting under its protection, the "unit" was defined as equivalent to the energy contained in a current of one thousand amperes flowing under a pressure of one volt during one hour. The man in the street, for want of a better name, at once called this "a Board of Trade unit," and the rather cumbrous title has stuck to it. Were it not that this has been unfortunately shortened into "bot," the matter would hardly need any attention. We understand, however, that it is considered that there is a real need for some good name. We have found the expression "a supply unit," or even "a unit," is amply sufficient, but if any of our readers have a sensible name, not immortalising any distinguished electrician, or torturing the English or any other language, we shall be glad to hear of it.

**Trinidad-Demerara Cable.**—This cable is now repaired.

**The Old Students' Association.**—The concert given by the Old Students' Association last Saturday was of a very successful character, the programme being excellent.

**Royal Society.**—Amongst the Papers down for reading yesterday at the Royal Society was one by Prof. Roberts-Austen, "On the Mechanical Properties of Metals in Relation to the Periodic Law."

**The Ferranti Meter.**—In the description of this meter on p. 544 of our last issue, for starts with 3 amperes, read ·3 ampere; starts with 5 amperes read ·5 ampere, and starts with 2 amperes read ·2 ampere.

**Underground Telephone Wires.**—At the last meeting of the Commissioners of Sewers an application was received from the National Telephone Company for permission to lay cables beneath the public ways.

**The Reduction of the German Telegraph Tariff.**—The reduction in the German Telegraph Tariff, which came into force on February 1st, has resulted, during the first month, in an increase in the number of messages amounting to about 7 per cent.

**Reduced Cable Rates to Australia.**—The negotiations for the reduction, under a guarantee from the Australian Colonies, of the rate for telegrams to Australia to 4s. per word are almost completed, and the new rate will probably come into force on April 1st next.

**Leamington.**—An inquiry into the applications of the Corporation and the Midland Electric Light and Power Company for Provisional Orders for lighting Leamington by electricity was held in that town on Tuesday, by Major Marindin, of the Board of Trade.

**Accumulator Traction.**—According to the *Elektrotechnisches Echo*, Messrs. Hostmann and Co., who, with the Oerlikon Company, have been carrying on traction experiments in the neighbourhood of Hildburghausen, have decided to abandon the use of accumulators.

**Duty on an International Telephone Cable.**—The United States Treasury has decided that the American portion of the telephone cable passing through the St. Clair river tunnel, connecting Sarnia, in Canada, with Port Huron, in the United States, is subject to duty.

**The Mechanical Equivalent of Heat.**—At the ordinary meeting of the Manchester Association of Engineers, held on the 28th ult., Mr. John Angell delivered a Paper descriptive of the labours of the late Dr. Joule during his demonstration of the mechanical equivalent of heat.

**Triplicate Aden-Bombay Cable.**—The Telegraph Construction and Maintenance Company's ss. "Calabria" sailed last Saturday with the shore ends of the new Triplicate Aden-Bombay cable for the Eastern Telegraph Company. The ss. "Scotia," with the main cable on board, sails to-morrow.

**Stafford.**—At the last meeting of the Town Council the Electric Lighting Committee reported that to the 54 circulars issued only 27 replies had been received, and of these only two were favourable to the adoption of the electric light. The committee, therefore, did not feel justified in recommending the adoption of the light at present.

**Belgrade.**—The Town Council of Belgrade have decided to adopt electricity to light their streets. For this purpose 65 arcs of 1,000 c.p. and 1,000 glow lamps of 16 c.p. will be required, and it is estimated that from 2,500 to 3,000 additional glow lamps will have to be installed for public and private lighting. The concession is to last 41 years.

**Flexible Glass Tubes.**—The *Electrical Review* of New York reports that Mr. Alex. P. Wright, of Boston, has produced a flexible glass tube intended for indoor wiring purposes. The glass tube conduit is enclosed in a strong woven jacket, giving it high tensile strength and strong abrasion resistance. The whole conduit is then soaked in an insulating material.

**Matlock Bath.**—Mr. Geen, of Okehampton, has sent in a report to the Local Authority, in which he estimates the cost of the adoption of the electric light at from £1,300 to £2,500, providing the motive power is taken at a minimum expense from the river Derwent. A deputation has been appointed to approach Mr. F. C. Arkwright, of Willersley Castle, to get the necessary permission to fix the plant in the river.

**Electric Traction in New South Wales.**—An electric tramway, on the Thomson-Houston system, has been installed on a line between Waverley and Randwick, in New South Wales. The line is a little over two miles in length. There is scarcely a level stretch over the whole distance. Curves varying from half a chain radius to two chains, and all on heavy grades, are constantly met with, while the grades vary from 1 in 16 to 1 in 30.

**The Lighting of the City.**—At the last meeting of the Commissioners of Sewers the Streets Committee reported on the letter from the Board of Trade relative to the City of London (East District) Electric Lighting Order, 1890, and submitted a further letter from the Board, signifying that, after consideration of the further evidence furnished, they were satisfied that the undertakers were in a position to discharge the duties and obligations imposed upon them by the order.

**Electrical Standards Committee.** — This Committee met yesterday (Thursday) morning, when the following members were present:—Sir William Thomson, Lord Rayleigh, Dr. John Hopkinson, Professor Ayrton, Mr. Preece, Major Cardew, and Mr. Courtenay Boyle. Mr. Thomas Parker, Chief Electrician of the Electric Construction Corporation, and Mr. Hugh Erat Harrison, Principal of the Electrical Standardizing, Testing, and Training Institution, attended and gave evidence.

**Litigation in Connection with Transformer Sub-stations.**—In the Chancery Division of the High Court of Justice on Tuesday, last Mr. Justice Kekewich, on the application of Mr. C. M. Warmington, Q.C., and with the consent of all parties, appointed Tuesday April 14th, for the hearing of the motion Savory and Moore *v.* London Electric Supply Corporation. The object of this action is to obtain an injunction to restrain the defendants from so carrying on their business as to be an annoyance to the plaintiffs.

**Leicester.**—On Thursday last week the National Telephone Company opened their Leicester Exchange, and placed the town in communication with the 133 towns now connected together in this district. The Post Office have for many years been working an exchange in Leicester, but for some time past it has been felt that they did not give to the town the advantages possessed by other towns worked by the National Telephone Company. The opening ceremony was presided over by the Mayor. The exchange starts with 170 subscribers.

**Palladium Plating.**—Palladium, a whiter, lighter, and more fusible metal than platinum, has of recent years been much used to plate watch movements with. According to M. Pilet, four milligrammes (about one-seventeenth of a grain) of palladium are sufficient to coat the works of an ordinary sized watch. M. Pilet recommends the following bath:—Water, 2 litres; chloride

Digitized by Google

of palladium, 10 grammes; phosphate of ammonia, 100 grammes; phosphate of soda, 500 grammes; benzoic acid, 5 grammes. This bath is suitable for all metals except zinc.

**The London Electric Supply Corporation and the Marylebone Vestry.**—The Works Committee of this Vestry have presented a report with reference to the notice from the London Electric Supply Corporation of their intention to lay a distributing main along the south side of Oxford-street, from Marble-arch to Wardour-street, to which proposed works the Vestry had given the Corporation formal notice of disapproval. An intimation has been received from the Corporation of their intention to appeal to the Board of Trade.

**Electric Blasting.**—Speaking at the meeting last Monday, of the Roburite Explosives Company, the Chairman referred to the experiments which had been conducted by Mr. Hall, H.M. Inspector of Mines, to test the influence of coal dust on mining explosions. This gentleman had proved that blown-out shots of gunpowder might in the presence of coal dust, even when gas was absent, produce explosions of great violence. The result of Mr. Hall's report was to discredit still more the use of gunpowder in coal mines, and to give a fresh impetus to the demand of safety explosives fired by electricity.

**Production of Phosphorus by Electricity.**—This process, to which we alluded on page 450 of our present volume, is now in operation at the Wednesfield Works of the Phosphorus Company (Limited), who now depend exclusively upon this process for their supply of phosphorus. A new plant of 700 H.P., was officially inspected in full work on Monday last by the Directors and officers of the Phosphorus Company (Limited), and of the Electric Construction Corporation (Limited) (the contractors for the plant), when the results, both as to quality of material and cost of production, were considered to be eminently satisfactory.

**Cable Extensions.**—A Bill will shortly be laid before the Reichstag for laying down an additional cable to Heligoland from the island of Wangeroog, as well as another from Emden to Lowestoft, the two existing ones between Germany and England being quite insufficient for the increased traffic. England will undertake half of the cost of this third cable. The supplementary German estimates for these two new cables, which are to be at once taken in hand, will amount to about 1,200,000 marks. The Imperial Government is also busy negotiating for laying extension cables to its chief colonies in East Africa and the Cameroons.

**Frankfort Exhibition.**—In order to show the application of electricity to aerial navigation, a captive balloon, capable of seating ten persons, will be exhibited by Captain Rodeck at the forthcoming Frankfort Exhibition. The pulley which controls the ascent and descent will be operated by an electric motor, and a telephone wire will enable conversation to be carried on between those in the balloon and the people at the starting-point below. Experiments will be made with the view to the steering of the balloon by electricity, and in the filling of the balloon with electrically prepared water-gas. Messrs. Siemens and Halske will make the electrical apparatus.

**Belting.**—At a recent meeting of the Manchester Philosophical Society, Prof. Osborne Reynolds gave an account of an observation in the laboratory of Owens College during the late foggy weather. Some new belting was kept running four hours, at about 4,000ft. per hour. The belting was bright and new when started, but on being stopped was found to be black and loaded with dirt collected during its rapid passage through the foggy air. It was much the dirtiest thing in the laboratory. Prof. Reynolds pointed out that this was due to the fact that the rapidly moving belt came in contact with a greater quantity of air in a given time than if it had been stationary, and therefore picked up a greater quantity of atmospheric pollution.

**The Central London Railway.**—At the last meeting of the Commission of Sewers a memorial, largely and influentially signed, from citizens of London against the Central London Railway scheme was submitted. The petitioners were headed by Mr. Jacques, of the firm of Messrs. Thomas Wallis and Co., who said the project would materially affect the stability and safety of the various buildings along the line of route. All the main streets would be injured by it, and there would be not only a detrimental effect upon trade, but a depreciation in the value of property, and a consequent reduction in the assessments of the districts. Such an underground railway was not really wanted. The memorial was sent to the Finance and Improvement Committee for consideration.

**The Jablochkoff Patent.**—On Wednesday, the case of *in re* the Jablochkoff patent of the Electrical Engineering Corporation came before Lords Watson, Hobhouse and Morris, and Sir R. Couch, at the Judicial Committee of the Privy Council. Mr. R. Wallace applied to their lordships to appoint as early a date as possible for the hearing of this petition, on the ground that Mr. Jablochkoff, the inventor, who was acting for the Russian Government in a professional capacity, could not remain in this country after the 15th of next month. He (the learned counsel) understood that their lordships did not sit at all until the 14th of April. The patent expired on the 22nd of May. Lord Watson said their lordships would fix Wednesday, April 15th, for the hearing of the petition.

**Launch of the "Electric."**—On Tuesday, the electrically propelled pinnace "Electric" was launched from the Strand Electric Launch Works, Chiswick. This pinnace has been built by Messrs. Woodhouse and Rawson for the conveyance of troops between Her Majesty's dockyards at Chatham and Sheerness. The "Electric" has a tonnage of 4¾, is 48ft. 6in. long over all, by 8ft. 9in. beam, with an average draught of 2ft. 3in., her full complement being 40 fully-equipped soldiers. The battery consists of 70 Epstein cells, and the motor, which drives a two-bladed screw 22in. in diameter, will develop 5½ B.H.P. at 750 revolutions. The anticipated speed is eight knots. It is the intention of the Royal Engineers to make some exhaustive trials with this type of boat.

**Godalming.**—At the last meeting of the Town Council the report of the Electric Lighting Committee recommending the adoption of the electric light was carried, after some discussion, by 11 votes to 3. The proposed municipal plant will comprise two 65-H.P. engines, two arc-light dynamos, and three incandescent-light dynamos. The mains are to be laid in subways; the street lamps to be 35 arcs of 300 c.p. each; provision for private lights to be 800 incandescent lamps of 16 c.p. It is estimated that the site and necessary buildings will cost from £1,200 to £1,500, making the total outlay for plant, site and buildings nearly £7,000. The profit shown amounts to £352. 10s. per annum. This is based on the condition of 700 lights being taken up at an average price of 27s. 6d. per light.

**Personal.**—Messrs. Miller and Woods have commenced business as electrical engineers and contractors. Mr. Miller, the inventor of the Miller ammeters and voltmeters, has been for the last three and a-half years in charge of the dynamo testing department of the Maschinenfabrik Oerlikon, near Zurich. He has erected many of the important transmission-of-power plants installed by the Maschinenfabrik, including the 600 H.P. transmission plant at Schaffhausen, referred to by Mr. Kapp in his recent Cantor Lecture. Mr. Woods has been for the last two years with the Liverpool Electric Supply Company. He is one of the joint authors with Prof. Ayrton of a Paper on Accumulators, read before the Society of Electrical Engineers at Edinburgh, and the winner of the Silver Medal at South Kensington Technological Examination.

**London County Council's General Powers Bill.**—In the Committee of Referees at the House of Commons, on Friday last, Mr. C. Parker presiding, the petitions of the various companies supplying the electric light in the Metropolis, to be heard against the London County Council (General Powers) Bill, were down for hearing. On the petitioners being called on, Mr. Wallace said he had come to an arrangement with Mr. Cripps, who appeared for the London County Council. It had been decided to strike out the petitions of the Brush Company, the Chelsea Electricity Supply Company, the Kensington and Knightsbridge Electric Light Company, the Metropolitan Electric Supply Company, and the Notting Hill Electric Light Company, leaving in the London Electric Supply Corporation and the Westminster Electric Supply Corporation. The Committee sanctioned the arrangement.

**Telegraphic Charges.**—"We agree with Mr. Henniker Heaton," says the *Financial News*, "that a State Department

Digitized by Google

with an annual surplus of £3,000,000 should be above profiting by lurking quibbles which would be discreditable to a struggling attorney. But the quibbles still lurk. Why should a telegram addressed to 'the Editor of the *Financial News*' be charged at full rates, while a communication addressed simply 'the *Financial News*' is treated as a press message? Why should 'Newcastle-on-Tyne' be one word and 'Clapham Junction' two words? Why should 'can't,' 'won't,' and 'don't' count as one word, while 'shan't' is treated as two? Possibly it is for the purpose of conveying a lesson in manners —at the price of one halfpenny; but that does not explain the fact that 'upstairs' is charged as one word and 'downstairs' as two."

**The National Telephone Company and its Border Subscribers.**—According to the Edinburgh *Evening News* of March 5th, a private meeting of the subscribers in the Border district of the National Telephone Company was held at Galashiels that afternoon to consider what steps should be taken with regard to the contracts and charges of the National Company. It was unanimously agreed that all the subscribers should give immediate notice to the Company to remove their telephones, and that those who had agreements with the Company which did not expire for six months should retain their instruments for that period. Notice was also to be given to the Company to remove their poles and wires from the subscribers' property at once. There are nearly 200 subscribers in the Border district. We are informed, however, that the National Company has received no confirmation of this announcement from their manager.

**United States Patent Publications.**—On Tuesday evening last Mr. Leng asked the Under-Secretary of State for Foreign Affairs whether he would direct the attention of Her Majesty's Minister in the United States of America to the fact that, while complete sets of the publications of the British Patent Office were presented to 12 of the most important cities in those States, a corresponding number of sets of the publications of the United States Patent Office were not sent to similar cities in this country, and that inventors were put to the inconvenience of visiting London to consult the only set of United States Patent Office publications accessible to them.——Mr. Stuart-Wortley stated, in reply, that the fact was as stated, but the matter was one which concerned the Board of Trade. The publications of the British Patent Office were not presented in consequence of any application made through the diplomatic channel from the Government of the United States. No application had been made to the Foreign Office to request from the United States Government copies of their publications in exchange.

**The Mica Industry in the United States.**—With the extraordinary growth of the electrical industry in the United States for a number of years past there has been created a new and steady demand for mica, says the *Engineering and Mining Journal*, which, curiously, has failed to stimulate the mica mining industry; the most important mines, indeed, show a decided decrease in production during this time, and the business is now in a depressed condition. In the construction of dynamos, electric motors, and other electrical appliances, mica is a very important element, valued on account of its flexibility and excellent insulating qualities. For this purpose, however, there is a decided preference for foreign mica, the Canadian "amber mica" being generally used. The foreign mica is considered preferable to that of North Carolina for electrical purposes, in that while the latter can be split into thin sheets, it is by no means so tough. The chief mines in the country are in New Hampshire and North Carolina, but principally in the latter State, these producing an excellent quality of the mineral. The total value of the production in the United States decreased from $368,525 in 1884 to $70,000 in 1890. During the same time the imports of mica, which, prior to 1884, had been of but trifling importance, increased from $28,284 to $57,541.

**Sibley College, Cornell University.**—The following extracts from a letter sent by Prof. R. H. Thurston to the Editor of *Industries* may be of interest:—"Until recently its charter permitted the holding of only $3,000,000, but that provision of the charter was repealed by the Legislature of the State of New York immediately upon the discovery that it was likely to cause the loss of a bequest, which now proves to have a value of about $2,000,000. The University has actually met with this great loss; but, the horse being stolen, the stable door has been effectively locked, which gives us the privilege of receiving and holding, hereafter, any number of millions. I am happy to say that this institution, pledged to make its 'leading object' for ever the promotion of the useful arts, now has above a million of pounds invested, and so well placed that its trustees receive an average of 6 per cent., and have never lost a fraction of a per cent. of the principal. We shall have, at the close of the current, or at the beginning of the coming collegiate year, about $200,000 in equipment. It will include an 'experimental steam engine' of about 200 H.P. triple-expansion, with Corliss valves, adjustable in all possible ways to enable us to make investigations of the effects of varying ratios of expansion from 0 to unity, varying steam-pressures from 2 to 15 atmospheres, varying speeds from a minimum to probably 200 revolutions a minute, and all desirable adjustments of steam and exhaust valves for other purposes. A number of other engines—steam, gas, and hot-air—are used in the regular course of laboratory instruction, a collection of dynamometers, steam-boiler injectors, hydraulic apparatus, and a great variety of testing machines, including—standing in a row—one of 50, one of 100, and one of 150 tons capacity, and a number of smaller ones of various types and sizes. With such an outfit we handle 200 students in the laboratory, having 450 (nearly) in all classes, including graduate students engaged in research."

**The Flow of Current Through an Electric Arc.**—In a recent number of the "Repertorium der Physik" there is a Paper by H. Luggin, which contains a minute description o experiments made to determine the laws which govern the flow of current across an electric arc between carbon-points, and from an abstract of this Paper, published by the Institution of Civil Engineers, we take the following facts. Referring to the anode, Luggin distinguishes two kinds of discharges, the one taking place from the crater with considerable current density, and the other from the surrounding rim with a smaller current density, and at lower temperature. The vertical variation of potential was investigated by means of test-pencils inserted at different points. When the point of the test-pencil (a carbon rod 1·3 millimetre diameter) was placed well within the crater, the mean potential difference between the luminous surface of the anode and the layer of hot gases immediately contiguous to it was found from a mean of five observations to be 33·7 volts. The corresponding value at the kathode was found from six observations as 8·78 volts, whereas Uppenhorn had previously determined the potential differences as 32·5 and 5·2 volts. According to the author's estimate, that part of the potential differences between the electrodes, which is caused by the transition from the solid to the gaseous conductor, and is therefore independent of the length of arc, amounts to 42·5 volts, which is the sum of the values above given. The experiments were made with currents up to 20 amperes, and electrodes of sufficient size in each case to prevent the arc from hissing. A series of experiments was made to determine the hissing-point, which the author found is reached when the current density exceeds about ½ ampere per square millimetre (323 amperes per square inch) of crater surface. For hissing arcs the potential difference between the anode surface and the layer of hot gases next to it is greater, but it does not increase in proportion with the current density, and it would therefore be incorrect to ascribe this potential difference to the existence of a constant resistance. Although this consideration would naturally lead to the assumption that the arc is the seat of a counter-electromotive force, the author has failed to detect the slightest polarisation of the electrodes after the current was interrupted. By carefully-contrived mechanism he was able to make connection between the electrodes and a delicate electrometer within the 0·005 part of a second after cutting off the current, and yet not a trace of charge could be detected in the electrometer needle. The author does not, therefore, believe it possible that the arc can be the seat of a counter-electromotive force of 40 volts as suggested by Dub.

Digitized by Google

## ELECTROMAGNETIC THEORY.—VI.

BY OLIVER HEAVISIDE.

*(Continued from page 508.)*

§ 33. The two sets of quantities, the electric and magnetic forces, with their corresponding fluxes and currents, and the connected products and ratios, may be considered quite independently of one another, without any explicit connection being stated between the electric set and the magnetic set, whether they coexist or not. But to have a dynamical electromagnetic theory, we require to know something more, viz., the cross-connections or interactions between **E** and **H**. Or, in another form, we require to know how an electric field and a magnetic field mutually influence one another.

One of these interactions has been already partially mentioned, though only incidentally, in stating the meanings of permeance and inductance. It was observed that the electric current in a simple conductive circuit was measured by the gaussage in the corresponding magnetic circuit.

A word has been much wanted to express in a convenient and concise manner the property possessed by some fluxes and other vectors of being distributed in closed circuits. This want has been recently supplied by Sir W. Thomson's introduction of the word "circuital" for the purpose. Thus electric current is a circuital flux, and so is magnetic induction. The fundamental basis of the property is that as much of a circuital flux enters any volume at some parts of its surface as leaves it at others, so that the flux has no divergence anywhere. This qualification, "anywhere," should be remembered, for a flux which may diverge locally, as, for instance, electric displacement, is not circuital in general, though even electric displacement may be circuital sometimes. Further, as a flux need not be distributed throughout a volume, but may be confined to a surface, or to a line, we have then specialised meanings of circuital and of divergence. Or a volume-distribution and a surface or line-distribution of a flux may be necessarily conjoined, without, however, any departure from the essential principle concerned.

The word "circuital," which will be often used, suggested to me the word "circuitation," to indicate the often-occurring operation of a line-integral in a closed circuit; as, for instance, in the estimation of circuital voltage or gaussage. Now, in the case of a moving fluid, Sir W. Thomson called the line-integral of the velocity in a closed circuit the "circulation." This is curiously like "circuitation." But "circulation" seems to have too specialised a meaning to be suitable for application to any vector, and I shall employ "circuitation." The operation of circuitation is applicable to any vector, whether it be circuital or not.

§ 34. Now in the case of a simple conductive circuit, we have two circuital fluxes. There is a circuital conducting core supporting an electric current, and there is a circuital flux of induction through the conductive circuit. In the electric circuit we have Ohm's law,

$$E = RC, \quad \dots\dots\dots \quad (1)$$

where E is the circuital voltage, C the current, and R the resistance. And in the magnetic circuit we have a formally similar relation,

$$H = L^{-1}B, \quad \dots\dots\dots \quad (2)$$

where H is the circuital gaussage, B the induction, and $L^{-1}$ the reluctance. Or,

$$B = LH, \quad \dots\dots\dots \quad (3)$$

where L is the inductance (or the permeance, when there is only one turn of wire).

Now, the cross-connection in this special case is implied in the assertion that H and C are the same quantity, when measured in rational units. The expression of the law of which this is an illustration, is contained in any of the following alternative statements.

The line-integral of the magnetic force in any closed circuit measures the electric current through any surface bounded by the circuit. Or,

The circuitation of the magnetic force measures the electric current through the circuit. Or,

The electric current is measured by the magnetic circuitation, or by the circuital gaussage.

The terminology of electromagnetism is in a transitional state at present, owing to the change that is taking place in popular ideas concerning electricity, and the unsuitability of the old terminology, founded upon the fluidity of electricity, for a comprehensive view of electromagnetism. This is the excuse for so many new words and forms of expression. Some of them may find permanent acceptation.

The above law applies to any circuit of any size or shape, and irrespective of the kind of matter it passes through, meaning by "circuit" merely a closed line, along which the gaussage is reckoned. By "the current" is to be understood *the* current; not merely the conduction current alone, or the displacement current alone, but their sum (the convection current term will be considered separately).

It is also necessary to understand that a certain convention is implied in the statement of the law, regarding positive senses of translation and rotation when taking line and surface integrals. Look at the face of a watch, and imagine its circumference to be the electric circuit. The ends of the pointers travel in this circuit in the positive sense, if you are looking through the circuit along its axis in the positive sense. Also, you are looking at the negative side of the circuit. Thus, when the current is positive in its circuit, the magnetic induction goes through it in the positive direction, from the negative side to the positive side. Otherwise, the positive sense of the current in a circuit and the induction through it are connected in the same way as the motions of rotation and translation of a nut on an ordinary right-handed screw. This is the "vine" system used by all British writers; but some continental writers use the "hop" system, in which the rotation is the other way, for the same translation. It is useless trying to work both systems, and when one comes across the left-handed system in papers, it is, perhaps, best to marginally put the matter straight, and then ignore the text.

§ 35. The other cross-connection required is a precisely similar relation between voltage and magnetic current, with, however, a change of sign. Thus :—

The negative line-integral of the electric force in any circuit (or the electric circuitation) measures the magnetic current through the circuit. Or

The voltage in any circuit measures the magnetic current through the circuit taken negatively.

Magnetic current is measured by the circuital voltage reversed ; and other alternative equivalent statements.

§ 36. In the above laws of circuitation the currents are the concrete currents (surface-integrals), and the forces also the concrete voltage or gaussage. When we pass to the unit volume it is the current-density that is the flux. The circuitation of the force is then called its "curl." Thus, if **J** be the electric current and **G** the magnetic current, the two laws are

$$\text{curl } \mathbf{H}_1 = \mathbf{J}, \quad \dots\dots\dots \quad (4)$$

$$-\text{curl } \mathbf{E}_1 = \mathbf{G}, \quad \dots\dots\dots \quad (5)$$

where $\mathbf{E}_1$ and $\mathbf{H}_1$ are the electric and magnetic force of the field. We may now say concisely that

The electric current is the curl of the magnetic force.

The magnetic current is the negative curl of the electric force.

There is nothing transcendental about "curl." Any man who understands the laws of circuitation also understands what "curl" means, though he may not himself be aware of his knowledge, being like the Frenchman who talked prose for many years without knowing it. The concrete circuitation is sufficient for many problems, especially those concerning linear conductors in magnetic theory. But it does not suffice for mathematical analysis, and to go into detail we require to pass from the concrete to the specific and use curl. How to manipulate "curl" is a different matter altogether from clearly understanding what it means and the part it plays. The latter is open to everybody; for the former, vector-analysis is most suitable.

Let a unit area be chosen perpendicular to the electric current **J**. Its edge is then the circuit to which $\mathbf{H}_1$ belongs in (4). The gaussage in this circuit measures the current-density. Similarly, regarding (5), the voltage in a unit circuit perpen-

Digitized by Google

dicular to the magnetic current measures its density (negatively). In short, what circuitation is in general, curl is the same per unit area.

§ 37. In the statement of the laws of circuitation, I have intentionally omitted all reference to impressed forces. That there must be impressed forces is obvious enough, because a dynamical system comprehending only the electric and magnetic stored energies and the Joulean waste, is only a part of the dynamical system of Nature. We require means of showing the communication of energy to or from our electromagnetic system without having to enlarge it by making it a portion of a more complex system. Thus, taking it as it stands at present, the activity per unit volume we have seen to be

$$\mathbf{EJ} + \mathbf{HG} = Q + \dot{U} + \dot{T}, \quad . \quad . \quad . \quad . \quad . \quad (6)$$

where the left side expresses the activity of the electric and the magnetic force on the corresponding currents, and the right side what results, viz., waste of energy, Q per second, and increase per second of the electric energy U and the magnetic T; and, as there are supposed to be no impressed forces, if we integrate through all space, we shall obtain

$$0 = \Sigma\,(Q + \dot{U} + \dot{T}), \quad . \quad . \quad . \quad . \quad . \quad (7)$$

where $\Sigma$ means summation of what follows it. Or, if $Q_0$ be the total waste, and similarly $U_0$ and $T_0$ the total energies,

$$0 = Q_0 + \dot{U}_0 + \dot{T}_0,$$

meaning, that whatever energy there be wasting itself is derived solely from the electric or magnetic energy, which decrease accordingly. This is the persistence of energy when there are no impressed forces.

Now, if there be impressed forces communicating energy at the rate A, the last equation must become

$$\Sigma\,\mathbf{fv} = A = Q_0 + \dot{U}_0 + \dot{T}_0, \quad . \quad . \quad . \quad . \quad (8)$$

and A must be the sum of the activities of the impressed forces **f** in the elements of volume, in whatever way space may be divided into elements, large or small, and however we may choose to reckon the impressed forces. There may be many ways of doing it; **f** may sometimes, for example, be an ordinary force, and **v** the velocity to match is then a translational velocity. But for our immediate purpose, it is naturally convenient to reckon the impressed forces electrically and magnetically; so that the corresponding velocities are the electric and magnetic currents. We shall then have, if **e** be the impressed electric, and **h** the impressed magnetic force,

$$\mathbf{eJ} + \mathbf{hG}$$

to represent their activity per unit volume, and in all space,

$$\Sigma\,(\mathbf{eJ} + \mathbf{hG}) = \Sigma\,(Q + \dot{U} + \dot{T}) \quad . \quad . \quad . \quad (9)$$

instead of (7). This is the integral equation of activity. We cannot remove the sign of summation and make the same form do for the unit volume, for this would make every unit volume independent of the rest, and do away with all mutual action between contiguous elements and transfer of energy between them. This matter will be returned to in connection with the transference of energy.

38. The distinction between $\mathbf{H}_1$ and **H** and between $\mathbf{E}_1$ and **E** is often a matter of considerable importance. We have

$$\mathbf{H} = \mathbf{h} + \mathbf{H}_1, \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

$$\mathbf{E} = \mathbf{e} + \mathbf{E}_1. \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

Now it is **E** and **H** that are effective in producing fluxes. Thus **E** is the force of the flux **D** and also of **C**; and **H** is the force of the flux **B**. On the other hand, in the laws of circuitation, as above expressed, the impressed forces do not count at all; so that we have, in terms of the forces **E** and **H**,

$$\text{curl}\,(\mathbf{H} - \mathbf{h}) = \mathbf{J}, \quad . \quad . \quad . \quad . \quad . \quad (12)$$

$$-\,\text{curl}\,(\mathbf{E} - \mathbf{e}) = \mathbf{G}, \quad . \quad . \quad . \quad . \quad . \quad (13)$$

equivalent to (4) and (5). To distinguish from the forces of the fluxes, I sometimes call $\mathbf{E}_1$ and $\mathbf{H}_1$ the forces "of the field." Of course they only differ where there is impressed force. As the distribution of the energy, as well as of the fluxes depends upon **E** and **H**, it is usually best to use them in the formulæ.

*(To be continued.)*

## ELECTRO-MAGNETIC REPULSION.*

BY PROF. J. A. FLEMING, M.A., D.SC., M.R.I.

§ 1. On the 2nd day of October, 1820, Ampère presented to the Royal Academy of Sciences in Paris an important memoir, in which he summed up the results of his own and Arago's previous investigations in the new science of electro-magnetism, and crowned that labour by the announcement of his great discovery of the dynamical action between conductors conveying electric currents.† Respecting that achievement, when developed in its experimental and mathematical completeness, no less a writer than Clerk Maxwell calls it "one of the most brilliant in the history of physical science." Our wonder at what was then accomplished is increased when we remember that hardly more than two months before that date John Christian Oersted had startled the scientific world by the announcement of the discovery of the magnetic qualities of the space near a current-traversed conductor. Oersted called the actions going on around the conductor the "electric conflict," and in his first Paper,‡ in describing the newly-observed facts, he says:—"It is sufficiently evident that the *electric conflict* is not confined to the conductor, but is dispersed pretty widely in the circumjacent space." "We may likewise collect," he adds, "that this conflict performs circles round the wire, for without this condition it seems impossible that one part of the wire when placed below the magnetic needle should drive its pole to the east and when placed above it to the west." These few words are taken from the original paper, which stimulated the philosophic thought of Ampère and his contemporaries, and started into existence a wave of discovery, placing us in possession of the facts which form our starting point to-night.

§ 2. It will be unnecessary to spend more than a moment or two in illustrating the now familiar interactions of two circuits traversed by currents in the same or opposite directions. Holding a circular coil traversed by a continuous electric current near to a similar circuit free to move, we are well aware that when the circuits are parallel to each other there is an attractive force between them if the currents in adjacent parts of the circuits flow in the same direction and a repulsive effect if they flow in the opposite. This is the electro-dynamic action discovered by Ampère and utilised in the construction of instruments for the measurement of electric currents in practical work. If one such conducting coil, such as that of the electro-magnet now before me, is traversed by an alternating current, and the other is simply a closed circuit or coil placed a little distance off, but in its field, I feel sure I am free to assume that all here are aware of the effect which will be produced. The closed circuit becomes the seat of an alternating induced current, which, if our inducing current is sufficiently powerful, can be made to render itself evident by illuminating a small incandescent lamp placed in the secondary circuit.|| Notice, however, that in performing the experiment the secondary circuit must be so placed that the magnetic lines of force of the primary coil perforate through the secondary circuit. If the secondary circuit is held in such a position that the reversal of direction

* A discourse delivered at the Royal Institution of Great Britain on Friday evening, March 6, 1891.

† Mémoire Présenté à l'Académie Royale des Sciences le 2 Octobre, 1820, où se trouve compris le résumé de ce qui avait été lu à la même Académie les 18me et 25me Septembre, 1820, sur les effets des courants Electrique par M. Ampère. *See* Vol. XV. *Annales de Chimie*, 1820.

‡ In the *Annals of Philosophy* for October, 1820, Vol. XVI., p. 274, is to be found an English translation of Oersted's original Latin essay, dated July 21, 1820, describing his immortal discovery. This Paper is entitled "Experiments on the Effect of a Current of Electricity on the Magnetic Needle," by John Christian Oersted, Knight of the Order of Danneborg, Professor of Natural Philosophy in Copenhagen.

|| The experiments here referred to were mostly performed with an alternating-current magnet, having a core of divided iron about 3in. in diameter and 12in. long, excited by a Siemens alternating-current dynamo giving a current at an electromotive force of rather less than 200 volts. A small shelf around the core a little above the middle serves as a support for rings, &c., to be projected. The performance of these experiments on a scale suitable for large audiences requires from 10 to 15 horse-power at least, and can hardly be shown well unless the alternator can provide a current of 100 amperes at 100 volts available at the moment of maximum demand. The magnet of course takes very little actual current until the metal plate or ring is held near it, when the impedance is immediately reduced.

Digitized by Google

of the primary current causes no reversal of direction of the magnetic field traversing the secondary circuit, because it is not linked with any of the lines of force of the primary, the secondary circuit is no longer the seat of any induced current.

Note also that this electro-magnetic induction whilst taking place across space, is not interfered with by the interposition of a non-conducting screen. The magnetic induction passes freely through an inch board or a plate of glass, but if we interpose a thick copper sheet (Fig. 1.) we cut off the secondary current or screen the secondary circuit from the inductive action of the primary. The secondary coil is, in fact, an electro-magnetic eye which can *see through* an inch of wood, but to which a sheet of zinc is semi-transparent, and a thick sheet of copper quite opaque, as far as the electro-magnetic radiation of the wave-length employed is concerned. The rapid heating of this copper screen makes us aware that the secondary currents are now being induced in the copper sheet in the form of eddy currents, and it screens the secondary circuit because the inductive action of these eddy currents on the side remote from the magnet is exactly equal and opposite to that of the primary circuit on the secondary coil.

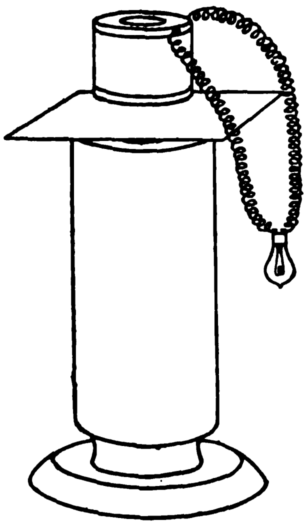


FIG. 1.—Copper Plate interposed between a Primary and a Secondary Coil, and shielding the Secondary from Induction.

§ 3. Connecting together these elementary facts, we are easily able to explain another well-known fact. If a continuous current is sent through the coils of a large electro-magnet, and we magnetise its iron core very powerfully, it is found to be impossible to strike the pole of the magnet a sharp blow by means of a sheet of copper. Holding a sheet of copper over such a magnetic pole, and energising the magnet, the hand holding the copper sheet feels a repulsive action at the moment when the current is put on and an attractive action when it is cut off. If we try to slap the magnet sharply with the copper sheet, it is found that this repulsive force prevents anything like such a sharp blow being given to the pole when the current is on, as can be given when the current is off. Moreover, when a very powerful electro-magnet is employed, it is found that a disc of copper let fall over the pole does not fall down sharply and quickly on to it when the current is flowing through the coils of the magnet, but settles down softly and slowly as if falling through some sticky fluid. We know that the correct explanation of these facts is to be found in the statement that the motion of the conductor towards the magnetic pole causes eddy electric currents to be generated in it by electro-magnetic induction, and that these being in the opposite direction to the energising current of the magnet cause a repulsive force to exist between the inducing and secondary circuits which creates the apparent resistance we feel.

In order to exhibit the stress brought into existence between an electro-magnet and a metal sheet held near it when induced currents are set up in the disc, we have arranged the following experiment :—Over the pole of a powerful electro-magnet we have balanced a small disc of copper, the size of a penny, carried on one end of a delicately-balanced bar. A mirror attached to that bar serves to reflect on to the screen a ray of light indicating the smallest motion of the copper piece. On magnetising the magnet the copper is suddenly repelled, but comes to rest again immediately in its initial position. When the magnet is demagnetised the copper experiences a momentary attraction. These attractions and repulsions are obviously due to the Ampèrian stress set up between the magnet and the metal by reason of the induced currents set up in the latter. Impulsive effects of this nature have been particularly studied by Mr. Boys (see *Proc. Phys. Soc. of London*, Vol. VI., p. 218, *A Magneto-electric Phenomenon*).

§ 4. Let me, in the next place, ask you to contemplate a circuit, say a closed conducting ring, suspended in front of the

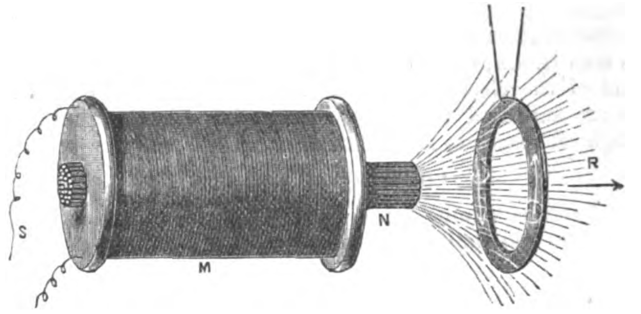



FIG. 2.—Copper Ring hung in the Field of an Electro-magnet, and repelled or attracted when the Current is put on or cut off.

pole of an electro-magnet, and that the coils of the electro-magnet are transversed by an alternating-current of electricity (Fig. 2). The magnetic field of the magnet is then an alternating field. We shall suppose it to vary in strength, according to a simple periodic law. The closed circuit is therefore subjected to an inductive action, and we know that the induced electromotive force in that circuit is at any instant proportional to the rate of change of the magnetic field in which it is immersed. If, therefore, the variation in strength of that field is represented geometrically by the ordinates of a periodic

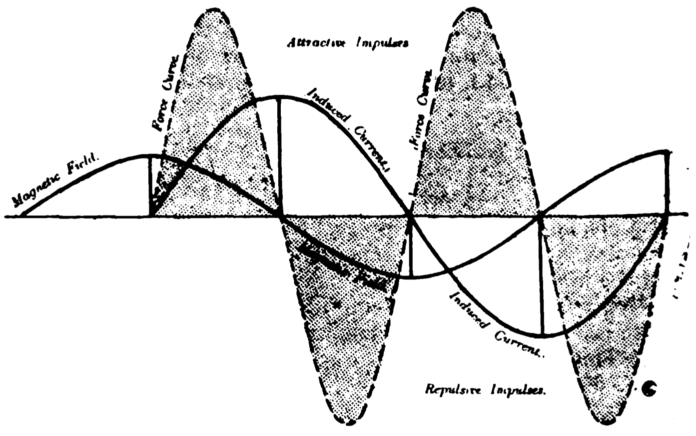



FIG. 3.—Diagram showing the equality of the attractive and repulsive impulses in a non-inductive circuit when held in an alternating Magnetic Field.

curve, the varying electromotive force acting in the ring circuit is represented by the ordinates of another such curve of equal wave length, shifted a quarter of a wave length behind the first. In the diagram before you the variation of the induced magnetic field, and the induced electromotive force in the circuit, are represented as usual by two harmonic curves. This induced electromotive force creates an induced current flowing backwards and forwards in the ring, and we shall, in the first instance, suppose that this current flows in exact synchronism with its electromotive force. The induced current and the inducing magnetic field may therefore be represented as to relative phase and strength by the curves in the diagram (Fig. 3). The dynamical action, or the force which the ring experiences, is at any instant proportional to the product of the strength of the magnetic field

Digitized by Google

in which the ring is immersed and to the strength of the induced current created in it. If we multiply together the numerical values of the ordinates of these two curves at any and every point on the horizontal line, and set up a new ordinate at that point representing this product, the extremities of these last ordinates define a curve, which is a curve representing the *force* acting on the secondary circuit, and it is, as you see from the diagram Fig. 3, a wavy curve having a wave length equal to half that of the first two curves. Moreover, the whole area enclosed between the outline of this force curve and the horizontal line represents to a certain scale the time integral of that force, or the *impulse* acting on the secondary circuit, and the theory shows us that, under the assumptions made the secondary circuit so acted upon experiences in each period of the current four impulses, two positive or repulsive, and two negative or attractive. Hence, it comes to this, that such an ideal conducting circuit held in front of an alternating electro-magnet should experience a rapid alternate series of equal pushes and pulls, or of little impulses to and from the magnet. These equal and opposite impulses in quick succession would neutralise one another, and our supposed circuit would not, on the whole, be subject to any resultant force.

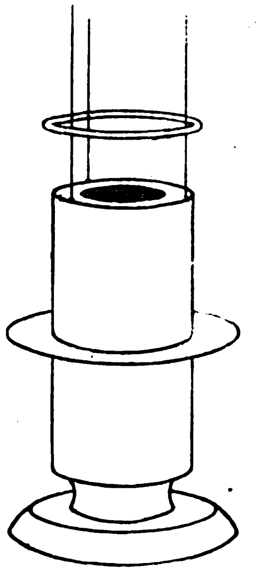


FIG. 4.—Aluminium ring projected rom the pole of an alternating electro-magnet, and floating over the ole when restrained by three strings.

§ 5. Quite otherwise is it, however, when we present a real conducting circuit to the pole of an electro-magnet traversed by a powerful alternating current. We find that under the actual circumstances there is a powerful repulsive action between the pole and the circuit. The exact nature of the electro-magnetic repulsion it is our business now to explore.

Taking in my hands a copper ring, I hold it over the pole of this powerful vertical alternating electro-magnet, and find at once that there is a perceptible and strong repulsion. Letting the ring go, it jumps up into the air, impelled so to do by the electro-magnetic repulsion acting upon it (Fig. 4). All good conducting rings will execute this gymnastic feat, and rings of copper and aluminium are found to be most nimble of all. Rings of zinc and brass are sluggish, and a ring of lead will not jump at all. We owe the discovery of this striking effect to Prof. Elihu Thomson, and he has explored in all directions the consequences and nature of this interesting effect. Why is it that our real copper and metal rings behave so differently, when immersed in an alternating field, to ideal rings of conducting matter? The explanation is not very difficult to find. The real ring possesses a quality, called its inductance, of which we took no account in our examination of the case a moment ago.

§ 6. Before me lies a very large bobbin of wire (Fig. 5), and the ends of this coil are connected to an incandescent lamp. We send a current of electricity through the bobbin and the lamp, and have arranged matters as in the diagram before you, so that the current divides through the two circuits of lamp and bobbin. Under these circumstances, the divided current is just sufficient to illuminate faintly the lamp. I break the circuit of the battery, and you see that the lamp flashes up for a moment, and we are well aware that this effect is due to the electro-magnetic momentum of the coil, or to its inductance, in virtue of which the current continues to flow on in the bobbin for a short period after the impressed electromotive force is withdrawn. Also, we know that there is a small but definite time required before the current practically reaches its full strength in the bobbin when the electromotive force is again applied. These effects are the self-induc-

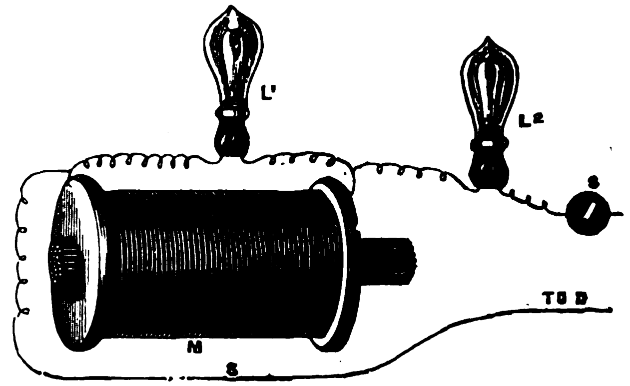



FIG. 5.—Incandescent Lamp and coil arranged to exhibit the effect of the inductance of the coil.

tive effects of a coil first noticed by Prof. Joseph Henry in 1832, and subsequently fully examined in the ninth series of Faraday's Experimental Researches in Electricity. Every circuit of any kind, disc, ring, or coil of wire, possesses a certain degree of this quality of self-induction, and, as a natural consequence, it follows therefrom that if that circuit is subjected to a periodically varying electro-motive force acting upon it, that the current produced in it will always be in arrear of the electromotive force in phase. The current induced lags in phase behind the inducing electromotive force. This "lag" of the current behind the impressed harmonically varying electromotive force in conse-

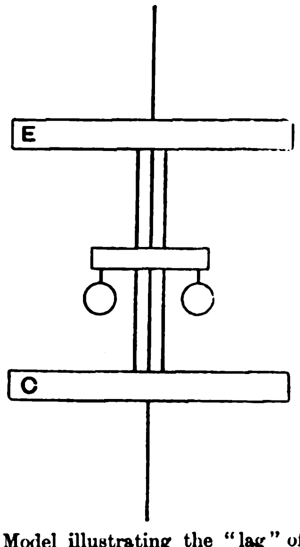



FIG. 6.—Mechanical Model illustrating the "lag" of the current in an inductive circuit.

quence of self-induction may be illustrated mechanically thus: Three light wooden laths are connected together by a flat steel band, and the system hung up by a string like a pair of astatic magnetic needles (Fig. 6). If we take hold of the upper rod and move it backwards and forwards on a horizontal plane, compelling it to execute harmonic oscillations, the upper and lower rods move together synchronously. Let the upper rod symbolise impressed electromotive force, and the lower rod resulting current. Under present circumstances, these two move always in step with one another. Next load down the middle rod or connecting mechanism by means of two lead weights, and give it *inertia*. On again taking hold of the upper rod and causing it to execute forced harmonic oscillations, the

Digitized by Google

lower rod no longer vibrates in tune with it. It lags in phase behind the top one, and we thus illustrate, though not perhaps by a perfect mechanical analogy, the effect of electric inertia in the intermediate mechanism in causing a lag of current behind impressed electromotive force.

§ 7. Returning for an instant to the diagram we considered just now, we must correct it to make it fit in with the facts of nature, and we must represent the periodic curve which stands for the fluctuations of the induced current in the ring as shifted backwards or lagging behind the curve which represents the electromotive force in the circuit brought into existence by the fluctuating magnetic field. Making this change in our diagram (Fig. 7), and forming as before a force curve to represent the impulses on the ring, we now find that owing to the "lag" of the secondary current, one set of the impulses, namely, the positive or repulsive impulses have been enlarged at the expense of the negative or attractive impulses. Theory, therefore, points out that as a consequence of the self-induction of the ring the balance between the attractive impulses and repulsive impulses is upset and that the latter predominate. Our real ring behaves, therefore, very differently to our ideal ring. The real ring, is strongly repelled because the resultant action of all the impulses is to produce on the whole an electro-magnetic repulsion. This repulsion is evidence of the self-induction of the circuit exposed to the magnetic field, and it forms a new way of detecting it. But although this is part of the truth,

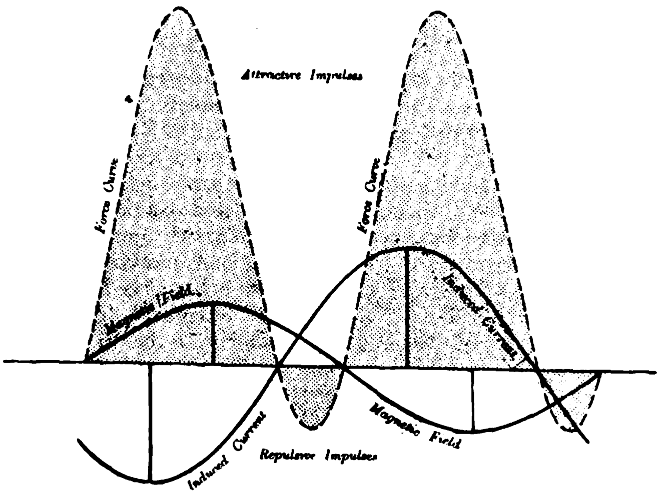



Fig. 7.—Diagram showing the inequality of the attractive and repulsive impulses in the case of an inductive circuit when held in an alternating Magnetic Field.

it is not the whole truth. The lag of the induced current in the ring, and hence the predominance of the repulsive impulses depends on the conductivity of the material of which the ring or circuit is made; and the better this conductivity the greater is that repulsion, both because the induced current and the "lag" are thereby increased. Hence it comes to pass that there are two factors involved in making this repulsive effect, the conductance of the ring or disc and its inductance. For equal conductivities, the greater the self-induction the greater the repulsion. For equal self-inductions, the greater the conductivity of the circuit so much the more repulsive effect will be produced. Time does not permit me to enlarge on the strict analysis of the effect. Its broad outlines are indicated, perhaps, sufficiently by what has been said.

§ 8. We can show the effect of the relative conductivity by discs of equal size, and therefore of equal self-induction, of *weighing* similar discs of various metals over an alternating pole. Here, for instance, are discs of copper, zinc, and brass of equal form and size. Placing these discs on the scale pan of a balance, and suspending them over the alternating pole, I am able to prove that the repulsion on the copper disc is greater than that on the zinc, and that on the zinc greater than that on the brass.*

* Experiments of this kind have been made by M. Borgman. See *Comptes Rendus*, No. 16, April 21, 1890, p. 849, and also February 3, 1890, Vol. CX., p. 233.

The same result can be illustrated by placing over the pole of our alternating magnet a paper tube. Taking one of the copper rings in my hand, and first exciting the magnet, I let the ring drop down the tube. It falls as if on an invisible cushion that buoys it up, and it remains floating in the air. If rings of different metals and equal size are placed on the tube, they float at different levels like various specific-gravity beads in a liquid. The greater the conductivity of the ring the greater is the repulsion on it, in any given part of the alternating field, and hence the highly conducting rings will be sustained on a weaker field than the

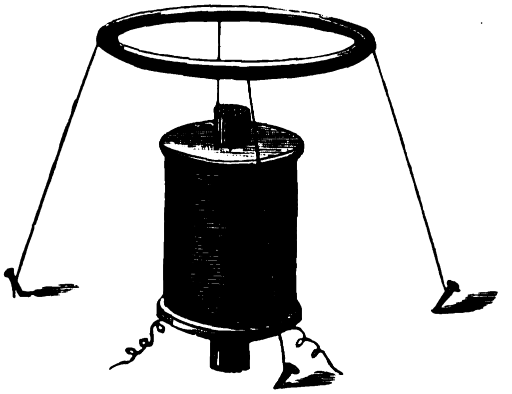


Fig. 8.—Copper ring "floating" in air over the pole of an alternating current electromagnet, when restrained by three strings.

feebler conducting rings, assuming the rings to have about equal weights. Moreover, we are able to show by another experiment the fact that these rings are traversed, when so held, by powerful electric currents. If we press down the copper ring upon the zinc or brass ring floating beneath it, the rings are attracted together and the copper ring holds up the zinc. This is obviously because the rings are all traversed by induced currents circulating in the same direction.

§ 9. It is, of course, an immediately obvious corollary, from all that has just been said, that any cutting of a ring or disc

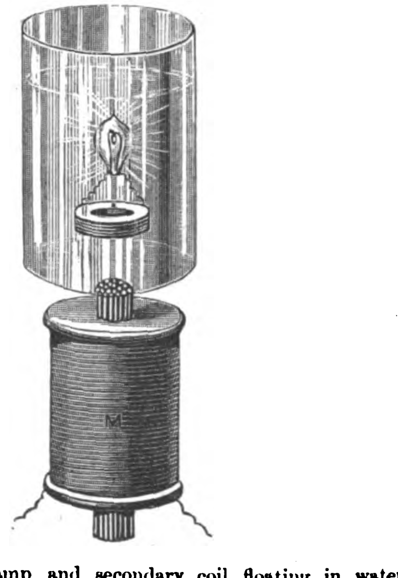


Fig. 9.—Incandescent lamp and secondary coil floating in water and repelled by an alternating current electromagnet, placed beneath.

which hinders the flow of the induced currents causes the whole of the repulsion effects to vanish. We illustrate this by causing a ring of copper wire to jump off the pole, and then cutting it with pliers, find it has ceased to be capable of giving signs of life. When the metallic masses or circuits which are presented to the alternating magnetic pole are of very low resistance the electromagnetic repulsion may become very powerful, many pounds of thrust or push being produced by apparatus of quite moderate size. It is, in fact, quite startling to hold over the pole of such an alternating magnet as I have before me a very thick

Digitized by Google

plate of high conductivity copper. It would greatly surprise any one not acquainted with these principles to be told that a massive copper ring weighing eight or ten pounds could be made to float in the air, but you have ocular demonstration before you that this feat can be performed. The ring needs to be tethered by a couple of light strings, to prevent it from being thrown off laterally, although these strings in no way support its weight (Fig. 8).

One of the most beautiful of Prof. Elihu Thomson's experiments exhibits this effect of electro-magnetic repulsion on a closed coil, which is buoyed up in water by a small incandescent lamp in circuit therewith. In the glass vase before you floats a little glow-lamp like a balloon (Fig. 9). The car consists of a coil of insulated wire, and the ends of this coil are connected with the lamp. The whole arrangement is accurately adjusted to just, or only just, float in water. Placing the vase over an alternating magnetic pole, you see that the magnetic induction creates a current in the coil which lights the lamp, and, moreover, that the electro-magnetic repulsion on the coil causes the lamp and coil to rise upward in the water.

*(To be continued.)*

## PHYSICAL SOCIETY.

At a meeting of this society on March 6, 1891, Mr. James Swinburne read a

**"Note on Electrostatic Wattmeters."**

After referring to the history of the electrometer method of measuring power developed by alternating currents, the author pointed out that the necessity for taking two readings from which to determine the watts might be obviated by having the quadrants

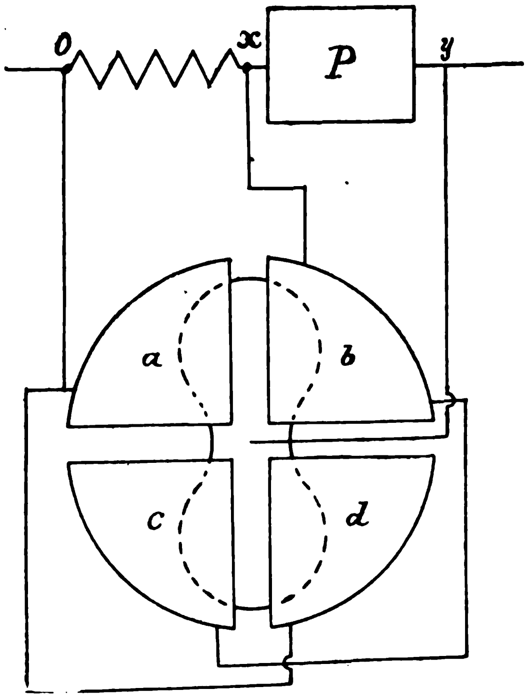



Fig. 1.—Electrometer arranged to measure watts with two readings.

separate instead of connected in pairs, as in the ordinary method. When Joubert published his tests of a Siemens dynamo, Profs. Fitzgerald and Ayrton simultaneously suggested the use of an electrometer as wattmeter. Non-inductive resistances are connected to the transformer, motor, or other apparatus in which the power is to be measured, so as to be in series with the apparatus, and on opposite sides of it, and the four ends of these two resistances are connected with the four quadrants. Under these circumstances the deflection of the needle is a measure of the watts. The disposition is shown in Fig. 1. A non-inductive resistance, $o$, $x$, is in series with the part of the circuit to be measured, and the quadrants, $a$, $b$, $c$, $d$, are in shunt to it, so that their potentials are $o$ and $x$. The needle is connected to the other side of the circuit to be tested, and is at potential $y$. If the fall of potential over the resistance is small, the instrument is not sensitive—if large, it is not accurate. Prof. Ayrton has, therefore, introduced an accurate method depending on two readings. By using two equal resistances the quadrant electrometer may be arranged to read power directly. This is shown in Fig. 2. The quadrants, $a$, $b$, $c$, $d$, are at the potentials $o$, $x$ and $y$, and $x+y$ respectively. As this arrangement involves an end, or a side pull on the needle, another arrangement

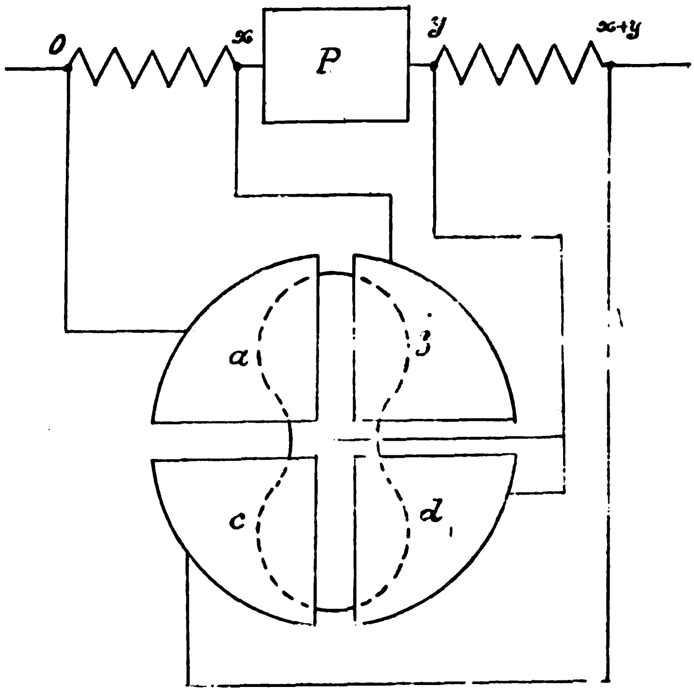



Fig. 2.—Electrometer arranged to read Power directly.

shown in Fig. 3 is better for commercial work. To increase the maximum deflection obtainable so as to make an instrument capable of being read by a pointer, the needle is made in two halves fixed one below the other on the same stem, and, instead of quadrants, semicircular boxes are employed. The needle consists of two half-discs, each between pairs of fixed half-discs. A metal torsion suspension may then be used, and the needle may have a mirror or index. It can be made to read direct, through an arc of 120° or so. The electromagnetic wattmeter is the most suitable instrument for measuring low pressure powers, but it needs many spare coils to

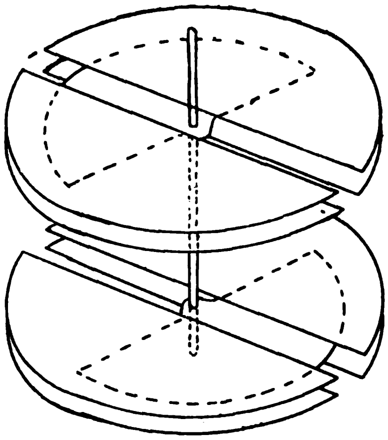


Fig. 3.—Electrometer with semicircular "needles" for measuring watts.

give it a large range. For high pressure work, such as measuring power lost in condensers, the electrometer is more convenient.

Prof. Perry inquired as to what kind of *law* the instrument had, and Mr. Blakesley asked whether it was convenient to use.

Mr. E. W. Smith pointed out that there was no necessity to take two observations in the ordinary electro-meter method, for, by using a false zero, one deflection gave the watts. Further, the use of the false zero rendered it unnecessary to employ any other voltmeter when experimenting at constant pressure.

The President said the historical part of the Paper was not quite correct, and recalled attention to the fact that when high pressures were used, a single reading obtained with the ordinary method of connecting up gave the power. For ordinary low voltages, however, the false zero method, described by Mr. Smith, was very convenient.

Digitized by Google

Mr. Swinburne, in reply to Mr. Smith, said the observation of the false zero really meant another reading. As to the law of his wattmeter, referred to by Prof. Perry and the President, he said he never calculated a law, but calibrated the instruments directly.

Prof. S. P. Thompson, D.Sc., now took the chair, and a Paper on "Interference with Alternating Currents," by Prof. W. E. Ayrton, F.R.S., and S. Sumpner, was read by the latter. The Paper relates to the phenomena which occur when alternating electric pressures are impressed on circuits made up of various combinations of resistances, condensers, arcs, and inductive coils; to the characteristics of alternators, to the properties of transformers, and to the peculiarities exhibited by the Ferranti mains. In one of the experiments an inductive coil and a condenser were connected in series, and a pressure of 25 volts, as measured by a Cardew voltmeter, impressed on its terminals; the pressures on the two parts, measured in the same way, were 110 and 104 volts respectively, thus showing that each of the two parts was much greater than the whole. On joining a condenser and inductive coil in parallel, an ammeter in the main circuit indicated 5·5 amperes, whilst those in the branches showed 6·4 amperes passing through the condenser and 10 amperes through the coil. Other experiments of a similar nature were described, and it was pointed out that the ratio of the sum of the two parts to the measured total may be large, being about eight in the case first mentioned. Theoretically this ratio might be anything, depending as it does on the phases of the pressures in the two parts, and these phases are determined by the ratio of the impedance of the coil to its resistance; practically, however, it was not easy to get a coil of large self-induction and very small resistance.

Alternate-current arcs and condensers give results of the same general character as those above described, as also do arcs and inductive coils, such as the regulating coils of lamps; this may cause considerable error in estimating the power supplied to such lamps. The magnitude of the error was found to depend greatly on the quality of the carbons and the character of the arc. With bad carbons and a hissing arc the error was very great, but with good cored carbons, burning steadily, it was not very serious.

Combinations of inductive and non-inductive coils exhibit marked peculiarities, particularly if the inductive one be a transformer coil. This last arrangement gave distinct evidence of interference or difference of phase when the secondary of the transformer was open, but when closed and with a moderate load, the difference of phase disappeared, thus showing that under these circumstances the primary coil had no appreciable self-induction.

On the subject of alternator characteristics, a graphical method of drawing the E.M.F. curve from the terminal curve was described, and the dependence of the terminal curves on the character of the external circuit pointed out. Keeping the speed, exciting current, and armature current constant, the pressure between the terminals was shown to be dependent on whether the external circuit consisted of condensers, resistances, or inductive coils, the pressure being greatest in the former case and least in the latter. The true E.M.F. of the dynamo, however, was the same in all the cases, but it became less as the armature current increased. From these results the authors conclude that the drop in E.M.F. with large currents is due to reaction on the field, but that the change of terminal pressure cannot be all attributed to this cause.

Transformers, it was shown, are powerful controllers of phase, for the primary and secondary currents are nearly always circulating in opposite senses, the phase angle for a 1 to 1 Mordey transformer experimented on, varying from 170deg. at no load to 180deg. at full load. The relation between the strengths of the primary and secondary currents, $A_p$ and $A_s$ was found to be a linear one, of the form $\frac{P}{S} A_p = a + \beta A_p$, where P and S are the number of turns in the primary and secondary respectively, and $a$ and $\beta$ constants; $a$ representing the exciting current and $\beta$ being nearly unity. The phase angle $\phi$ between the currents was given by the equation

$$-\cos\phi = \frac{\frac{1+\beta^2}{2} A_s + a\beta}{\beta A_s + a}$$

The results of numerous experiments on a transformer of the Mordey type, in which coils having different numbers of turns were put in parallel with each other, were given. In some cases resistances were put in circuit with the coils, and in others one or more of these resistances were cut out. Remarkable interference effects were thus produced, for in some combinations the volts or currents were additive, whilst in others they were nearly differential. In connection with the Ferranti effect, experiments had been made by putting a condenser on the terminals of the secondary of a transformer, and noting the resulting increases in pressure, both in the primary and secondary circuits. The results obtained with a given condenser, and approximately constant secondary pressure show:

1st. That whether the transformation be up or down, the percentage rise in the secondary is greater than that in the primary.

2nd. That these percentage rises diminish as the secondary current increases.

3rd. That they increase with the ratio of transformation.

4th. That the rise in the secondary may be considerable without that in the primary being appreciable.

5th. That the rise in the secondary still persists, even when large currents are flowing.

These facts lead the authors to believe that the "Ferranti effect" is due to some kind of interaction between the cable condenser and the self-induction of the transformer, and that is not wholly due to armature reactions in the dynamo.

DISCUSSION.

In the discussion on the Paper, Mr. SWINBURNE said the character of the "Ferranti effect" had been wrongly stated, for he understood Prof. Ayrton to say that the pressure between the Ferranti mains was greater at the London end than at Deptford. This, he contended, was impossible. He also said the effects now described of putting a condenser on the secondary of a transformer, and noticing the rise in both primary and secondary volts, were due to the waste field of the transformer. In large transformers such as those at Deptford the magnetic leakage was proportionately much less, and no such effects would be noticeable with them. Referring to the relation between the primary and secondary currents in transformers, he said it was convenient to look at the primary from two points of view, and consider one part of it as producing the magnetisation and the other as neutralising the effect of the secondary current.

Mr. MORDEY described an experiment on armature reactions in alternators in which one of the armature coils of a 50-H.P. machine was isolated from the rest and connected directly to a Cardew voltmeter. On varying the load from 0 to the full output (20 amperes) the voltmeter on the isolated coil was quite stationary, thus showing that no appreciable armature reaction occurred.

Mr. E. W. SMITH remarked that the formula connecting the primary and secondary currents holds true over a very wide range, for he had experimented on a Kapp transformer which gave ($a$) constant and ($\beta$) = 1 for frequencies varying from 20 to 200.

Mr. BLAKESLEY gave the following formula as applying to transformer currents generally:—

$$\left(\frac{A_p}{A_s}\right)^2 = \frac{n^2}{m^2}\left\{(1 + k\,r_2^2) + \frac{q\,r^2}{v}\right\},$$

where $r_2$ = resistance of secondary, $v$ is proportional to the frequency, $m$ and $n$ the primary and secondary terms, and $k$ and $q$ are constants depending on the disposition of the iron. This formula he found to very nearly represent Ferrari's results, and he hoped others would test its applicability to various types of transformers. He believed himself to be the first who carried out an interference experiment, when he put a condenser in parallel with an inductive coil six years ago. He mentioned the matter now because that arrangement had been put forward by Mr. Glazebrook in explanation of the "Ferranti effect." Mr. Glazebrook, however, had made an error in stating that under certain conditions one of the currents may become infinite.

Dr. THOMPSON thought the word interference had been used in a somewhat different sense to its ordinary usage in optics, and asked for an authoritative definition of its meaning in the Paper under discussion. The experiments on the alternating arc he considered very remarkable, as well as those on the dynamo, which give various terminal pressures when its E.M.F. and current were the same, but the external circuit of different character.

Prof. AYRTON pointed out that the measurements on the rise of volts by putting on condensers, mentioned in the Paper, were not strictly analogous to those made by Mr. Ferranti, for his were made by pilot transformers, one placed between the primary terminals of the Deptford transformer, and the other on the secondary of the London transformer; whereas in the cases now brought forward the volts measured were those at the primary and secondary of the same transformer. On the subject of arc lamps, he said Messrs. Kolkhorst, Thornton, and Weekes, who made the experiments, found that great lag only occurred when the carbons were bad and the arc hissing. If the apparent and the true power spent in such an arc were measured, a great difference existed between them. Dr. Hopkinson, he said, had shown that this might be expected if the arc had a constant back E.M.F. which changed sign with the direction of the current.

A Paper on "The Theory of Dissociation into Ions and its Consequences," by Prof. S. U. Pickering, F.R.S., and another on "Some Points in Electrolysis," by Mr. J. Swinburne, were postponed.

Addendum to Report of Physical Society Meeting on February 27, 1891. The transformer on which the tests described in Prof. Ayrton and Mr. Taylor's Paper were made, was of the Mordey type, having been kindly lent by the British Electrical Engineering Corporation.

## THE PARIS-NEW YORK TELEGRAPH COMPANY.*

The big *coup*, upon the strength of which during the past eight months the initiated on the Bourse have been manipulating for an upward movement and some premium upon the shares of the P.Q. Cable, was officially announced last week, by which time it was an open secret. The following is the basis of this operation which one might well wish to have been realised otherwise than by a company without a future and virtually in a state of liquidation. The project consists in connecting the solitary P.Q. Cable with a new cable

* From the *Bulletin de l'Electricité.*

Digitized by Google

going from New York to Puerto-Plata, where it would join the important system which the Société Française des Télégraphes Sous-marins has established amongst the Antilles and along the coast of Guiana and Brazil. The cable is to be laid by Messrs. Siemens Bros., of London, which is very curious for reasons we shall enlarge upon later. The money will be provided by an Anglo-French syndicate, which will take 14,000 shares, 5,000 of which will be immediately issued to the public. The Société Française will obtain by this new line the important advantage of direct communication with Europe, and of being able to transmit by its cables messages from the Antilles, Guiana, and Brazil to Europe and *vice versâ*, which will stimulate its traffic. The P.Q. Company should also have an element of increased activity, and it is pretty certain to make use of this fact, especially to solicit new favours from the French Government under the cover of its concession for the benefit of its American proprietors, the Commercial Cable Company, and Messrs. Bennett and Mackay. It is well known that these gentlemen are holders at the present moment of nearly half the shares of the P.Q. Company, bought at a very low price, and are the real masters through a Council of Administration absolutely in their interests. We will briefly detail the history of this capture and the causes which led to it.

We understand, however, that the news, published in advance by several journals, of an arrangement between the Société Française and the P.Q. Company is at least premature. Another thing that renders the project sufficiently problematical, is that the financial syndicate which is to take the 14,000 shares has imposed as a condition the termination of the lawsuit now pending between the Anglo-American Telegraph Company and the P.Q. Company. This action is based on the breaking of an agreement made between the two companies and repudiated at the end of December, 1886, by the new Board placed at the head of the P.Q. Cable by Mr. Mackay to continue in Europe the war which he had declared in the United States against Mr. Jay Gould, a participator in the Anglo-American Pool through the American Cable Company. The P.Q. Company lost its case before the Tribunal of Commerce of the Seine, and was condemned to pay to the Anglo-American Pool an amount equal to 2,000fr. for every day since December 31, 1886, up to the date of renewing the agreement with the Pool. By this judgment the tidy sum of nearly £120,000 damages to be paid by a Company which has no reserves but only debts. The P.Q. Company appealed from this judgment and invoked the famous letter from M. Granet of December 18, 1886, which ordered it to break the agreement in question concluded without the express and written authority of the French Government, an authority which M. Cochery, M. Granet's predecessor, did not consider necessary according to the *cahier des charges* of 1889. The Court of Appeal did not wish to decide before this particular incident was dealt with by the Administrative Tribunals, and it is in this position that the matter has been for more than two years, first before the Council of the Prefecture then before the Council of State. It will be seen that the action lost in the first instance by the P.Q. Company has not arrived at its second stage, that of appeal, which will only commence after the Council of State have pronounced upon the interpretation which ought to be given to the letter of M. Granet; whether it was a case of *force majeure*, or whether the letter only convenient complaisance intended to furnish the P.Q. Company with a pretext. A previous Minister did not consider necessary that which one of his successors declared indispensable. It will thus be seen that the accomplishment of this new cable scheme is deferred to a date which appears to be distant. If, however, it does ultimately come off it will give rise to a very curious consideration which ought to place M. Jules Roche, Minister of Commerce, Posts and Telegraphs, under the necessity of intervening afresh as M. Granet's successor. In fact, if the P.Q. Company is so dependent on the French Government by its *cahier des charges*, which we will consider later, that it cannot make an agreement without its consent (see letter from M. Granet of December 18, 1886), it is absolutely indispensable that in exchange for this Governmental control M. Jules Roche should take the following decision: "The P.Q. Company in virtue of its French origin, of its *cahier des charges*, and of the privileges it possesses on this account, ought now that French firms have established in France factories for the manufacture of submarine cables to apply to French industry for all new cables which it is about to lay." This will be so much the more easy for the P.Q. Company that it will enable it to use its ship, the "Pouyer-Quartier." It seems to us that this decision of the Minister would be logical and would perhaps operate in favour of the Company with the Council of State, by strengthening the letter of M. Granet and the arguments of its advocate. The *employés* of the Company nominated by Mr. Mackay should seriously consider this new means of defence to safeguard the interests of their patron. But this question of the manufacture and laying of the projected cable between New York and Puerto-Plata by the P.Q. Company is much more serious than appears. And this is why :—

When this Company was established in 1879 by M. Pouyer-Quertier, with a capital of 42 million francs, it undertook to lay two cables from France to the United States, through Messrs. Siemens Brothers, at the price of £800,000 per cable. The Company was to complete the purchase of the second cable, upon which it paid Messrs. Siemens £400,000 on account, by issuing bonds for the purpose, its share capital being exhausted by the cost of ships, land lines, formation of the Company, &c. But the £400,000 on account of the second cable, paid to Messrs. Siemens, who now undertake to make the new cable, have never, it is presumed, been returned by them to the P.Q. Company, or, at least, if they have been, the shareholders have seen and known nothing of it. At all general meetings which have taken place since 1881, there has never, in fact, been the slightest allusion to this point, which is as delicate as it is important. Before 1886 the writer asked many times for explanations from the old Board, but was treated as indiscreet. Nevertheless, the new Board, which is entirely devoted to the cause of the shareholders, cleared up the question. It has talked and done nothing, as if it were an akward matter, and has contented itself with living peacefully at No. 53 in Rue Chateaudunas, worthy *employés* of Messrs. Mackay and Bennett, of the Commercial Cable Company. However, of two things, one, either Messrs. Siemens have returned the money, and it is useless to create new obligations to pay for the new cable, which should not cost more than £200,000, or Messrs. Siemens have not returned the money, and it is still more useless to create new obligations. In either case the shareholders should unite and take severe measures against their directors, and we will assist them with all our power.

A. R.

## MEETINGS OF SCIENTIFIC SOCIETIES, &c.

**FRIDAY, March 13th.**

SOCIETY OF ARTS.

*4.30 p.m.* Popular Afternoon Lecture: "The Science of Colour," by Captain ABNEY, C.B., F.R.S.

INSTITUTION OF CIVIL ENGINEERS.

*7.30 p.m.* Students' Meeting. Paper to be read: "The Lanarkshire and Ayrshire Railways," by A. P. TAIT, B.Sc., Stud. Inst.C.E.

ROYAL INSTITUTION.

*9 p.m.* Evening Discourse: "The Culture of the Singing Voice," by FELIX SIMON, M.D.

**SATURDAY, March 14th.**

ROYAL INSTITUTION.

*3 p.m.* Afternoon Lecture: "The Forces of Cohesion," by LORD RAYLEIGH, F.R.S.

**MONDAY, March 16th.**

SOCIETY OF ARTS.

*8 p.m.* Cantor Lecture IV. 2. "Photographic Chemistry," by Prof. R. MELDOLA, F.R.S.

**TUESDAY, March 17th.**

INSTITUTION OF CIVIL ENGINEERS.

Ordinary Meeting. Paper to be discussed: "On the Subterranean Water in the Chalk Formation of the Upper Thames, and its Relation to the Supply of London," by JOHN THORNHILL HARRISON, M.I.C.E.

**WEDNESDAY, March 18th.**

INSTITUTION OF CIVIL ENGINEERS.

*2 p.m.* Students' Visit. The Goods Depôt of the London, Tilbury and Southend Railway, at Whitechapel.

ROYAL METEOROLOGICAL SOCIETY.

*7 p.m.* Ordinary Meeting. Paper to be read: "A Contribution to the History of Rain Gauges." By G. J. SYMONS, F.R.S.

SOCIETY OF ARTS.

*8 p.m.* Ordinary Meeting. Paper to be read: "Harbours, Natural and Artificial." By F. H. CHEESEWRIGHT.

**THURSDAY, March 19th.**

ROYAL INSTITUTION.

*3 p.m.* Afternoon Lecture: "Modern Chemistry in Relation to Sanitation," by Prof. C. MEYMOTT TIDY, F.C.S.

INSTITUTION OF MECHANICAL ENGINEERS.

*7.30 p.m.* Ordinary General Meeting. Papers to be read and discussed, as far as time permits: "Fourth Report of the Research Committee on Friction: Experiments on the Friction of a Pivot Bearing." "On recent Trials of Rock Drills." By EDWARD H. CARBUTT, and HENRY DAVEY.

**FRIDAY, March 20th.**

PHYSICAL SOCIETY.

*5 p.m.* Ordinary Meeting. Papers to be read: (1) "The Theory of Dissociation into Ions and its Consequences," by Mr. S. U. PICKERING, F.R.S. (2) "Some Points in Electrolysis," by J. SWINBURNE. (3) "The Variation of Surface Tension with Temperature," by A. L. Selby, M.A. (4) "On Magnetic Proof Pieces and Proof Planes," by Prof. S. P. THOMPSON.

Digitized by Google

# The Electrician.

Published every Friday, Price Fourpence; Post Free, Fourpence Halfpenny.
Editorial, Publishing, and Printing Offices:
SALISBURY COURT, FLEET ST., LONDON, E.C.
*Telephone No.* 2714. *Telegrams:* "ELECTRICIAN NEWSPAPER, LONDON."

*All Letters relating to Subscriptions, Advertisements and other business matters should be addressed to the Publisher, "*THE ELECTRICIAN,*" Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to "*THE ELECTRICIAN*" Printing and Publishing Company, Limited, and be crossed "Coutts and Co." All other letters to be addressed to the Editor.*

*All letters intended for insertion in "*THE ELECTRICIAN,*" or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

*"*THE ELECTRICIAN*" is published every Friday morning, in time for the morning mails. Subscribers should receive their copies by the first post on Friday morning.*

*"*THE ELECTRICIAN*" is on sale at the railway bookstalls throughout the Kingdom on Friday morning, and can be obtained of all Booksellers and Newsvendors; or direct from the Publishing Offices as above.*

*New Volumes of "*THE ELECTRICIAN*" commence in May and November.*

## SUBSCRIPTION RATES.

The rates for Subscriptions to "THE ELECTRICIAN" are as follows:—

| | 3 months | 6 months. | 12 months. |
|---|---|---|---|
| | s. d. | s. d. | s. d. |
| For the United Kingdom | 5 0 | 10 0 | 19 6 |
| For Foreign Parts and Colonies:— Within Postal Union | 6 6 | 12 6 | 24 0 |
| For Aden, Borneo, Ceylon, China, India, Japan, Java, Labuan, Mozambique, New Caledonia, Persia, Philippine Islands, Siam, Transvaal, and Zanzibar | 7 6 | 14 6 | 28 0 |



## TO ADVERTISERS.

"THE ELECTRICIAN" *offers exceptional advantages to Advertisers.*
**It has by far the largest circulation of any English Electrical paper, and circulates all over the World.**

*Particulars relating to Advertisements will be promptly forwarded on application to the Offices as above.*

TRADE ADVERTISEMENTS *intended for the current issue must reach the Offices not later than First Post on Thursday morning. Renewals of expiring advertisement orders and alterations to standing advertisements should be in the Publisher's hands by Wednesday at latest. No alteration can be made in Wrapper advertisements after Wednesday evening.*

SMALL PREPAID ADVERTISEMENTS *(for Rates see page xv.) are accepted up to 4 p.m. on Thursday.*

## TECHNICAL PRINTING.

"THE ELECTRICIAN" PRINTING AND PUBLISHING COMPANY (LIMITED) *inform Electricians, Electric Light Engineers, &c., that they make a specialty of Technical Printing, and have a large Staff thoroughly acquainted with Electro-Technology. They can, therefore, promise Accuracy and Despatch in the Printing of Electro-Technical Literature, &c.*

## "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. (Royal 8vo.)

*Early in each year is issued "*THE ELECTRICIAN*" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. The DIRECTORY was established in 1883, and the 1891 Edition, published on the 23rd February, consists of 900 pages of printed matter. The names and addresses of all persons engaged in the Electrical Industries at home and abroad may be relied upon as accurate. Useful Tables and Electrical Formulæ, and information specially compiled for this work are given, together with popularly-written Biographical Notices of the leading Electricians, Electrical Engineers, &c., accompanied in many cases by Portraits.*

*The issue for 1891 is ready, and should be ordered at once. Price 5s., post free 5s. 9d. Abroad postage extra. Full particulars on application.*

## ELECTRICAL BOOKS AND PUBLICATIONS.

*All Books, Newspapers, and other publications, dealing with Electrical and kindred subjects, can be ordered direct of "*THE ELECTRICIAN*" Printing and Publishing Company, who are proprietors of the well-known "*ELECTRICIAN*" Series of Standard Electrical Works, and are agents for all the leading publishing houses at home and abroad.*


## CONTENTS OF THE CURRENT NUMBER.


NOTES ... 561
Electromagnetic Theory.—VI. By Oliver Heaviside. Continued ... 566
Electromagnetic Repulsion. By Prof. J. A. Fleming, M.A., D.Sc. M.R.I. Illustrated ... 567
Physical Society—
Note on Electrostatic Wattmeters. Illustrated ... 571
The Paris-New York Telegraph Company ... 572
Meetings of Scientific Societies 573
ELECTRICAL STANDARDS ... 574
The Electric Current and its Laws.—III. By John T. Sprague. Continued ... 576
The Government and the Telephones in Belgium ... 577
The Electric Arc and its use in Lighting. By Elihu Thompson. Illustrated ... 577
Electricity in relation to the Human Body, its Dangers and its Uses. By H. Newman Lawrence and Arthur Harries, M.D. ... 582
Report of the Committee on the Proper Classification of the Lighting Power of Incandescent Lamps ... 582
The Electric Light at Bristol... 583
Parliamentary Intelligence ... 584
American Notes ... 585
Paris Notes ... 586
CORRESPONDENCE—
Barking Road Cars—W. G. M. Mackenzie and Frank King ... 586
Legal Intelligence ... 587
Trade Notes and Notices ... 587
PATENT RECORD ... 588
COMPANIES' MEETINGS, &c.—
London Electric Supply Corporation (Limited) ... 589
South of England Telephone Company (Limited) ... 589
The British Tanning Company (Limited) ... 590
Direct Spanish Telegraph Company (Limited) ... 591
New Companies registered ... 591
City Notes, &c. ... 591
Companies' Share List ... 592


## ELECTRICAL STANDARDS.

The preparation of recommendations to Her Majesty in Council, relating to electrical standards (a task upon which the Board of Trade is just now engaged), is one, perhaps, of greater importance to electrical progress than any which that Department has yet been called upon to undertake. Electric Lighting Acts may be passed in haste and repealed at leisure; inquiries may be held, reports presented, and model Provisional Orders drafted. It is never too late to mend all these. Experience shows how one point is unworkable and how another has been overlooked, and ultimately the law of electric lighting will be found rather in the Provisional Orders than in the Acts themselves. But when the question of electrical standards comes before Parliament a subject will be dealt with whose very purpose is fixity, and whose nature is accuracy. A mistaken clause in an Act of Parliament can be set right as soon as it has been proved beyond doubt, to the satisfaction of all parties, that the need for revision exists; a defect in a Provisional Order can be remedied, and in such cases there is little beyond mere words to be undone. But the legalisation of standards of measurement is a matter which affects every member of the electrical industry, and whatever is done must stand. The need for such special care arises from the correlation of electrical with mechanical and other measurements. Fifteen years ago electricians—for there were no electrical engineers —were satisfied with a Daniel's cell as a unit of voltage, and they were wont to express a resistance as being equal to so many miles of telegraph wire. They did not feel the want of a unit of current, and the output of batteries and of the earliest dynamos was estimated by the heating to redness of so many inches or feet of platinum wire.

All ordinary measurements, scientific or otherwise, are based upon three units—length, mass, and time. There is no absolute reason for this selection, but they are more convenient than units of energy, or density, or acceleration, and, except, for certain problems in thermo-

Digitized by Google

dynamics, they are sufficient for all physical science. In electrical science, too, all quantities can be referred to length, mass, and time, but only by means of very clumsy expressions fringed with fractional indices. Practically, all ordinary electrical measurements are made in terms of, or can be referred to, the common units of resistance, current, and voltage. To the determination of the ohm we need not refer. It is a unit which is very conveniently expressed as the resistance of a column of mercury 106·3 centimetres long with a constant cross section of one square millimetre, and it may be very conveniently embodied in a coil of metal wire. This metal wire will then become the imperial ohm, precisely as the bronze bar made by Bird in 1760 was declared to be the standard yard of the British empire by the Act of 1824. In event of the ohm being lost or damaged, it is to be replaced by comparison of other copies, as was the yard, when the original standard was destroyed only ten years after it was legalised.

It would at first sight appear that the units of current and pressure cannot be embodied in such a tangible and passive a manner as the ohm. One cannot keep a standard ampere in a massive cast iron box, such as that which contains the imperial yard, in the cellar beneath the Jewel Tower at Westminster. Accordingly, it is proposed that the ampere shall be defined by the description, in a few words, of a very delicate laboratory operation which could not be properly explained in less than two of our pages. And this explanation, with full practical directions, being given, a skilful experimentalist would still be required to execute the work which has to be carried on continuously and with perfect regularity for a considerable time. The definition, then, consists in a reference to the electro-chemical equivalent of silver, and throws upon anyone who wishes to determine the strength of any current a research comparable to that which would be necessary if he attempted to arrive at a yard by the definition given in the Act of 1824. Here it was stated that "in the event of this bar and all authentic copies and facsimiles of it being destroyed, its length should be considered equal to 36 inches such that 39·13929 of them are equal to the length of a pendulum vibrating seconds in vacuo at the sea-level, in the latitude of London." Now this definition was omitted in the Act of 1885, no doubt because Captain Kater and others had made careful pendulum experiments, and had discovered that the figure given was erroneous, more recent determinations making it 39·1383 inches. The present proposals of the Board of Trade Committee recognise the principle of the second Act, in recommending that the ohm, if lost, shall be replaced by means of copies, but do not carry this out with the unit current. They do not suggest that in the event of any catastrophe the ohm shall be redetermined, and as the sale of amperes, or rather of ampere-hours, is far more common than that of ohms, it seems that every facility should be given for multiplying copies of it. It may be argued that Prof. Threlfall may at once set to work at the antipodes, and deposit his 0.001118 gramme of silver per second, and thus arrive at the imperial ampere without troubling any of our instrument makers for any material construction of brass, glass and ebonite. He would perhaps be justified in placing more reliance on his silver deposition than on the accuracy of an instrument which had been at the mercy of the packers and the waves. We should like, however, to see an ampere deposited in some such imperial sanctuary as that which is guarded by Mr. Chaney beneath the shadow of the Victoria Tower, and the form of it would be a simple pair of rings of wire, by which "on the principle of a balance" their mutual attraction might be determined, either by suspension in parallel, horizontal, or vertical planes, or by angular displacement as in a dynamometer, weighing, of course, against gravity.

Having arrived at a standard ohm and ampere, there is no scientific reason why any definition need be given of a volt. The Standards Department of the Board of Trade have a foot and a pound, but they do not keep a foot-pound as a unit of work. Electrical engineers have to measure volts every day of their lives, and they ought to do so to within one-quarter per cent. for ordinary commercial purposes, and one-tenth per cent. for special occasions, while any accurate laboratory measurements should be carried considerably farther. But this affords no reason for the introduction of a third imperial unit. The volt is defined very properly as the pressure which if steadily applied to a conductor whose resistance is one ohm, will produce a current of one ampere. With proper instruments for measuring current and resistance, the officers of the Board of Trade would have no difficulty whatever in calibrating a voltmeter, and similarly Mr. Chaney could, if called upon, measure velocity, moment of inertia and density in terms of the standards of which he is the custodian. Besides the yard and the pound there are indeed at the Standards office numerous other measures, such as the gallon and the cubic foot. Parts and multiples of the cubic foot were deposited with the Comptroller-General of the Exchequer in 1860, and were subsequently transferred to the Board of Trade in pursuance of the Standards Act of 1866. But these are all secondary, and have been determined from the imperial standard pound and yard.

The final clause of the draft resolutions of the Board of Trade Committee (*Electrician*, February 13th, p. 451) introduces the Clark cell as a practical standard, and very wisely refers to a specification of its construction. Given such a specification, it is comparatively easy for any one to make up a few dozen, and to discard those which fail to agree, and to take the mean of the remainder. Of course it will not do to take a mere text-book description, but the directions must be followed with care. Not so much care, indeed, is required as in the determination of the ampere by deposition of silver or of copper, and there is the farther advantage that the result in the one case is a standard which will at any time produce a steady deflection on an electrometer, to be leisurely read, or will give a balance on a galvanometer when arranged for potentiometer methods. The sole precaution to be taken is the observation of the temperature, and, by a modification of the arrangements, this need introduce no additional factor into the calculation. Well-made cells remain constant within the limits of excellent laboratory measurements for many years. They may be, and have been, sent across the Atlantic and back, by post, without the smallest deterioration, and they are familiar to every electrician. This being so, and the cell being officially recognised, it is not surprising to learn that, in the opinion of several practical men, the scientific arguments should be put aside, and the Clark cell should be used, not only to measure volts, but amperes. All the arguments are readily reversible if the cell be once accepted. That simple arrangement, which is known by the sonorous title of potentiometer, will measure current in terms of a standard of pressure with the no less ease and accuracy than it will measure voltage when a standard current is passing. It is thus that electric currents may be most easily measured in the laboratory, and it is used for workshop purposes every day.

Under these circumstances it might seem desirable to separate the strictly definitive matters from those relating to measurement. There is no question about the theoretical

Digitized by Google

definitions, but we venture to think that the proposals before us confuse two distinct functions; for we look to the Crown for standards, and to the Board of Trade for methods of comparison. To follow the precedents of the Standards Department, the ohm would, as proposed, be practically defined as the resistance of a certain coil of wire deposited with the Board of Trade. The additional piece of information that it should have the value 1,000,000,000 in terms of the centimetre and second can only be of value in future centuries as showing the skill of our experimentalists in their adoption of the figure 106·3 as the result of their determination of the specific resistance of mercury. To carry out the system, the ampere practically should be the current which will cause a certain deflection in a certain dynamometer deposited with the Board of Trade. Any official statements about deposition of silver would be valuable; but as they refer to an experiment which may be made, and not to an actual concrete standard, they cannot be classed as definitions. Similarly, reference might be made to the relation between the ohm, the Clark cell, and the ampere, as being an excellent way of reproducing a definite current. Having defined the ohm and the ampere, the standard of electrical pressure is perhaps best defined as in §12 of the draft resolutions referred to above as being "the pressure which, if steadily applied to a conductor whose resistance is one ohm, will produce a current of one ampere." Unless the third unit is derived from the other two, the door is opened as is the case with the dictum about the silver ampere, and as was the case with the pendulum definition, to uncertainty in the future. But having adopted the Clark cell as a valuable method of measurement, it of course is pre-eminently adapted to determine, for practical purposes, but not to define for legislative purposes, the unit of electrical pressure.

## THE ELECTRIC CURRENT AND ITS LAWS.—III.

BY JOHN T. SPRAGUE.

*(Continued from p. 544.)*

§17. Figures 1 and 2, p. 543, exhibit several things which vary in a different manner and at different parts of the circuit, and our theory must take them all into account and explain them. We have—

(*a*) *Current* which both theories admit to be carried *by the conductor*: this is exactly equal at every part of the circuit, including the source.

(*b*) *Magnetism*, also equal at every part of the circuit; to be found in the conductor, but extending to a considerable distance, and existing as we know and can show experimentally in the form of closed rings around the whole length of the circuit.

(*c*) *Heat* developed *in the conductor* and proportional to the physical properties and dimensions of the conductor and also to the square of the current.

(*d*) *Static electric stress* outside the conductor, dependent upon the nature of the matter surrounding the conductor, and upon the voltage or E.M.F. of the source, and other conditions.

(*e*) *Electric pressure*, or stress related to the last, but irrespective of the matter around the conductor, proportional to the effective E.M.F. existing between any two parts of the circuit. This, which is called the slope or fall of potential, may be expressed either as one line or slope or as two, that is, as + and − pressure. I shall use the latter plan, as it corresponds with the double direction of energy, as shown in Figs. 1 and 2, and also to the analogies I shall have to employ.

(*f*) *Chemical powers* proportioned exactly to the current, and related to the molecular construction of the substances made to form part of the conductor.

(*g*) *Chemical Energy* controlled solely by the chemical affinities of the substances the current travels by and acts upon.

§18. Now we have to show how energy reaches the positions in which each of these conditions or things exists. Does it come from the outside as in Fig. 1, or from the conductor as in Fig. 2?

Let us first consider that it comes from the outside, as in Fig. 1, originating in the source, which it leaves at the poles to enter the "medium," where its direction is controlled by the conductor. It appears to follow that the current is not really produced by the source, because the source does not send energy into the conductor at all; it sends it into the medium. It follows that at every point of the circuit an amount of energy must enter the conductor, sufficient to work the mechanism, be it what it may, which transmits, or is the current. We have now to solve this problem, how does the current which does not exist, attract from outside space the energy which is to produce the current and control the outside energy? That problem is the concern of those who hold the new doctrines.

§19. But the current is exactly equal at all parts: the energy needed is not equal at all parts; it increases in the same ratio as the capacity of the conductor diminishes; at the narrow ends of Figs. 1 and 2, it would require per unit of length twice as much energy as the same current would need at the thick part adjoining the source. Here is another problem: it seems that after all it is not the current which controls the energy and prevents it from taking its normal radiant course. Problem: How does the external energy distinguish where much or little of it is wanted?

§20. Then at the arc lamp A, what brings the energy crowding down upon it? Not the current; the current exerts no more action there, *qua* current, than at any other two inches in length of the current, as its magnetic reaction will prove. But if we examine that arc, and enlarge it by lenses, we can, as a matter of well-known fact, see mechanical actions—that is to say, energy traversing the arc *longitudinally*; we see nothing pouring into it from surrounding space; we do see lines connecting the two ends of the conductor, and, in fact, completing the circuit itself; and we see energy going outwards.

How are we to conceive the energy rushing inwards from space, merely to rush out again as radiant light and heat?

§21. Space, again, and medium are good words; what do they mean? How far from the controlling conductor do the streams of energy extend? What should limit them? Does this shell of energy extend as far as the magnetism §17 (*b*) extends? It must do so if the energy of this magnetic field is derived from streams of energy flowing inwards towards the wire; it would seem also that these streams must come perpendicularly to the conductor, and twist about in all directions in outside space to follow the conductor.

§22. But I quoted, §4, Mr. Heaviside, as saying that in a sheathed cable "the energy is transmitted wholly through the gutta-percha." In this case we have a current in opposite directions supplied with energy by a stream in one direction, internal and external conductors both being connected to the source; or do the usual two streams of energy divide the gutta percha between them.

§23. Will anyone explain what confines that stream of energy to the gutta-percha? If the outer sheath were not there that energy would extend to outer space, for that is the hypothesis, that it issues radiant from the poles of the source, and is turned back on the conductor. But here there is no manifestation of magnetism, only because two equal opposite tendencies exist in the two conductors and neutralise each other.

§24. Let the sheath be insulated from the water, and let one end only be connected to the source. What results? The electrostatic action (*d*) is confined within the gutta-percha, the cable becomes a long Leyden jar. But the magnetic action (*b*) extends as far into space as if no sheath were present, if the sheath is non magnetic, or it is nearly confined in the sheath itself, if it is of iron, and capable of taking up the whole magnetance of the current.

Digitized by Google

§ 25. Space, it appears, is very obliging. Why should it surrender its functions to the gutta-percha, except to an extent proportioned to the relative capacities of gutta-percha, air, and ether? Is space conscious, or how does it distinguish between the calls of these various functions?

§ 26. Turn now to the chemical actions in the decomposition cell D (Figs. 1 and 2). The current here is equal to that in all other parts; but we learn something here which no other parts manifest, viz., that the mechanism of the current is identical with the structure of matter. This will have to be examined later on, as will the other points I have indicated here, merely to show what we have to consider.

§ 27. But we have a new and special call upon the lines of energy. At the plates an action occurs (at least wherever products of decomposition are really set free) which absorbs energy and renders it latent; it disappears; it does not become heat, or work. Unless, between the two plates, there exists the stress ($e$) representing energy adequate to furnish this energy (*g* 17), the current will not be generated in any part of the circuit; but a stress will be set up between the plates equivalent to the energy actually available, and the cell D becomes a condenser, or charged Leyden jar. How do the outside streams of energy recognise this peculiar call upon them?

§ 28. As we consider all this, it seems more and more evident that the conductor, which we are told "conducts nothing," and is a mere waste-pipe, exerts absolute control over all these functions, and that the "so-called current" is the active agent. But I will leave my orthodox opponents to explain these points, if they can, only claiming that they shall not bury the explanation in abstract symbols, but give us an intelligible conception of what may really occur. Of course, some of the points may be met, in the usual fashion, by attributing any necessary properties to the air or the ether; but unless there is evidence that these properties are really possessed, this is merely stating the fact itself in another form, not explaining it. Nor will that explain away the fundamental difficulty. Why should the energy, being developed within the conducting circuit in the source, leave that circuit merely to get back to it in a roundabout manner?

§ 29. On my theory, the old and practical theory, the "source" is a mechanism which sets up the current, and transforms the energy it receives into electric energy, which is charged upon the current and the conductors, exactly as other sources or motors set up a transmission of energy by means of belts, wheels, &c. The most perfect analogue is to be found in the hydraulic current, and this analogy I shall fully work out; the form of hydraulic current I shall employ, as most perfectly comparable with electric conditions, is a completely closed circuit of water piping, with a turbine for the source of power, drawing in the water at one end and forcing it out at the other; similar turbines will represent various forms of work done by the current. But I must defer the working all this out to my next article.

## THE GOVERNMENT AND THE TELEPHONES IN BELGIUM.

The question of State purchase of the telephone system, which was settled in a characteristically high-handed manner in France in the summer of 1889, and treated in an equally charateristic manner by our own Government last July, is now about to come prominently to the front in Belgium. M. Bede has, it seems, recently been refused a telephone concession, and the result is an indictment of the Compagnie Belge du Téléphone Bell, in *L'Ingenieur-Conseil*, from which it may be gathered that the situation in Belgium is very similar to that which obtained in this country at the time of the amalgamation of the telephone companies.

The 25 years' concession granted to the Bell Company is dated September 22, 1883, and stipulates that the State shall be at liberty to purchase the system from the tenth year of exploitation by giving those concerned one year's notice. The Company, it is thought, will probably maintain that means that the State may only purchase *after* the tenth years, that is to say, after September 22, 1893. The Minister of Posts and Telegraphs does not, however, read the clause in this way; according to him, "from the tenth year" is to be interpreted "from the *commencement* of the tenth year," that is to say, on and after September 22, 1892.

In either case the question of what action the Belgian Government shall take will soon have to be settled. The clauses of the *cahier des charges* bearing on the subject of purchase are Nos. 26 and 27, which run as follows:—§ 26. The purchase includes the system, material, and installations of all descriptions. It involves the subrogation for the benefit of the State of all the rights of the concessionaires in respect of third parties. If the Government obliges the concessionaire to substitute an underground for an aerial system, the power of purchase only commences at the expiration of the third year from the date fixed for this substitution. § 27. As the price of the purchase, the concessionaire will receive until the expiration of his concession, an annual sum equivalent to the average net profit of the last three years, plus a premium of 15 per cent. The net profit will be calculated by deducting from the gross receipts, general expenses, working expenses, and commercial depreciation.

These conditions obviously afford scope for the exercise of a little book-keeping ingenuity, and, according to the *L'Ingenieur Conseil*, this is not being overlooked by the Bell Company. For the first six years of its existence the Company apparently languished, the ordinary shareholders received but a modest interest, and the founders none at all. But the seventh year was prosperous, the eighth still more so, and the ninth is expected to be better still; the result being that the State, if it purchases without examination, will have to pay the Company an annual income of 565,000 francs for 15 years, which the author of the article considers to be excessive, in view of the fact that the wires are overhead, the circuits earthed, and the instruments antiquated. As the State, however, may, in virtue of clause 2, either grant competing concessions or become a competitor itself, there can scarcely be any danger of too high a price being paid to the Bell Company, a conclusion, indeed, which is finally arrived at by the writer of the article in our Belgian contemporary.

## THE ELECTRIC ARC AND ITS USE IN LIGHTING.*

BY ELIHU THOMSON.

It is curious that notwithstanding the fact that as a source of illumination the electric arc has been known since the beginning of the century, the scientific study of its nature has been but little pursued. It began to be known as a sort of scientific curiosity, being at first set apart as one of the many phenomena observed in the use of powerful batteries. It was not till about 20 years after its discovery by Sir Humphrey Davy that any proposals were made to use it in lighting, and, subsequently, for many years it was occasionally employed either in lecture demonstration or in obtaining an intense light for some special purpose.

The efforts to use it in lighthouses led to the designing and construction of machines on the magneto-electric principle to replace the cumbrous and costly batteries otherwise required. I remember vividly the hours of labour and time necessary to prepare a battery of 40 Bunsen cells for use in working a single small arc light for, at most, two or three hours. But I remember far more vividly the suffocating fumes and risk of acid spilling, with accompanying ruin concomitant on the taking down of a partially exhausted battery. Even to work with the arc for an hour or two was, however, adjudged a sufficient compensation for the disadvantages in obtaining the current. All this has, however, been changed, and the past 10 or 15 years has made the arc as a source of illumination one of the indispensables of a progressive community. Instead of the original sticks of boxwood or charcoal used as "points," which were only "points" because is was not expected that the arc would be burned for more than a few minutes without exhausting the battery, there came later on the little hard carbon sticks about two inches long and three-sixteenths square, sawn from hard gas-retort carbon, or from battery plates, and lastly came the moulded and forced carbons

* Abstract of a Paper read at the Electric Light Convention, Providence, U.S.A., February, 1891.

Digitized by Google

made from a paste in a powerful press, millions of which are now required every week to keep the lamps at present in use supplied.

The charcoal points of Davy were touched together horizontally after attachment of the wires to the battery, and were then separated. The stream of hot flame which followed or joined the points being deflected by air currents took the form of an arch or curve, which gave the name to the phenomenon. Even with one carbon directly over the other, the curved form of the stream is the rule when the carbons are widely separated. Davy's original experiment was made with a battery of 2,000 cells, with zinc and copper plates about six inches square, the exciting fluid being very dilute sulphuric and nitric acids.

Davy's description is as follows:—"When pieces of charcoal about an inch long and one-sixth of an inch in diameter were brought near each other (within the thirtieth or fortieth part of an inch) a bright spark was produced, and more than half the volume of the charcoal became ignited to whiteness; and, by withdrawing the points from each other, a constant discharge took place through the heated air in a space equal at least to four inches, producing a most brilliant ascending arch light, broad and conical in form in the middle." This was evidently a long-flaming and horizontal arc. I find this form shown in a book published as late as 1846, "Davis' Manual of Magnetism." Indeed, I know of no more forcible example of the persistency of old ideas than is afforded by the accounts given in the books concerning the nature of the electric arc. The carbons are generally shown crusted over with dense masses of impurities melted into globules or adhering to their sides. Such figures would not now be recognised as resembling arcs formed with good, pure carbons, such as must be used for commercial results in arc work.

In regard to the idea put forward as to the nature of the electric arc there is even a wider divergence than in the figures used for representing it. But these views are remarkable for their general inaccuracy or crudity, and evidently have been handed down with modifications. Few of those who have written about the electric arc, at least in the text-books, seem to have had the courage to look at the arc, or they may have seen it "through a glass darkly and not face to face." It would require too many and lengthy quotations to give these various views. In most of them the light of the arc is attributed to intensely heated carbon particles transported by the current from one pole to the other. In most of them the idea of carbon vapour as a possible factor never seems to have arisen. Others attribute the arc to the heated air between the carbons which carries carbon particles, some of which are burned.

The following quotation from a book on electric lighting, published in 1884, is a type of many such accounts:—"In arc lamps, as we have already stated, the resistance which converts the current into heat is that of the heated air between the ends of two carbon rods, from one to the other of which the current passes. The light is produced by the incandescence of the ends of the carbon poles, and of the minute particles of carbon which become detached and float in the heated air between them. The heated air containing the particles of carbon forms what is called the electric arc." Here the heated air and carbon particles floating therein are definitely stated to form the "electric arc." Nothing is said of carbon vapour having anything to do with it.

Even the statement that the positive carbon burns twice as fast as the negative is very frequently found unqualified in any way whatever. The experience of the lamp trimmer is, I need scarcely say, not in accordance therewith, the fact being that the rate of consumption, even in direct current arcs with the same size carbon in both holders, varied sometimes quite widely from the proportion stated. However, we shall make better progress if we discard at once the older notions, and, adhering only to that modicum of truth which often accompanies error, supplant the error by the results of our own observations and experiments. My endeavour will, therefore, be to state as briefly as I can such views of the nature of the electric arc as seem to be borne out by observation during many years, and under greatly varying conditions of its production.

Let an attempt be made to separate any part of a circuit in which the current is maintained by a sufficient E.M.F. or potential, and we find that if the separated ends are moved quickly we get a flash or spark of varying length, which becomes a flame of great heating effect if the current be of large rate of flow. If the separation of the two parts of the circuit be made slowly, a continuous flame or discharge will take place between the ends if they be not too widely separated, or so widely separated that the potential or pressure of the current is not sufficient to force current across the space. With considerable potentials and heavy currents a space of many inches may thus be bridged. Whether the separated ends be of iron, copper, platinum, zinc or other conductor, the hot discharge is still formed. Therefore, while the electric arc is generally spoken of as that flux occurring between *carbon* ends separated, of course it cannot be so limited, and we frequently, therefore, refer to copper arcs, iron arcs, carbon arcs, to distinguish one from the other. What, then, is the arc so formed? Is it heated air between the ends separated containing detached particles of the conductor in process of carriage, as was apparently thought for a long time to be the case? No, the arc proper is composed of a stream of vapour arising from the actual boiling or vaporisation of the solid of fused ends of the separated conductors. In so far as the surrounding air mixes or combines with this vapour stream, it is modified by the presence of oxygen and nitrogen, but the air, or any other gas, is not essential to be present and is merely incidental to the formation of the true arc stream in air. Indeed, it may seem strange to some to speak of vapour of carbon, copper, iron, platinum, &c., but their production is merely a question of temperature in any case. In the electric arc there is a real distillation of the conductors forming it, and this accounts for the variation of colour and temperature to be found in different arcs. The copper arc evolves a peculiar green light, which is exceedingly trying to the eyes, as those who have experienced its effects well known. Zinc gives a whitish blue, while the carbon arc proper is purplish in tint. The arcs from various metals give, in the spectroscope, the characteristic lines of the vapour of each metal.

As a curious incident, showing the presence of the metal vapour in the arc, I may mention the fact that when by accident a person has had a portion of his clothing bathed for an instant in a heavy copper arc caused by a short circuit of heavy current mains there has been found a considerable deposit of copper, enough, in some cases, to give the reddish colour of copper to the surface bathed, which if moistened turns green by oxidation. It also gives a deep blue to dilute ammonia in which it is washed, thus showing the presence of copper. In like manner these metallic arcs will give a deposit of the metal on cold surfaces which they touch.

It appears to be the positive pole which gives out the vapour stream. With carbon the positive vaporises steadily, and is consumed much faster than the negative. In the use of the arc, however, for lighting, we have learned to distinguish between what is called a "short-arc" and a "long-arc" system. In short arc systems the carbons are burned much nearer together than in the long arc systems. Let us suppose the case of two carbons touching each other with a current passing, and then that we very slowly separate them, stopping to observe effects. When the contact is light, before actual separation a visible heating of the meeting ends is seen. On attaining a small separation the space between seems filled with hot vapour, and we have a short arc where the separation is perhaps not over two to three one-hundredths of an inch. There is also noted an active transfer of carbon from the flattened end of the positive and a deposition of carbon on the end of the negative carbon. This deposited carbon takes the form of a mushroom end after a time, and breaks off. Meanwhile combustion goes on at both poles, and wears away the sides of the positive carbon while the transfer of carbon wears away its tip or crater. The burning also wears away the negative at the sides, while the tip is built up by the mushroom deposit from the arc. But the cutting in of the negative finally severs the mushroom tip, and it falls away. Hence both carbons are eventually consumed. To develop a short arc there is required a little over half the potential that is needed for a long arc, or about 25 volts more or less, and therefore to give out equal heat energy in the arc the current must be doubled in the short arc over what it would be in the long arc. The short arc is subject to the objection of a continual frying sound emitted and great variations of luminosity; it requires a very dense and hard carbon to conduct the current without great loss, and involves line loss of at least four times the amount with the long arc if equal gauge wires be used.

In fact, while in the past such arcs were common, their number is diminishing, as they are being replaced by the more efficient and completely developed arcs called "long arcs," which are so-called to distinguish them from the "short arcs." Returning to our separating carbons, we find that as the space or arc is lengthened from the short arc condition we pass a stage of great flickering and unsteadiness and a fluctuating potential between the carbons, and then reach the stage of production of the long or quiet arc. With 10 amperes the separation may now be about one-sixteenth to one-tenth inch or more. Smaller currents require less separation, and larger ones an increased separation. At this stage the arc is quiet, with good, pure carbons very steady, and the potential difference remains at about 45 volts, if, of course, the carbon is properly fed to make up for combustion. The perfect arc is really a beautiful phenomenon. While the positive carbon still loses by volatilisation from its tip or crater and by combustion from its sides, the negative gains no deposit, but wastes at a less rate than the other, and by combustion only. The carbon vapour carried off from the positive is consumed by the oxygen of the air before it can deposit on the negative. Hence, the outer zone of flame, which can easily be distinguished from the central zone or arc flux proper, is probably a zone of combustion similar to that existing in ordinary flames. The removal of carbon by evaporation from the positive end gives rise to the crater or cup which is so prominent a feature of carbon arcs produced by continuous currents. The size or area of the crater is a rough measure of current strength, but varies with different

Digitized by Google

qualities of carbon. With very long arcs the crater or hollowed end disappears and the ends become rounded. A well-formed crater with the arc or flame confined thereto means usually a steady light, since the chief source of light in an electric arc is from the positive crater, which shines like a diminutive sun, and represents the hottest part of the arc. The vapour light proper or flame-light is comparatively very feeble, and of a purple quality in air. Hence the arc light is as truly an incandescent source of light as is the incandescent carbon filament, with the difference that to run the latter at the temperature of vaporisation or boiling point of carbon, so to speak, means instant destruction, while by the necessities of the case the light obtained from the arc is chiefly that emitted from a surface of carbon at its temperature of boiling, or, more correctly, of sublimation at atmospheric pressure. This temperature is exceedingly high, and accounts for the well-known superior economy in light production of the arc over all other kinds of lighting. The temperature of the positive carbon crater is so high that the carbon exists there in a soft or plastic condition capable of receiving an impression like putty. I have proved this with very large arcs of 150 to 200 amperes by suddenly forcing the carbons together when the current had been cut off, and finding that they would fit each other perfectly, the negative impressing its form on the positive crater.

As an interesting fact in this connection I may state that I have been able to bend carbon sticks of three-sixteenths to one-quarter of an inch in diameter by passing current through them of sufficient amount to almost vapourise the sticks and cause them to emit an intensity of light approaching that of the arc.

These facts would point to the possible fusion of carbon into liquid carbon at arc temperature under a high pressure of inert gas. No one has yet seen carbon in this liquid condition, and the electric arc alone has made us acquainted with carbon vapour. One cannot fail to be impressed with the fact that the conveyance of carbon in the arc has a striking resemblance to a plating process where metal is taken up by the bath from the positive plate and deposited on the negative. In the arc the hot vapour stream of flame takes the part of the bath and probably acts by molecular interchanges of carbon atoms in molecules of carbon to cause the transfer which occurs, just as in the plating bath the molecules of the plating compound are polarised and allow atomic interchange, which results in conveyance of metal through the bath.

Another curious fact in relation to the arc is the distribution of potential in it. Dr. A. J. Fleming has recently shown that the difference of potential between the positive carbon and the arc flame is about 40 volts; and the few volts which express the difference between the flame and the negative make up the total potential, say 45 volts. Hence the real work of the arc is not in the flame, the energy is not used in overcoming flame resistance, but chiefly in vapourising carbon in the positive crater. It is certainly not strange that, with 40 volts and, say, 10 amperes or 400 watts expended virtually at the crater surface of the positive carbon, the temperature and luminous effects should there be so great.

The distribution of potential in the arc just noted was also brought out about the year 1884 in some testimony in an interference in our Patent Office concerning an arc lamp cut-out which I had invented, and which took advantage of the potential differences between the carbons and the arc flame to cut out the lamp when the arc was too long. It is of course well known that the value of an arc light for general illumination is greatly enhanced by the fact of the distribution of light being mainly in a downward direction in continuous-current arcs. This, of course, follows from the fact of the positive carbon crater being above, such crater being the part from which most of the light comes.

This matter has been very thoroughly investigated, and many diagrams of distribution are to be found in the literature of the subject as published from time to time. They show that with the long arc the maximum intensity of light is from 40 degrees to 60 degrees downward from the horizontal, and that the horizontal intensity is generally much less than one-half as great, while of course the intensity diminishes above the horizontal direction and ultimately becomes zero before reaching the upward vertical direction. In like manner the approach to the downward vertical from the direction of maximum intensity is attended with similar rapid diminution.

The spherical candle-power of arc lights would therefore be only a fraction of the rated candle-power which is generally taken at the maximum light obtainable in the best direction from the particular arc or kind of arc in question.

For this reason the term 2,000 C.P. arc has little significance as indicating the illuminating power of an arc. It is a conversion only, and a poor one at that. It is now generally taken to mean an arc with 10 amperes and not less than 45 volts potential difference between the carbons, or a 450-watt arc. The quality of the carbons will determine whether the 450 watts will be expended in obtaining the most light or not, or whether that light will have a maximum intensity at one angle or another within certain limits.

When arcs are operated on by alternating currents, the effects mentioned are only partially exhibited, and the phenomena of the crater are, of course, masked or obliterated on account of reversal of function of the carbons. Unless the alternations are rapid such arcs are liable to extinction at the zero points of current, particularly when run in a draft of air. A strong draught of air or a displacing magnetic field may of course so disturb an arc as to cause its extinguishment.

In the early years of the growth of arc lighting, as a means of illumination, the effects obtained were not of the best. Unsteadiness was the rule, and it required much persistent effort to discover the causes and find the remedy.

The prominent defects were, and we may add are still, hissing, sputtering, flaming, and general unsteadiness. Hissing or frying comes, of course, with too short an arc, and may be connected with too vigorous vaporisation. They may also be due in some cases to a carbon of too coarse a grain. Sputtering may arise from impurities in the carbons, and flaming from too long arcs, from impure carbons, or from carbons insufficiently baked and containing unexpelled gases. Running an arc at a length between the long-arc condition and the short-arc condition may cause great unsteadiness of light. There is, in fact, a critical point in the length below which there is a considerable fall of luminosity and a drop of nearly one-third of potential. As an arc lengthens by combustion of its carbons beginning below this critical point, great unsteadiness will be manifested on arriving at the critical state; and a little longer arc brings about a sudden and very marked increase of potential, of illumination, and of steadiness.

Any observer may easily detect these conditions without special effort. The earlier carbons used with arc lamps in the United States were both badly conducting, impure and badly made. Copper coating was a necessity. French or Carrè carbons were much better, but were too costly to import. The use of the petroleum carbon, or the carbon obtained by the carbonisation of the tarry residue left in the distillation of crude oil, made a wonderful difference in the purity of the carbons, and improved machinery gave accuracy of form and cheapness. To one familiar with the former cost of same carbons for battery arcs, the reductions in cost are very striking. Carbons three-sixteenths of an inch square cost a number of cents an inch before the year 1878.

Another important matter in relation to carbons is that the size of section or diameter must be proportioned to the current used. Where attempts have been made to prolong the hours of burning of a carbon by enlarging its diameter beyond certain limits it has resulted in injury to the character and distribution of the light. Large diameters of carbon may burn too blunt to let the light out between them. Likewise, where attempts have been made to prolong the hours of use by employing a harder or denser carbon than before, it has frequently been found that a sacrifice of light has been incurred, rendering the results much less satisfactory.

One of the chief obstacles to the employment of very small arcs with currents of three or four amperes is the difficulty of obtaining suitably uniform carbons. Arcs of even as low as two amperes at 45 volts are easily produced, and such small arcs might even have commercial utility if the difficulties in relation to carbons were removed. An arc consuming 90 to 100 watts means, of course, about seven or eight to the electrical horse-power.

On the other hand, very large or heavy current arcs are difficult to control. They are apt to be unstable at times, and when they get to hissing, or rather roaring, it is difficult to restore quietness and steady action. The introduction of cored carbons for the positive has, however, done much to remedy the difficulty, and, indeed, to render it possible to obtain very uniform results from arcs in general wherever such results are indispensable. The introduction of the central soft core into the carbon locates the arc centrally, hold it from fluttering or shifting its position on the end of the positive; in other words, the core fixes the position of the crater, and so benefits the light.

The fall of resistance with increase of current has an important bearing on the construction of dynamos for arc lighting and the running of lamps on constant potential or incandescent circuits, and will be referred to later on. Attempts have been made at various times to save carbons in arcs by excluding the oxygen of the air, which is the cause of their waste or consumption by burning. The gain has not apparently compensated for the disadvantages incurred, particularly as the total exclusion of oxygen means that the carbons become blunt. They would be prevented from pointing themselves or acquiring tapered ends by burning, a condition essential to good working and distribution of light. Even when the arc is formed in a vacuum the carbons, though not burned, are slowly consumed and carbon deposited as a soot on the sides of the vacuum chamber, an effect consequent upon the vapourised carbon in the arc being carried off and condensed again as soon as the vapour escapes the heat of the arc stream. In fact, I have found it possible to coat objects on the inside of a bulb with silver or other metals volatilised suddenly by arcs in vacuo, and have obtained in some cases coherent brilliant deposits. The metal is raised in

Digitized by Google

vapour as a metallic arc and distils and condenses on the surfaces near at hand.

Before passing to the consideration of the running of arc lamps in series, or in multiple, and the conditions to be fulfilled in each case, we may state that, although in ordinary cases an arc is formed by a single pair of electrodes or carbons, and by a single-circuit current, compound arcs, or arcs produced by combinations of two or more currents with three or more electrodes, are possible. I am not aware that any others than myself have experimented in this direction. I have, however, produced lights with two positives and one negative, with one positive carbon, or crater, and two, three, or more negatives, and with two positives and two negatives. I have caused arcs to cross each other, as when four carbons are used, pointing towards a centre, the two pairs opposite being respectively connected with different circuits. In this way direct arcs have

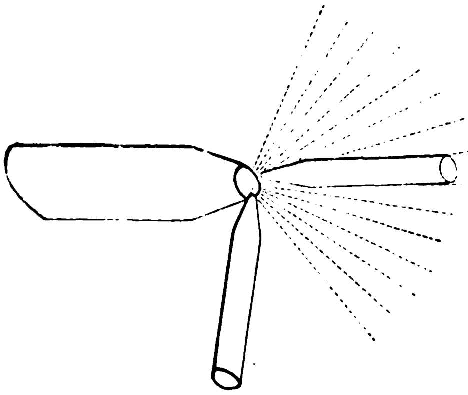


FIG. 1.—Arrangement of three carbons for projectors.

been, as it were, mixed with alternating arcs and a curious compound effect produced by crossing two arcs made with two alternating currents, the waves of which are displaced in phase. Without going fully into these experiments, I will present figures showing two good examples. Fig. 1 is formed by two currents sent into a positive and dividing after passing the crater into two streams going to the two negatives. In this case the positive crater is fully exposed horizontally, and gives a most intense light in a direction forward. Such an arc is well adapted for projection by mirrors or lenses.

Fig. 2 shows the arc formed by crossing two alternating currents out of phase. In this case there is at successive times an exchange of current between all four carbons in varying directions, so that the arc flame becomes, as it were, a ball or disc of very hot flame,

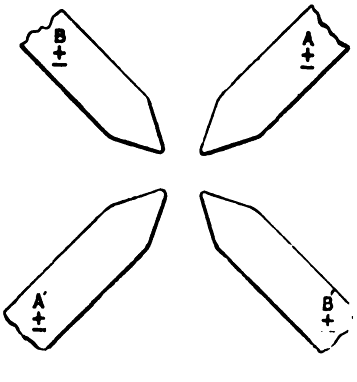



FIG. 2.—Four carbons arranged for use with alternating currents out of phase.

supported by the four carbons. These experiments have not been fully described as yet, owing to the lack of time ; but they show very well that even when we have fully studied the single, simple, arc we will not then have exhausted the subject, as these compound arcs may be varied in character to a great extent and present new effects.

In regard to that portion of our subject which concerns the use of the electric arc for lighting, it is true that there is a wide field before us. I cannot hope to do more in this Paper than to outline, in addition to the considerations already alluded to, some of the other prominent features of this subject. It is well known that by far the larger proportion of electric arc lights in operation is run on circuits of constant current, the lights being in series. If arc lamps be connected in parallel, as on low potential incandescent mains, special devices are required to keep the current supplied to each lamp at the right amount. It may appear at first to one who has not had occasion to closely study these matters that, given a constant potential circuit of 50 volts, arc lamps requiring 50 volts could be connected in multiple or parallel without difficulty. The fact is, however, that the condition of electric arcs being supplied with a constant potential involves a theoretical impossibility. Theoretically such an arc would take an infinite current and energy. Practically the current in an arc with constant potential becomes very heavy, and if the carbons be separated to cut the current down as by a lamp-magnet mechanism, a condition of fluctuation and instability results. This is a direct consequence of the fact before stated, that the resistance of an arc is not like a wire resistance, but falls with increase of current, and *vice versa*. For stability the resistance should not be dependent wholly on the current passing. To remedy the instability a resistance known as a "choking coil" or "sluggishing coil" is inserted in the arc branch, and the potential raised to 65 or 70 volts. Under these conditions, that is, with a resistance taking up 15 to 20 volts in series with the arc, it may be run in multiple with incandescent lamps or with other arcs. There is, however, a waste of energy equal to the product of the current strength by the loss of potential, 15 or 20 volts, in the resistance. A great deal of useless experimenting has been and probably is yet carried on with the vain endeavour of getting rid of the resistance or choking coil in this case, but the difficulty is inherent in the nature of the arc, the relation of resistance to current giving rise to instability of current in the arc.

Similarly, not all dynamos, even if of sufficient potential, will run arc lamps in series. Arc machines require special properties, or the current will be unstable and the lights will fluctuate, or "surge," as we sometimes call it, possibly to an extent amounting to extinctions and relightings occurring at short periods apart. This action, like the other, is dependent on the relation of current and resistance as inherent in electric arcs, and the series of lights would in each case require dead resistance up to a certain amount in circuit to render the current stable. Then, whether a series be operated or a single arc be operated, either a dead resistance must exist in circuit or the current-supplying apparatus must have special properties. The arcs produced from batteries were stable because the resistance of the battery itself was sufficient to insure this. Arcs are not stable as fed from accumulators of very low internal resistance unless the arc is one of enormous current.

Briefly, the property required to be possessed by an arc dynamo is that, as its current rises above the normal, the electromotive force must fall ; as the current diminishes to a little below the normal, the electromotive force of the dynamo must rise. It is not sufficient to secure this changing E.M.F. by regulators, as they are generally behind time for causing stability of current, however well they may operate to regulate for varying numbers of arcs in the series to be supplied.

The properties of dynamos are sometimes expressed by what are called "characteristics" or "characteristic curves," obtained, for example, by laying off vertically or on the ordinates the electromotive forces corresponding to varying currents given out by a machine, which currents are laid off horizontally or as abcissæ. In arc machines the curve so produced is convex upward, and droops at its outer end. Assuming normal current at 10 amperes, and an E.M.F. of 500 volts at 11 amperes, the E.M.F. may have fallen to 420 volts and at nine amperes risen to 530. We would then be working on the "droop" of the curve when at 10 amperes, and such a machine is stable as to current for running arc lamps. There appears to be required not merely a droop in the curve for securing stability, but more than a certain amount of rate of droop or dip. If the line could be made to droop or dip vertically after passing the normal current the machine would regulate without a regulator, or be a constant-current automatic machine.

In what respect, then, do arc dynamos differ from others to produce this relation of droop in the characteristic curve? Without doubt the effect is mostly due to the reactionary effects of the armature on the field, which effects in arc machines are made greater than in others ; and the field magnets meanwhile are frequently saturated magnets, so called, and not greatly sensitive to the current in their coils. The armature of an arc machine is indeed so powerful an electro-magnet that it is able to control the magnetism of a portion of the field in which it turns. A sort of balance of magnetic forces is established at certain portions of the field, which on an increase of current in the armature produces polarity opposing the field polarity at the portions mentioned, such as will cut off some of the lines of magnetism from entering the armature core and so lower its electromotive force ; while a lessened current in the armature will weaken its polar portions and an increased number of lines will enter the armature core from the field and so increase the electromotive force at the brushes of the commutator.

Could the droop or fall in the characteristic curve be made a vertical, as stated before, then we should have a self-regulating machine not needing a regulator to preserve a constant current under all loads. This condition can be arrived at by interactions occurring between the armature and field. In this case the armature currents react upon the field with a force producing at times a balancing of magnetism between the two. In the recent alterna-

Digitized by Google

ting machine for constant current brought out by Mr. Wm. Stanley we have an excellent example of the application of similar principles of construction, the arc lights are run from the transformers with the primary coils in the Stanley apparatus.

The relation of current to constancy is, however, in continuous current dynamos for arc lighting generally effected by regulators, as they are called, which so alter the dynamo on a slight increase or decrease of current as to raise or lower its electromotive force according to the resistance in circuit or speed.

It follows, from the fact that the voltage required to sustain an arc with large or small currents ranges about 45 to 50 volts, that the larger the current passing in an arc the less its electrical resistance. Hence, well developed arcs with 4 amperes will have about 11 ohms; with 10 amperes 4·5 ohms resistance, and with 100 amperes ·45 ohm. This fall of resistance with increasing current is easily explained by the broadening or thickening of the arc stream and the widening of the crater on the positive carbon. This widening of the crater also gives increased illuminating power without increase of temperature. It is probable that the actual crater temperature is as great in the small arcs as in the large ones; in fact, this is implied by the quality of the light remaining the same. Nevertheless, the larger the arc the greater the economy or the greater the light-giving power per unit of energy. This would naturally be expected, as the concentration of heat and lessened chances for escape of heat by convection and conduction would conduce to that result.

On account of the fact that with the addition of arc lights in a series a higher and higher potential difference is required at the terminals of the dynamo, it becomes a question how far this increase may properly be carried. It is not unusual in the present practice to run from 50 to 60 lights in a series, each demanding from 45 to 50 volts, or a total of, say, 3,000 volts. In going beyond this amount, the difficulties of insulation are greatly increased, as well as the dangers of high potentials, while the consequent risk of breakdowns resulting from failure of insulation or leakage are often sufficient to offset any saving of wire conductor that might be obtained by running more lights in series. Instances have occurred in which, with ordinary wiring and precautions, 120 to 150 arcs have been run for days together, but such a practice is to be condemned as involving hazard of all kinds.

It has been supposed by some electricians that there existed a peculiar fitness for arc lighting in series in dynamos of the open-coil type, such as the Brush or Thomson-Houston, over those of the closed-coil types, such as the Gramme or Siemens forms. While personally I have never been prepared to admit this peculiar fitness, constructors of machines of the closed-coil type have certainly succeeded in removing any doubts on that score.

I had intended at the outset of this Paper to discuss in a general way the question of the different types or classes of lamps used for arc lighting. It is a department of the subject which is of considerable importance, but for the present I will simply allude to one or two general features. Concerning the manner of feeding the carbons, the mechanisms in use may roughly be divided into clutch and gear mechanisms. Whether one or the other type is to be selected will depend largely on the conditions of use, assuming both to be equally well constructed and kept clear. Arc lamps may also be divided according to the way in which the magnet system acts to control the feed of the carbon. Before arc lamps were run in series it was sufficient to have the controlling magnet in the main circuit, and this was the case in almost all the older forms of lamp. At the present time the differential lamp magnet system is of several kinds, according to the relative disposition of the main and shunt coils. In the Brush arc lamp they are disposed one over the other on the same axis and affecting the same magnetic cores. The only objection to this disposition, which has the advantage of simplicity, is that the shunt circuit can never act positively to feed the carbons or release the clutch or gear, but can only weaken the effect of the main coil or overpower its lighting or separating action on the carbons.

Other forms of differential lamp embody the two circuits acting on separate magnets pulling in opposite directions, the main circuit to separate the carbons and the shunt to feed them. In this case the action of the shunt is more definite and positive, as it is not limited simply to overcoming the force of the direct or main magnet. A third arrangement involves the application of the repulsive action of the two coils, as when the direct coil is wound on the fixed magnet and the other, or shunt, upon the feed controlling armature therefor, and tending to cause repulsion of the armature from the main magnet. The arrangement is both simple and positive in its action.

The differential types of lamp act well when the circuit current is kept constant, and require readjustment generally for each change of current strength by which they may be operated. Hence, if a portion of line be leaky the lights are apt to burn badly, owing to diminished current, while the dynamo may be furnishing full current. Of course, such a line ought to be condemned and its insulation improved. Nevertheless I have frequently seen lights suffer from leakage on extended circuits in cities, especially in very wet weather. This is a state of things which the line superintendent can do more than any one else to correct by attending to the correct disposition of the wiring, and its character as regards leaks.

The type of arc lamp in which the shunt magnet alone controls the feed of the carbons is not sensitive to slight variations of current, but maintains a full, quiet arc with the current it gets. This is because the main current is not concerned in the feeding action, but the action is solely dependent on the potential difference of the carbons. Hence its behaviour is, on the whole, more uniform than the differential type, and within limits it does not require readjustment for different current strength.

This principle has been extensively introduced in the Thomson-Rice lamp of the Thomson-Houston Company. In this lamp the carbons are separate at the start and are brought together on the first passage of the current, after which they separate solely under the influence of the shunt circuit magnet, and the feed is likewise controlled thereby. The carbons in these lamps are not so apt to slide by or alongside each other by jarring when no current is on the lamp, as may occur, particularly with careless trimming, in those lamps in which the full weight of the upper holder and carbon must be borne by the under carbon when the lamp is not lighted.

Arc lamps have been made with many variations in the magnetic arrangements controlling the carbons, a brief statement of some of which is as follows:—Carbons lifted or separated by direct or main magnet; shunt magnet acting on a variable resistance to cut out the main magnet in feeding. Carbons lifted by main magnet as before and shunt acting to put the main magnet (made movable) into position for feeding.

Carbons separated by main magnet armature; shunt circuiting magnet acting to divert or shunt the magnetism of the main magnet from its armature.

Carbons separated by main magnet and shunt acting to free the carbon holder independently of the support given by the main magnet.

Carbons separated by a spring allowed to act by the main magnet lifting a weight which otherwise holds the spring from acting; shunt magnet acts against the spring to feed and regulate length of arc.

One carbon, generally the lower, separated by main magnet, while the other holder is released for feeding only, such feeding being under the control either of a differential system or a shunt magnet only.

Carbons separated by main magnet, which lifts the shunt and its armature together, while the shunt magnet armature acting on the feeding mechanism controls the arc and feed of the carbons.

Carbon feeding mechanism independently attached to main magnet armature and to shunt armature, so as to receive opposite movements of separation and feed from each respectively.

Carbons separated by a feeding mechanism moved by the main magnet and fed by a further movement of said mechanism, causing release or return of same under the accumulated force of both shunt and main magnets acting in the same direction.

Differential clock gear for separation and feed of carbons under control of the regulating magnet system, either simple or differential. Some of the older clockwork lamps embodied this principle.

Carbons controlled by armature of a small electric motor under control of a differential field which turns the armature in one direction for separating and in the other or reversed direction for feeding the carbons.

Carbons controlled by a motor running at a certain speed when the arc is of normal length and varying in speed when the arc is too short or too long, combined with a centrifugal governor on the shaft of the motor acting on variations of speed to gear motor shaft to screw carbons together or apart as needed to maintain the normal arc. This mechanism has been applied by me to large arc lamps such as naval search lights, and has the advantage of great positiveness and an ability to handle heavy mechanism.

There are also a considerable number of modifications from these principles stated which cannot be referred to here.

Another excellent mechanism, and one of the most powerful and positive in feeding the carbons, embodies a main magnet separating the carbons and striking the arc and an intermittently acting shunt magnet for working a pawl, which by a suitable gearing forces the feeding action on approach of the carbons as required. I have used an endless screw gearing with the pawl acting on a ratchet wheel to turn the screw, the worm-wheel being on a shaft carrying a pinion meshing into a rack on the carbon rod. The worm-wheel gearing is lifted by the main magnet to strike the arc, and the shunt magnet in operating its pawl breaks its own circuit and repeats its feeding action as often as may be necessary.

It is interesting to note in this connection that I have built such lamps in which each feeding movement of the carbon is not over one-five-thousandths of an inch, and that if the upper carbon rod is held in a vice the mechanism will lift the whole lamp, of about 20lb. weight, in feeding, so positive is the action. At the same time the length of arc is maintained constant at all times. With so slight and yet positive a feeding action the feed takes place almost continuously.

Digitized by Google

## REPORT OF THE COMMITTEE ON THE PROPER CLASSIFICATION OF THE LIGHTING POWER OF INCANDESCENT LAMPS.*

DR. LOUIS BELL, CHAIRMAN.

The necessity for some rational rating of the candle-power of incandescent lamps becomes evident in the experience of nearly every central station manager who has enterprise enough to keep watch of the lamps he is using. Now, evidently it is for the best interest, both of the central station man and of the consumer, that each should know exactly what is intended by 16 C.P. glow lamps. The questions that arose were as follows:—First, how shall we classify the power of incandescent lamps at all? Shall we classify it entirely by candle-power? Or if not by candle-power, to what standard shall we refer the light? Or shall we classify it by watts consumed with specifications for efficiency or by watts consumed with specifications of candle-power to some limitations on the efficiency? After a considerable amount of deliberation your committee came to the conclusion that the last-mentioned method of classification was the simplest one to enforce—that is, incandescent lamps should be rated by the watts consumed, the actual power for which the consumer pays, but with a specification as to the candle power to limit the efficiency of the lamp to a practical value. By practical value I mean such as will not on the one hand produce an inordinate waste of energy, or on the other hand force the lamp far above its proper candle-power, and consequently rapidly burn it out. The interest of the lamp manufacturer lies towards greater efficiency, because, by producing a very efficient lamp he is enabled in the first place to give a fine, brilliant light that pleases customers. Unfortunately, when this is carried beyond a certain point, the life of the lamp is enormously shortened. Having determined the proper way in general of rating incandescent lamps, there arose the important question of proper limitations to be set. We have been so long used to speaking of and dealing in 16 C.P. lamps, it seems inadvisable to abandon that standard. Do we mean by that, 16 candles mean horizontal, or 16 *candles mean spherical illumination?* Your committee is emphatically of the opinion that the mean horizontal candle power should be specified; in other words, that the normal 16 C.P. lamp should give 16 C.P., taking the average of the horizontal illumination in all azimuths.

Next came the question of practical limits within which the candle power might be allowed to vary. Taking the limits as they are found in actual practice, we find them 5 C.P. on either side of 16, sometimes even 7 or 8. These limits your committee considered far too wide, and, therefore, it entered into consultation with the lamp makers for the purpose of ascertaining how close to 16 C.P. the limits could be set, and yet leave the manufacturer a simple and practical process. The result of this deliberation was to settle on about 1 C.P. on either side of 16; that is, on the one hand, the largest variation which we could agree to admit in defining the normal lamp, and on the other hand being a variation which came easily within the lines of commercial manufacture.

As to the possible efficiency of incandescent lamps giving a reasonably long life, there are as many opinions as there are lamp makers, besides a few stray opinions advanced by theorists, and still fewer advanced by practical electricians. Some experts advocated lamps giving the candle-power on not less than four watts; others, three or two and a-half watts. In this regard we shall have to appeal to the central station manager. Your committee, after a large amount of consultation, considered for general central station use, taking into account the fact that sometimes they sell light by contract and sometimes by meter, a consumption of more than four watts per candle undesirable, particularly if the electricity is furnished by meter, for when the consumer is paying for more than four watts per candle he objects very seriously to the bills sent as not representing the proper quantity of light. Then, as to the limits of efficiency—on how small a number of watts is it possible to produce a candle-power and at the same time have a lamp of reasonably long life and giving a reasonably uniform efficiency throughout its life? The very best commercial practice seems to set the figure at a little over three watts. Without specifying, then, the efficiency of the normal standard lamp, your committee would suggest that a lamp giving over 15 and not over 17 mean horizontal C.P. on a consumption of less than 60 and not less than 55 watts represents the average conditions of central station practice better than any other type of lamp that could be readily found. I am quite aware that in setting this 55 watt limit your committee is running in the face of opinions which are entitled to some consideration, but it would call the attention of anyone who is opposed to that limit to the fact that with the normal standard lamp thus defined, if any lamp can be produced giving a candle-power with good life on a little over 3 watts it still falls within the standard. The effect in that case would simply be this:—That the manufacturer who could produce a lamp giving the candle power well and steadily on a little over 3 watts could furnish as the standard lamp a lamp that would come very near to the 17 C.P. limit; in other words, he would get the credit of having a little brighter lamp than some of his contemporaries, and so would not in any way suffer by the establishment of the 55 watt standard.

Now as to determining the mean horizontal candle power. In the first place, the distribution of light that is given by incandescent lamps is not altogether uniform. In lamps with twisted filaments, particularly if of round section, the distribution is very uniform, in lamps with straight filaments of round section fairly uniform; in lamps with straight filaments of square or nearly square sections showing the maximum at very nearly 45 degrees from the plane of the filament; when filaments of rectangular section are employed having a considerable difference between the sides of the rectangle, the light varies in the most erratic fashion.

There is one way, however, to determine the mean horizontal candle-power, and that is by spinning the lamp above an axis as it is being tested; if a lamp be mounted in a rotating socket and spun rapidly about its own axis, the mean horizontal candle-power can be obtained at once if the velocity of the rotation rises to about 300 or 400 turns per minute. This process has been tried several times with more or less success; it is tried in at least one lamp factory with uniform and unvaried success, and it is certainly worth an experiment in case we have to deal with very irregular lamps which throw their light erratically around a horizontal axis.

* Abstract of a Report presented to the Electric Light Convention, Providence, U.S.A., February, 1891.

## ELECTRICITY IN RELATION TO THE HUMAN BODY, ITS DANGERS AND ITS USES.*

BY H. NEWMAN LAWRENCE AND ARTHUR HARRIES, M.D.

It is manifest that any consideration of the relation between electricity and the human body must divide itself into two parts: the one, *possible dangers* to the body, and the other, *possible advantages*. First among the dangers is that from lightning. The physiological problems connected with lightning stroke are many and interesting, but beyond our present scope. We have rather to deal with dangers arising from accidental contact with conductors which are used to convey electric currents to and from the various lamps, machines, or apparatus they are intended to actuate. That electric engineers (in England at any rate) have done, and will do, all that is possible to safeguard the public we gladly believe and acknowledge. With proper care on the part of the engineer, and with a minimum of caution on the part of the public, accidental contact by the human body with conductors carrying dangerous currents becomes almost an impossibility.

The results of contact with currents passing at a fixed rate of E.M.F. (as is generally the case in light and power circuits) depend upon resistance, sensation, and local effect. Upon the resistance offered by the body depends the quantity of current passed; sensation and local effect are produced upon the body by such current as it really receives. Resistance, in its turn, depends upon the condition of the skin at the sites of contact, and upon the extent of the contact area. These points are all-important in deciding the seriousness or otherwise of accidental contact. We have noted with regret that there is a tendency among electrical engineers to draw unfair inferences from the slight results which have sometimes followed accidental contact. They argue that because A received no harm from an accident on a particular circuit, therefore no harm can come to B and C, or anyone else, on the same or some similar circuit, quite forgetting that A's hands may have been exceptionally dry, or that the area of his skin in contact may have been very small. We have made experiments on both these questions, and find that, with continuous current, resistance with the skin moist at point of contact, is about one-third the average of that found when the skin is dry. With wet skin, resistance is further reduced to one-fourth. With alternating current, the proportionate decrease of resistance between the conditions of dry, moist, and wet skin is slightly less, but is still well marked. We find also that, other conditions being the same, the current passed with a given E.M.F. is as nearly as possible in direct proportion to the surface area in contact. In other words, the possibilities for harm are dependent upon these factors to such an extent, that when both are favourable to the subject, contact with wires carrying current in the highest degree dangerous may produce results in no sense serious on the other hand, when both are unfavourable, the subject may receive serious if not fatal injury from a circuit which might be safely handled under conditions more favourable to himself.

* Abstract of a Paper read before the Society of Arts, March 11, 1891.

Digitized by Google

*Sensation.*

We have made many experiments to determine how the sensations of individuals are affected by currents of such strength as could be borne. We find with dynamo generated currents, when bare metal electrodes, having a surface area of 45 sq. c. each, are grasped in the hands so that the current passes through the arms and chest, that with continuous current at 104 volts, an average current of 0·0183 ampere produced what we have called discomfort point, while with alternating current at about the same voltage (and a frequency of 23 per second) 0·007 ampere was sufficient to produce comparable discomfort. Further, that with the alternating current 0·0079 ampere produced muscular fixation, while with the continuous current in no case was muscular fixation, or any sensation approaching thereto, reached.

*Local Effect.*

*A.*—With continuous currents we observe :—

1. Electrolysis at the parts in contact, accompanied by a gradually increasing sensation of heat.

2. Shock to the muscles in the neighbourhood is felt with sudden make or break.

3. The parts become reddened, more so at the negative than the positive pole.

*B.*—With intermittent and alternating currents :—

1. Repeated shock, with more or less tonic contraction of neighbouring muscles, which is practically persistent during the time of contact. Closure of circuit is marked by painful jerk, felt not so much in neighbouring muscles as in those some short distance away.

2. Reddening of the parts.

Light and power circuits carry currents very many times stronger than any used in the above experiments; and we may fairly conclude that the result of contact therewith would be severe shock to the nervous system, and strong burning sensation at the points of contact with either form of current.

*The Uses of Electricity to the Human Body.*

The health of the body seems to be intimately connected with and, perhaps, to a large extent dependent upon electricity, or the immediate results of electrical action both internal and external. That electricity ordinarily exists in the air we breathe has been shown by many well-known experimentalists, from Lemonnier, in 1752, downwards, and we have it on the authority of Sprague that the average electrical condition of the atmosphere has an important bearing upon the climatic qualities of any place, though he adds "as yet very little is known on the subject." Again, ozone is a most important constituent in a healthy atmosphere, and it is probable that electrical action is one of the chief factors in its production. Physiologists have long taught us that electricity is generated in our bodies during each functional process of whatever nature. It has been shown to be present during the action of the heart by Dr. Augustus Waller in his beautiful experiments before the Medical School of St. Mary's Hospital, in October, 1888, and more recently at the International Medical Congress at Berlin. We are ourselves engaged upon a long series of experiments which, so far as they have gone, clearly indicate that small but measurable currents of electricity are being continuously generated in the body. We further find that these currents differ in potential according to the parts tested, and we have reason to believe that such difference of electric potential is produced at the centres of function—thus in muscle, brain, gland structures, lungs, and various parts of the digestive system there is a separate, continuous, though apparently irregular, generation of current. We are thus brought face to face with the fact that electricity forms a most important factor in the processes and functions which together constitute life. A confirmation of our conclusions is found in the experiments of Dr. B. W. Richardson upon the effect of administering frequently used oxygen to animals. He found that oxygen alone will not continuously support life—in presence of nitrogen, of course—unless it be frequently revivified by the passage of electricity through it. The same action of electricity and its revivifying power upon the atmosphere is found after a thunderstorm, when, as is well known, ozone is largely present owing to the electric disturbance accompanying the storm. The artificial electrical generation of ozone for restorative purposes may also be considered as one of the uses of electricity to the body. It is one, moreover, which may probably prove of considerable importance in large cities, where the atmosphere is vitiated by the exhalations of a large and crowded population. We have made certain investigations into this subject, and carried out some interesting experiments with persons placed in an ozonised cabinet, wherein the air was charged with ozone by electrical action. The results seem promising; but the number and extent of the observations necessary prevent the rapid completion of such research, and we must postpone more definite conclusions for the present.

The next part of our Paper deals with the uses of electricity in disease. Such uses are numerous, valuable, and steadily on the increase. Without trespassing upon the distinctly medical aspect of the subject, we may refer to those well known but little under stood effects of electricity upon the nerves and muscles of the body, by means of which many diseases depending upon nerve derangement may be ameliorated or even cured. Speaking generally, continuous currents, properly applied, tend to promote disintegration and nutrition, while alternating currents act as local stimulants. But in this connection it is most necessary to bear in mind that it is only by accurate measurement of the currents used, and by careful attention to the electro-physiological or electro-chemical changes it is desired to bring about, that satisfactory results can be obtained. Extreme care is necessary in making electrical applications to the body. Care in diagnosis, so that a definite idea may be obtained as to what it is the electricity is to be directed against; care in the selection of that form of current best suited to do the work required to be done; care in choosing the position of the electrodes and the direction of the current; and, lastly, care in measuring the dose precisely, both as regards current, strength, and time.

With the methods of electrical treatment this Paper has nothing to do, but there is one use of electricity in disease not indicated above, which is new as regards its practicability, and which, moreover, opens up a field of usefulness little expected a short time back. We refer to "cataphoric medication," or the process of passing drugs in solution through the skin by means of the cataphoric power of continuous electric currents. Experiments have been made both in Germany and America, within the last few years, by which evidence, more or less uncertain, had been obtained of the power of electric currents to carry drugs in solution with them through the skin; but as far as our information goes nothing reliable had been arrived at, and some of the experimenters were even uncertain as to which pole should carry the solution to the body. In the early autumn of 1889 we conducted a series of experiments in this department of work, and found the results so promising that we at once proceeded to use it as a method of treatment. We have been much gratified with the results of its application in many cases of actual disease. From the reports of the International Medical Congress at Berlin in 1890, we find that subsequent to our adoption of this method in practice, Mr. Edison, of New York, has been making experiments in the same direction.

1. We note that a continuous current, passing from one vessel to another along a moistened conductor, will carry with it from + to − sufficient of the drug in solution at the + to produce a precipitate in the solution at the − pole. 2. That a portion of the drug in solution will pass through a porous septum in the direction of current flow. 3. That a portion of a drug in solution will pass into the human body through the skin also in the direction of the current flow, the skin here representing the porous septum.

Repeated qualitative tests have shown clearly that the drug used has passed into the system, and we are now endeavouring to obtain quantitative tests which we hope may lead to the adoption of definite dosage by this method.

In conclusion, it may perhaps be well to say a few words by way of summary. The dangers of electricity to the body are considerable, but, fortunately, they are provided against, and generally in a very secure manner. In fact, they concern only the comparatively few whose work necessitates their constant presence among such conductors. The uses, however, affect a far larger number and outweigh the dangers to an enormous extent.

## THE ELECTRIC LIGHT AT BRISTOL.

At the meeting of the Bristol Town Council on Tuesday last, the report of the Electrical Committee came up for consideration. The report advised the Council as to the area to be at first lighted. The installation recommended by Mr. Preece was, it stated, only intended as a commencement, and was so designed as to be capable of future extension to every portion of the city to which it might be considered desirable to extend electric lighting. The report recommended that the alternate current transformer system should be adopted; that the committee should be authorised to carry out an installation, capable of supplying electricity to 100 arc lamps for street lighting, and 10,000 glow lamps for private lighting, at a cost estimated not to exceed £66,000.

Mr. Preece, in his report, stated that the site selected for the central station, in Temple Backs, was admirable. The space was ample for the purpose, and being on the water side secured all the advantages of cheap transit in coals and easy disposal of cinders and a supply of water for engine purposes. He estimated the capital expenditure necessary for carrying out the installation to be £66,000, divided as follows:—Buildings £5,000, machinery and plant £24,000, mains, &c., £20,000, distribution £6,000, working

Digitized by Google

capital £5,000, 10 per cent. for contingencies, £6,000; total, £66,000. The annual revenue to be derived from this installation, regarded as a distinct undertaking, if all the lamps be taken up and used, was estimated as follows:—Arc lamps £2,500, glow lamps, £10,500; total £13,000. Working expenses:—Arc lamps £2,500, glow lamps £7,100; total, £9,600. Profits £3,400, or about 5 per cent. on the capital expenditure (£66,000). The estimated revenue was based on the assumption that each lamp alight and in daily use earned 21s. per annum, which meant that each lamp fixed earned 10s. 6d. per annum. Companies derived an average annual income of 24s. 6d. per lamp alight, or 12s. 3d. per lamp fixed. The estimated working expenses were based on actual experience, and had been checked in various ways. The working expenses per unit could be tabulated thus:—1. Manufacture of Electrical Energy —Coal, labour, oil, and waste and water 2·25 pence. 2. Repairs and renewals, 0·8 pence. 3. Distribution and maintenance, 0·8 pence. 4. Management, 0·4 pence. Total 4·25 pence. The report then went on to state that the alternate current transformer system was the only one suitable for Bristol. Six transformer sub-stations would be required at first, and their probable positions had been chosen. The public and private lighting should be kept entirely separate. For public lighting at first only 500 watt arc lamps fixed at an average distance of about 50 yards apart, and arranged in two circuits along the streets would be used.

Mr. G. PEARSON moved—"That the area to be at first lighted by electricity under the Bristol Electric Lighting Order, 1883, be the area recommended in the report of the committee."

Alderman PROCTOR BAKER seconded the resolution, and said, though he did not throw the slightest doubt upon Mr. Preece's figures, he would remind the council that the committee had entirely to rely upon Mr. Preece for the calculation, and that the figures were those of Mr. Preece, and not those of the committee.

Several members then spoke in favour of the area being extended, and finally the motion was agreed to.

Mr. PEARSON next moved—"That the high-pressure alternate current transformer system be adopted for electric lighting by the authority."

This was agreed to.

Mr. PEARSON proposed—"That the committee be authorised to carry out the installation recommended in the report, and to obtain tenders for the necessary machinery and works, and to employ such professional and other assistance as they may require."

The resolution was agreed to, as also was one sanctioning the appropriation of properties in Temple Backs for the erection of a central station.

The Council then rose.

## PARLIAMENTARY INTELLIGENCE.

### The Central London Railway Bill.

BILL BEFORE THE HOUSE OF COMMONS SELECT COMMITTEE.

THURSDAY, MARCH 4TH.

The Select Committee of the House of Commons, consisting of Mr. Hanbury (chairman), Mr. Barran, Mr. Gane, and Mr. F. Parker, on Thursday, resumed the consideration of the Central London Railway Bill.

The case for the promoters having concluded on the previous day, Mr. LITTLER, Q.C., addressed the Committee on behalf of the Ecclesiastical Commissioners and the City of London. He said that as negotiations were still proceeding between the representatives of the promoters and of the City, he did not propose to deal with the opposition of the latter. The proposed scheme would pass under the most important line of streets in what they all knew to be the greatest metropolis in the world, and he asked the Committee not to hand over such an important thoroughfare to a speculating syndicate on the mere statement of an enterprising American. If the promoters desired to construct a railway they ought to bring in a Bill for the construction of an ordinary railway, with an ordinary gauge, so that it might be brought into communication with other systems. The learned counsel said that clause 56 of the Bill proposed that the Company might, without making any payment or compensation, appropriate and use the sub-soil and under-surface of any street, road, or footway necessary for the construction, maintenance, working, and use of their railway; and the promoters had stated that they would not take the Bill without such a clause. That statement was conclusive evidence to his mind that the promoters knew they were going to do considerable damage to the property under which the line would pass. The promoters had made out no case to justify the clause depriving his clients of their rights as landowners to the sub-soil.

Mr. CRIPPS, Q.C., on behalf of the Vestry of Marylebone and Lord Portman, argued that the promoters of the Bill were not entitled to deprive the owners of property along the route of the proposed line of their common law right to compensation for disturbance of the sub-soil.

Mr. GRAHAM, on behalf of the Trustees of the Paddington estate, said his clients' property was worth about a million sterling. They opposed the scheme on two grounds, namely, that the promoters were not entitled to take the sub-soil without paying compensation; and that the proposed line was not the best that could be constructed.

Mr. BIDDER, Q.C., who represented the Trustees of the late Duke of Portland, said his clients' first objection to the Bill was that it proposed to confiscate some of the rights of owners of property. Another objection to the scheme was that they did not know whether it was likely to be successful and remunerative. According to the evidence of Mr. Greathead, the engineer, in the space of two months the City and South London Railway Company had carried 900,000 passengers, earned about £750 a week, and had had some twenty mishaps through short circuits, &c. Not a word, however, had been said as to whether or not the line paid its working expenses. Dr. Hopkinson, who was called for the promoters, said he did not know whether it did or not. Last year the promoters called Mr. Mather, who stated that he had entered into a contract to work the City and South London line at ninepence per train mile, and that he was prepared, if Parliament passed the present Bill, to work it also at ninepence per mile. Where was Mr. Mather now? That gentleman had had his experience; he had had two months of it, and he knew whether the line was succeeding or whether he had burned his fingers. Why had he not come before the Committee this year to tell them that he was still willing to work the line at ninepence per train mile? Because he is a wiser man now than he was last year. He had had two months' experience of the City and South London Railway, and that had sickened him. Mr. Mather would no more undertake to work the line at ninepence per mile now than he would think of financing the whole undertaking. Mr. Greathead, in his cross-examination, admitted that he could not say whether or not the City and South London line paid its expenses. Therefore he (the learned counsel) thought that Parliament acted wisely last year in saying that until the City and South London experiment had been tried it would not commit the public to further schemes of this kind. If the Committee agreed with that view then they ought to say that they would not sanction the scheme until it was shown that the line could be worked successfully from a financial point of view. It is now said that the City and South London Railway earned about £750 a week. The proposed line was double the length of the City and South London, and it might carry double the amount of traffic. The question of the cost of electric traction was an important one. On the proposed line there was to be a two minutes' service, and every train had to run six miles. If they ran for 16 hours they would have to cover 3,840 train miles per day. At Mr. Mather's figure of 9d. per mile the cost of traction alone would be £144 a day. That was considerably more than the gross earnings on the City and South London Railway. In addition to that sum the Company would have to provide for officials, drivers, wear and tear of plant and rolling stock, and rates and taxes. If the promoters got any person to take the contract at Mr. Mather's figure, they would have to pay £864 a week for the electrical traction alone. It was a very moot point whether the cost of working would not swallow up the whole earnings.

The CHAIRMAN: He qualified that statement to which you have referred by saying he had no doubt there would be a profit.

Mr. BIDDER, continuing, said he had no doubt the figures of the City and South London Company would show whether or not a profit was being made. Mr. Greathead was only able to say that, because he had not got the figures before him. Mr. Mather had got the figures; but he did not come to make such a statement. While he (the learned counsel) was not able to prove that the City and South London Railway was not working at a profit, he could with perfect confidence submit that there was a total absence of any proof of a profit having been made. The evidence with regard to the South London experiment, for which Parliament said it would wait before it sanctioned similar schemes, had been carefully kept back from the Committee, and he (the learned counsel) unhesitatingly asserted that the working of that experiment had been disastrously unremunerative, and that if evidence on the point had been called it would have been fatal to the present scheme. The scheme was really promoted by a few gentlemen who had come across the water to see what they could make out of the simplicity of the Londoner. In fact, the whole thing from beginning to end was an extremely clever Yankee speculation upon which Parliament should put its foot down. In conclusion, he submitted that the Committee ought to reject the Bill on the ground that it was premature, the witnesses called on behalf of the promoters having admitted that they could not say whether or not the City and South London Railway paid its working expenses.

Mr. POPE, Q.C., on behalf of the London County Council, said that if the Committee passed the Bill the County Council desired them to insert a clause enabling them to purchase the undertaking after the lapse of a certain period. The proposed railway was not a national but a local enterprise, though it was not to be carried out with local capital. The object of the promoters of the Bill was to make money, and he (the learned counsel) thought it was a reasonable request on the part of the County Council that they should have power to resume possession of the main arterial thoroughfare after the expiration of a certain number of years. Forty-two years was the period fixed for electric lighting, and he suggested that that period should be inserted in the present Bill. The proposed railway would be practically another underground street upon which electric tramcars would be run.

Mr. PEMBER, Q.C., having drawn the attention of the Committee to the fact that as the opponents of the Bill had not called any evidence, he was precluded from replying upon the whole case on behalf of the promoters.

The CHAIRMAN directed that the room should be cleared. On the public being readmitted, the Chairman announced the decision of the Committee. He said: We consider that the preamble is proved, but we also consider that the scheme must be carried out as a whole, if at all —that is to say, from one end to the other—and for that reason, when we come to clause 48, we shall have to consider whether it would not be advisable, although we know it is a clause which has been come to by agreement between the promoters and the Commissioners of Sewers, to alter that clause so as to limit by arbitration or otherwise the large powers given to the Commissioners by the clause in its present shape. We foresee that

Digitized by Google

the Commissioners might so use their veto that they might say, "The line shall not go under Holborn-viaduct." We say if it does not run the whole length then we do not grant it at all. With regard to the claim of the London County Council to have the right to purchase the undertaking, we refuse that. Then as to the sub-soil, we think it only fair that Mr. Pember should be heard upon that point.

The Committee then adjourned till Friday.

FRIDAY, MARCH 6.

Mr. PEMBER, Q.C., who appeared for the promoters, said, since the adjournment his clients had considered the Chairman's remarks with regard to clause 48, and had agreed to a modification of the clause. The clause at present provided that before the promoters commenced their works under Holborn-viaduct they should give the Commissioners of Sewers one month's notice of their intentions, and that pending the sanction or refusal of the commissioners they should not commence them. That clause appeared to give the commissioners the right of veto, inasmuch as there was no power to refer the question to arbitration. The commissioners had agreed to a sub-section being inserted to the effect that the withholding of their consent should be deemed to be a difference between the parties, and should be considered by an arbitrator. The promoters would also consent to a clause, providing that no part of the proposed line should be commenced until any question at issue between them and the Commissioners of Sewers with regard to passing under Holborn-viaduct had been settled.

With regard to the use of the subsoil, the CHAIRMAN, after the Committee had deliberated, said it was the opinion of the Committee that sufficient reason had not been shown for allowing the clause, to the effect that the promoters should not be liable to pay compensation for the appropriation and use of the sub-soil to remain in the Bill. It, therefore, would be struck out. The Committee, of course, gave the promoters leave to take the sub-soil, but they were not prepared to go beyond the provisions of the general law as to compensation.

It having been stated that there were clauses to be argued affecting the London County Council, the Marylebone Vestry, the Duke of Westminster, and the Dean and Chapter of St. Paul's, the Committee adjourned the consideration of them till Wednesday next.

WEDNESDAY, MARCH 11TH.

Mr. FREEMAN, on behalf of the promoters, said the clause with regard to the fares to be charged on the proposed railway had been modified. It now stated that the Company would run at least two trains each way every morning and evening, Sundays and holidays excepted, not later than seven o'clock in the morning or earlier than six o'clock in the evening, for artisans, at a halfpenny per mile. The proposed railway had to compete with the omnibus traffic, and he asked the Committee to bear in mind that while the latter contributed nothing to the rates, the former would have to pay a considerable sum.

Later on it was stated that the promoters would agree to run two trains each way at a minimum fare of twopence.

The CHAIRMAN: That won't do. We think you ought to fix the fare at a penny per journey for each passenger.

Mr. PEMBER said it would be hard on the promoters to insist upon their fixing such a small maximum rate for workmen's trains. The cost of constructing the proposed line would be £600,000 per mile.

The CHAIRMAN: We shall insist upon the penny fare.

Mr. PEMBER said he did not believe there was a single case in which a railway company was called upon to carry workmen at the rate of a penny for six miles.

The CHAIRMAN said the Committee were doubtful whether two workmen's trains each way would be sufficient. They therefore suggested that the number should be increased to three.

After considerable discussion the clause was amended in accordance with the decision of the Committee.

Mr. CRIPPS, Q.C., on behalf of the Marylebone Vestry, proposed a new clause, providing that no soil excavated in the construction of the railway should be conveyed along Oxford-street between the hours of 10 a.m. and 6 p.m.

Mr. FREEMAN objected on behalf of the promoters to the clause, which was rejected.

A clause agreed to by the promoters and the Westminster Electric Supply Corporation was then inserted in the Bill. It provided that the promoters should not sink any shaft in connection with their railway at any point within a distance of 100ft. from the north wall of the Westminster Corporations's central station or depôt, situate in Davis-street.

The Bill then passed through Committee, and will be reported, as amended, to the House in the usual way.

## The City and South London Railway Bill.

In the House of Commons, on Friday evening last, this Bill having been read a second time,

Mr. T. H. BOLTON moved:—"That the Committee do insert clauses in the Bill providing either (1) for payment to the local authority of a royalty or share of earnings after interest on capital and working expenses; or (2) for specially reduced fares on certain trains between hours most convenient for the working classes and for clerks and others engaged in business, the railway company being required to run a specified number of such trains daily." He said that the House would remember that during the discussion which took place a short while since on this subject he suggested two ways of compensating the public in these matters—namely, by giving a royalty to the local authorities, or by giving them a share of the earnings after interest on capital and working expenses had been paid. The right hon. gentleman the Chairman of Committees suggested another way, and that was by a provision for cheap fares. In deference to the right hon. gentleman he withdrew his instruction, but at the same time the impression was left on his mind, and he believed on the mind of other members of the House, that this question should be considered by the Committee; but counsel who appeared for the promoters ignored what had taken place in the House, and treated the subject of his motion with indifference, stating that he had withdrawn the motion because it had been unfavourably received by the House. He had, therefore, put the motion on the paper again. He did not propose to reargue the claims of the public, because he believed it was generally admitted that the public had a very substantial interest in the matter. The promoters themselves took a most sanguine view of these tunnel undertakings. In one of them it was proposed to provide facilities for carrying as many as 350,000 people a day, and the railway which was already working on the other side of the Thames had in a little over two months carried 900,000 passengers. That was conclusive evidence that the privilege asked for was one of enormous value, and therefore it was the duty of the House to take care that the public interests in the matter were very well looked after. Having no interest except the public interest at heart, he moved the instruction in no spirit of hostility to the undertaking, but he believed that this was so good a thing that the Company could well afford to give the public some return for the very large Parliamentary powers they asked for.

Mr. COURTNEY suggested that the hon. member should wait until the Committee finished their work before moving this instruction, which was premature. He strongly deprecated the moving of this instruction just at the time the Committee were considering the matter.

The House divided and the numbers were—

| | |
|---|---|
| For the instruction | 71 |
| Against | 111 |
| Majority against | 40 |

Mr. T. H. BOLTON moved a similar instruction in connection with the Central London Railway Bill. The instruction was negatived without a division, as was also a similar instruction moved by the hon. member in connection with the South Kensington and Paddington Subway Bill.

## North Metropolitan Tramway Company's Bill.

On Monday the North Metropolitan Tramways Bill came before a Select Committee of the House of Commons, consisting of Mr. Hanbury (Chairman), Mr. Barran, Mr. F. Parker, and Mr. Gane.

Mr. POPE, Q.C., in opening the case for the promoters, said the object of the Bill was to amend the Act of last year by giving an appeal to the arbitration of the Board of Trade against what was regarded as the unreasonable action of the West Ham Corporation in refusing the Company permission to use electricity as a motive power upon parts of their tramway. The Company desired to use electricity upon the line from Clapton to Moorgate-street, and also from Leytonstone to Stratford, and they applied for the assent of both the London County Council and the West Ham Corporation. The London County Council had assented upon the terms that the Company put the tram route into a proper condition for the use of electricity and submitted from time to time any requirements which the County Council might think necessary in order to secure the safety of the traffic and the safety of the passengers during transit; but the West Ham Corporation had refused to assent to the seven years' licence, insisting that the Company should be liable to remove their electrical engines and plant at 24 hours' notice. The Company, therefore, proposed that in the event of the West Ham Corporation refusing to grant them reasonable facilities, there should be an appeal to the Board of Trade.

Major-General HUTCHINSON, of the Beard of Trade, gave evidence in suport of the Bill. He said the Board of Trade had at their disposal electrical engineers and experts who would be able to assist the Board to arrive at a proper decision. He could not regard as reasonable the stipulation of the West Ham Corporation.

At the conclusion of the case for the promoters, the Chairman, without calling upon counsel on the other side—Mr. Sanders, Q.C., and Mr. Baggallay—ordered the room to be cleared. On the public being re-admitted, the Chairman announced that the Committee did not consider that the preamble had been proved. The Bill was accordingly thrown out.

# AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *February* 27, 1891.

**High Speed Electric Traction.**—The meeting of the Institute of Electrical Engineers on Tuesday evening last was of unusual interest. It has long been known that a remarkable series of experiments on electric traction at enormous speeds was carried out at Laurel, Maryland, about a year ago, under the direction of Mr. O. T. Crosby. No full report of the work, however, had been given until now, when Mr. Crosby read an elaborate Paper giving his experience in work under those very unusual conditions. In spite of a peculiarly bad track of narrow gauge, laid with rails weighing only 16lb. to the yard, and running part of the way on trestles over a swamp, a speed of 120 miles an

Digitized by Google

hour was actually reached with a car weighing 2½ tons. No difficulty whatever was experienced in the use of a travelling contact at this speed, and some interesting data as to air resistance were obtained. After some months of experiment the work was abruptly concluded by an accident, owing to the bad track, that disabled the car and wrecked some 300ft. of track and trestle. The output required to reach the higher speeds was considerable, rising to as high as 50-H.P. In spite of their unfortunate termination the experiments were so successful as to encourage their continuance on a large scale, and plans were made for an electric locomotive of 500-H.P. to run on a track of standard gauge, either for experimental or regular railway service. Nothing has as yet come of the designs arranged by Mr. Crosby for this work, but it is expected that the Weems Company, which carried on the original experiments, will continue them shortly on a larger scale. Mr. Crosby's Paper attracted a great deal of attention, as it represented a phase of electric traction that is quite unique, no such speeds having been reached by any machine of human contrivance. In the discussion that followed some interesting facts were brought out concerning the mechanical properties that must be possessed by a railway track to sustain these remarkably high speeds. It was pointed out that rails constructed with special reference to great stiffness were absolutely necessary for such work, and that with such rails and proper care in track construction there was no reason why 120 miles an hour should not be a safe speed. It has already been shown that stiff rails mean decidedly less power required for traction, in addition to increased safety.

**Rapid Transit in New York.**—The monthly dinner of the New York Electric Club was held on Thursday evening of this week, and was the occasion of a symposium on the subject of rapid transit in New York. The chief speaker was Mr. Frank J. Sprague, who has followed the subject persistently from the very beginning of his work on electric traction to the present. Mr. Sprague is a firm believer in electric railway work at high speed, and under almost all conditions; and he expressed a thorough conviction that the only available means for rapid transit in this unfortunate city was to be found in an underground system operated by electric motors. Although he did not expressly make such a statement he evidently favoured the Greathead tunnel, that has made so signal a success in London. Mr. Sprague's plea included not only a four-track trunk line around the city, but connections under the East River, joining the New York underground road to a similar structure in Brooklyn. Following Mr. Sprague, Mr. Louis Sterne explained in detail the construction of the City and South London Railway. He was listened to with the keenest interest, for all eyes are just now turned toward that pioneer electric underground road as almost our only source of information to aid in the solution of the difficult problem that is before the public. At present public sentiment is undoubtedly in favour of an underground railroad, rather than any system of elevated structures or viaducts. Poor service, and a total disregard of public comfort, have been displayed by the elevated roads for so long a period has created a strong prejudice against them, that it is very doubtful if any system whatever that contemplated the use of elevated structures in the existing streets would be tolerated for an instant. The viaduct plan is an attractive one, and has many friends, but the feeling is growing that its enormous expense quite prohibits its use in the portions of the city that most feel the need of rapid transit. Something must be done, and that quickly, and the Greathead or some similar tunnel system will probably meet a favourable reception.

**Davenport's Model Electric Railway.**—After dinner there was displayed what we may call the first electric railway in the world. A little circular model electric railroad, constructed by Thomas Davenport, the Vermont blacksmith, about 1837. The motor was on the end of the pivoted arm, carrying three Grove cells as a counterpoise, and a simple armature with a two-part commutator operating the one small driving wheel through the medium of a bevelled gear. This model was but recently discovered, and has special interest as the first attempt at an electric road of any kind.

## PARIS NOTES.

(FROM OUR OWN CORRESPONDENT.)

PARIS, *March* 10, 1891.

At the last meeting of the Société Internationale des Electriciens, M. Hospitalier published the results of some tests of the wonderful de Meritens cell carried out at the Ecole de Physique et de Chimie. On open circuit the E.M.F. was 1·8 volt, but after momentarily closing the circuit it was only ·8 volt. A single cell gave 6·8 amperes on first closing the circuit, the E.M.F. being ·68 volt; when only one-half of the liquid was exhausted the current was 5 amperes, and the E.M.F. ·5 volt. The consumption of zinc was that indicated by theory. Per kilowatt-hour (1·34 H.P.H.) 5 to 7 kilogrammes of sulphuric acid at 66° Baumé and 2·18 kilogrammes of zinc are consumed, the total cost being nearly 2½ francs, and the total weight of liquid concerned being 75 kilogrammes. In his original paper M. de Meritens made much capital out of his proposal to electrolyse the spent solution using iron anodes, and thus recover his zinc, and generate a useful disinfectant at the same time. M. Hospitalier showed that more power was required to perform this operation than was given out by the cell. Another feature of M. de Meritens' cell was the employment of a perforated carbon negative covered with a lamina of platinised lead. Without this adjunct of platinised lead, the output indeed slightly diminished, but there was a considerable gain in constancy. Again, M. de Meritens employs chemically pure zinc, but with ordinary commercial zinc and without the platinised lead lamina, the consumption of zinc was but slightly increased. Various inaccuracies in M. de Meritens' statements were next pointed out by M. Picou.

At the same meeting M. d'Arsonval described an arrangement employed by him to run a motor at a given speed, and keep it running steadily at that speed. A hoop of springy metal is arranged between the end of the motor spindle and an adjustable screw, the current passing into the motor *viâ* the screw and the metal hoop. The mode of action is analogous to Delzen's circle. M. d'Arsonval has applied this device to the determination of the mechanical equivalent of heat by causing the motor to revolve, at a constant speed, a copper tube filled with water in a constant magnetic field, and measuring the temperature and the quantity of the outflowing water. M. d'Arsonval then described a method of running an alternating motor at a constant speed by connecting one terminal to a tuning fork and the other to the centre of a secondary battery, the terminals of which are connected to the two stops, against which the tuning fork impinges.

The last Paper of the meeting was one by M. J. J. Heilmann, in which he described a decidedly original kind of railway locomotive. The locomotive of to-day is a very wasteful animal, as we all know, and M. Heilmann's idea is to employ a tubular boiler, and a triple-expansion low-pressure engine driving a dynamo which is to furnish current to two motors on the bogie axle. M. Heilmann showed numerous curves and diagrams to support his claim for economy.

The Société Générale des Téléphones announces that having won its case in the Court of Appeal, all makers and sellers of infringing apparatus will be prosecuted with the utmost rigour of the law. The patent in question covers the use of the induction coil in telephonic instruments. One result of the successful issue of this lawsuit has been an immediate rise in the price of the Company's shares.

M. de Selves has announced that the principal towns in the Northern district, Lille, Roubaix, Tourcoing, &c., are to be placed in telephonic communication with the Belgian towns across the frontier, and that a third wire will shortly be erected between Paris and Brussels.

By 24 votes to 20 the Conseil Municipal of Lyons has given permission to the Compagnie Lyonnaise des Tramways et Chemins de Fer to run an electric line from the Gare des Dombes to the Garo de Perrache.

The Babcock and Wilcox boiler company have entered into an agreement with the Creusot Works to undertake the construction of their boilers.

## CORRESPONDENCE.

### BARKING ROAD CARS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have to thank Mr. Kapp for his offer to publish the authorised figures of the Barking-road installation. When my Board think it desirable to do so, I shall have no difficulty in bringing them before the public. The effort that is being made to prove that five cars cannot operate at the same cost as 300

is quite unnecessary. I would only add that, in response to invitations from various tramways companies and corporations owning tram lines, my company have been and are issuing tenders to electrically equip and maintain tram lines by the overhead, conduit, and accumulator systems.

If electro-traction by accumulators were more expensive than horse traction the North Metropolitan Tramways Company, who have now had something like two years' experience of the work of these cars, would not be, as they are at present, applying to Parliament for powers to extend the system at a capital outlay to themselves of £50,000.—Yours, &c.,

W. G. M. MACKENZIE, Secretary.

THE GENERAL ELECTRIC POWER AND TRACTION COMPANY (LTD.)

London, E.C., March 9, 1891.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In his letter appearing in your last issue Mr. Fraser states the life of E.P.S. secondary batteries on tramcars to be ten months, or 300 discharges. As a matter of fact, the life of the ordinary positive traction type plates is about 400 discharges *more or less, according to the degree of care in handling.* The life of the negative plates is for effective work about 750 discharges, but I have not up to the present time seen a plate which has actually broken down from fair wear and tear. When, in February, 1890, the positives of the first set of batteries at Barking-road required renewal, it was decided by the Traction Company to renew both positive and negative plates, but it was afterwards evident upon inspection of old plates sent in that the majority of the negatives would have certainly run for another year.

The experience of the past year, from February, 1889, to February, 1890, has proved that the maintenance rate for E.P.S. batteries on the Barking-road line, with all the manifest disadvantages of a small installation, has not exceeded *one penny* per car mile, and this with batteries of the old traction type.

Crucial experiments have now satisfied me that the positives of the "K" type traction plates will endure in actual work from 800 to 1,000 discharges, and that the maintenance of batteries will hereafter be fully covered by two-thirds of a penny per car mile.—Yours, &c., FRANK KING.

65, Chelverton-road, Putney, S.W.

# LEGAL INTELLIGENCE

### Reg. v. The Fareham Electric Light Company (Limited).

This action was tried at Winchester on Tuesday last before the Lord Chief Justice of England and a common jury. Mr. Bucknill, Q.C., and Mr. Bovill Smith were for the prosecution; Mr. Bullen appeared for the Company; Mr. J. Alderson Foote appeared for a syndicate employed by the Company and indicted with them; Mr. James Blake, one of the defendants, appeared in person.

This indictment was against the defendants for having obstructed some highways in the town of Fareham by digging holes and erecting posts and wires for the purpose of inaugurating a system of electric lighting. It was said that the posts were an obstruction to the highway, and even in some cases dangerous. There was, however, no real dispute as to the facts. Early in 1890 an agreement was entered into by the Fareham Local Board and Blake, on behalf of the Fareham Electric Light Company, whereby the Local Board granted to the Company, "so far as they lawfully could," leave and licence to erect all necessary posts and wires for the supply of electric light. In June a contract was entered into between the Electric Light Company and the Local Board for the lighting of the town by electricity for a term of three years. At that time, and for many years past, the local gas company had supplied the Local Board with gas for lighting the town, and the gas proprietors were practically the prosecutors in the present case, their contention being that the Local Board could not delegate to the Electric Light Company the power of erecting posts in the highway.

At the end of the arguments his Lordship said he must direct an acquittal. Undoubtedly the posts would have been an obstruction but for the statutory powers given to the Local Board by the Public Health Act, 1875. He then referred to Section 161 of that Act, and said he considered "other means of lighting" mentioned in it included electricity, even although electric lighting was practically unknown when that Act was passed, and that under the section the Local Board could contract with the electric light company. He directed the jury to find all the defendants not guilty.

# TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

"THE ELECTRICIAN"

**ELECTRICAL TRADES' DIRECTORY & HANDBOOK for 1891**

The new edition of our well-known Directory and Handbook is now ready, price 5s., postage extra. The book consists of over 900 pages, and has entailed this year a heavy amount of work. The HANDBOOK DIVISION contains a mass of most useful information. The DIRECTORY DIVISION consists of 430 pages, and contains a very carefully compiled Alphabetical and Classified List of Firms and Persons engaged in the Electrical and Allied Trades in all parts of the world. This Division has been corrected up to date, and the book is thoroughly reliable, the very numerous changes which take place at the beginning of the year being incorporated. By the aid of this Directory, makers of Electrical Machinery, Apparatus, Instruments, Fittings, Sundries, Novelties, and other goods, may safely communicate direct with probable customers without the annoyance and great expense consequent upon using books which are mere lists of Members of Scientific Societies repeated again and again. A large number of copies have been already subscribed for from the Colonies, the Continent, the United States, and other Foreign Countries, whilst at Home orders have been received from Local Authorities, Railway, Tramway, Mining, and other large Industrial Corporations, as well as from those for whom the Directory and Handbook is primarily compiled. The Colonial and Foreign Division will be found extensive and reliable. *Orders should be forwarded at once.*

TENDERS WANTED.—The Town Commissioners of Ballymena, Ireland, are desirous of receiving tenders for lighting the town by gas or electricity from August 16th, 1891, until May 16th, 1892. Tables of lighting and other information are to be obtained from Mr. Henry O'Hara, Ballymena, to whom sealed tenders are to be sent by Monday next, the 16th inst.

THE LIGHTING OF BELGRADE.—The municipal authorities of Belgrade propose to grant a 41 years' electric lighting concession. The public lighting will comprise 65 arcs and 1,000 16 C.P. incandescents. Tenders (in German, French, or Servian) will be received up to April 13th. Further particulars can be obtained of Herr Peter Tipkov, Belgrade.

DISSOLUTION OF PARTNERSHIP.—The *Gazette* announces the dissolution of partnership between Messrs. Kent and Stapylton, 5, Denman-street, London Bridge, electric lighting engineers.

ST. PANCRAS VESTRY ELECTRICAL EXHIBITION.—The General Electric Power and Traction Company are exhibiting at this exhition a very interesting show of motors driving, dometic, and other machinery, such as knife cleaners, washing machines, &c., as well as electric light fittings, switches, lamps, &c.

ELECTRIC LIGHTING AT MARGAM CASTLE.—Several leading firms were recently requested to submit competitive schemes for the lighting of the above, and the order for the work has been entrusted to Messrs. Drake and Gorham. The installation consists of about 350 incandescent lamps, and will be the largest of its kind which has been erected in the neighbourhood. The work will be carried out under the superintendence of Mr. A. A. Campbell Swinton.

CLUB LIGHTING.—Messrs. Henry F. Joel and Co. have recently installed the electric light at the new National Sporting Club, which occupies the premises for so many years known as Evans's, in Covent-garden, London. The installation consists at present of 160 lights, but provision is made for an extension to 300 lights. The fittings have been specially designed to assimilate with the general design of the building. The current is supplied by the Metropolitan Company.

MESSRS. H. BINKO AND CO.—This firm have received instructions to fix with their patent electrical mercurial thermostat all the bunkers and refrigerating rooms of the Union Steamship Company's new ss. "Scot," recently built by Messrs. Denny Bros., of Dumbarton.

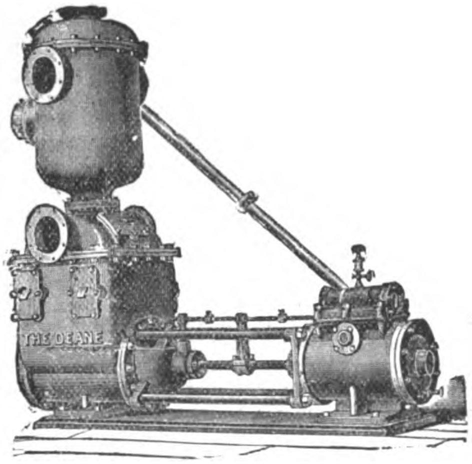
THE ACME ELECTRIC WORKS.—The West End business of the Acme Electric Works has been purchased by Messrs. Moat and Co., and for the future will be carried on under the name of C. Moat and Co., of whom all the "Acme" specialities may be obtained, as well as the goods of other manufacturers.

MESSRS. W. H. WILLCOX AND CO.—This firm forward us illustrated particulars of Ingall's patent boiler tube scraper and cleaner, and of a new and improved internal boiler tube cutter. Both tools are well made. The scraping arms in the former are made of cast iron with chilled working edges, and do not anneal from the effect of heat. The boiler tube cutter will cut a tube either inside or outside the tube plate, is constant feed, and is worked with a ratchet.

Digitized by Google

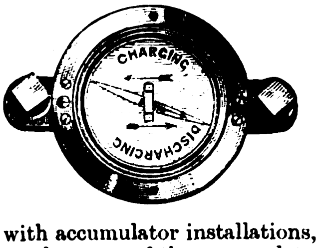
Mr. Wilson Hartnell.—Mr. Hartnell will open a branch office in London about the end of March at Mansion House-chambers, 11, Queen Victoria-street, E.C., which will be under the managment of Mr. Farrar, who is well known to many of our readers. In addition to electric lighting and power plant, Mr. Hartnell will continue the manufacture of general electrical work both for the home and foreign markets.

Independent Condensing Apparatus.—The Pulsometer Engineering Company are adding to their well-known manufactures, and are now making various types of condensing apparatus. Where water is to be had, these will undoubtedly contribute largely to the economy of high-pressure engines. One of the reasons why condensing has been so little used by electrical engineers, may, probably, be found in the fact, that while high-speed engines are particularly suited for running dynamos, they are, for two reasons, not readily suited for working with condensers. The single-acting engines depend largely upon uniformity of pressure in one direction, and air pumps are never run at such high piston speeds, as are usual in electric lighting engines. The condensing apparatus, which is



illustrated in the accompanying figure, is worked independently by a small cylinder of its own, on the principle of an ordinary direct steam-pump. It is possible, therefore, to connect two or more engines with one cendenser, and either can be stopped without interfering with the other. They run at a moderate speed and can readily be adapted to a varying load. Such a condensing apparatus is in use at Woking, where two vertical triple expansion 100 I.H.P. engines are working under 140lb. steam pressure at 300 revolutions, and we understand that the economy is very marked. We are also informed that it is proposed to place one at Queen Anne's Mansions in connection with the electric light engines, and to pump the water from the well. We are assured by the Pulsometer Engineering Company that sufficient economy can be gained to allow for the power required for pumping. Electrical engineers would do well to give more attention to the use of condensers which appears to have been very much neglected.

A Current Index.—We have received from Messrs. O. Berend and Co. some particulars of a new c rrent index, of which we give an illustration below. The inde is made by Messrs. Hartmann




and Braun for use with accumulator installations, and when in circuit shows at a glance the state of the accumulators whether charging or discharging. The instrument is well made and of compact shape.

## PATENT RECORD.

### APPLICATIONS FOR PATENTS.

February 17, 1891.

2,834. W. H. Elton. Exmouth. Automatically recording the value of shots upon targets by electric apparatus.

2,862. M. W. Dewey. London. Improvements in electric fire engines also applicable to other electrically propelled vehicles.

2,866. H. H. Lake. London. Improvements in electrical measuring instruments (E. Weston, United States).

2,902. G. S. Grimston and E. Wilson. London. An improvement in electric locomotives.

February 18, 1891.

2,985. E. Edwards. London. Improvements in apparatus actuated by electricity for stirring and turning over malt and grain (J. Sandt and H. Sturm, Germany).

February 19, 1891.

2,999. H. H. Bigland and J. Burns. Liverpool. Improvements in electric arc lamps.

3,003. E. W. Mayer. London. Improvement in element for electric battery.

3,030. M. R. Ward. London. Improvements in propelling vehicles by means of electric motors.

3,049. C. K. Mills. London. Improved circuit controller and alarm (C. M. Woolcott and A. E. Wilmot, United States).

February 20, 1891.

3,127. W. Cruyt. London. Apparatus for automatically indicating loss or diminution of current in electric circuits.

3,191. M. von Dolivo-Dobrowolsky and the Company Allegemeine Elektricitäts-Gesellschaft. London. Improvements in the transmission of alternating differential phase currents.

3,198. F. Poudroux. London. Improvements in galvanic batteries.

3,199. H. C. Harold and R. Jenkins. London. An improvement in electrical switches.

February 23, 1891.

3,239. J. S. Raworth, T. O. Callender, and C. E. Webber. London. Improvements in underground conduits for conductors of electricity.

3,262. E. A. Gimingham, of the Edison and Swan United Electric Light Company (Limited). London. An improvement in conductors for electrical glow lamps.

February 24, 1891.

3,331. S. C. C. Currie. London. Improvements in secondary or storage batteries.

3,336. H. H. Lake. London. Improvements relating to welding, brazing, or otherwise joining metal strips, bars, rods, and the like by electricity, and to apparatus therefor. (H. Lemp and L. M. Schmidt, United States).

3,338. J. A. Parker. London. Improvements in telegraphy.

3,349. M. W. Dewey. London. Improvements in electric welding apparatus.

3,357. H. H. Lake. London. Improvements relating to the jacketing of pipes and cocks, chiefly designed for use in connection with vacuum pumps for exhausting incandescent electric lamps (A. Berrenberg, United States).

3,364. H. H. Lake. London. Improvements relating to the manufacture of incandescent electric lamps (W. E. Nickerson and A. Berrenberg, United States).

3,373. G. F. Webb and J. A. Crisp. London. Improvements in and connected with medical batteries.

3,383. J. A. Kingdon. London. Improvements in dynamo-electric machines.

February 25, 1891.

3,398. A. E. Spencer. London. An improved electrical burglar alarm.

3,404. C. H. Elliot and E. F. Furtado. London. Improvements in switches for telephone circuits.

3,417. W. H. Munns. London. An improved galvanic battery (G. A. Smith, Canada).

3,426. H. J. Dowsing. London. Improvements in brushes and brush holders for electric machines.

3,449. P. Rabbidge. London. Improvements in telephones.

3,450. W. H. Power. London. Improvements in primary batteries.

3,455. W. A'Court G. Birkin. London. Improvements in electro-magnetic percussive rock drills and the like.

February 26, 1891.

3,495. C. M. Dorman and R. A. Smith. Manchester. Non-percussive quick-break electric switch.

3,518. E. Guyard. London. An improved inking device for use in telegraphic instruments.

3,524. R. D. Sanders. London. Improvements in apparatus for use in the manufacture of metal tubes by electro-deposition.

February 27, 1891.

3,538. J. Mackie. Glasgow. Improvements in electrical contact apparatus, and parts connected therewith, for automatic stop motions and analogous applications in spinning, twisting, winding and other machines or apparatus.

3,553. W. P. Thompson. Liverpool. Improvements in conduit electric railways (E. M. Reed, United States).

3,570. F. George. Southport. Improvements in electro-therapeutic apparatus.

3,589. H. H. Lake. London. Improvements in electric batteries (W. B. H. Dowse, United States).

3.592. W. Whitehead. London. Improvements in electric alarm apparatus.

Digitized by Google

## BOOKS, &c., RECEIVED.

"Intensity Coils." By "Dyer." Sixteenth Edition. (London: Perken, Son, and Rayment.)

"Journal of the Institution of Electrical Engineers." Vol. XX., No. 91. (London: E. and F. N. Spon.)

"L'Année Électrique." Ph. Delahaye. Septième Année. (Paris: Baudry et Cie.)

## COMPANIES' MEETINGS & REPORTS.

### London Electric Supply Corporation (Limited).

The following is the full text of the annual report for 1890, to be presented by the Directors at the annual general meeting, to be held at the Cannon-street Hotel this day (Friday), the 13th inst., at 12 noon :—

The general position of the works is described in the engineer's report appended thereto.

The causes which led to the fire at the Grosvenor distributing station are stated in the engineer's report. The Directors are assured that with the measures now being taken for the equipment of the permanent distributing stations, any recurrence of such a calamity will be impossible in future. The premises damaged by the fire were insured, and are now being reconstructed in the most substantial manner.

The interruption to business and the loss of income caused by the fire has been serious, and the Directors regret that it will not be possible to declare any dividend upon the Preference capital. The portion of the year during which supply was suspended is a period at which the revenue is, under ordinary circumstances, at its maximum, but, owing to the severity of the winter, revenue in excess of the ordinary rate would have been produced, which, had it been received, would have enabled the Directors to pay a dividend on the Preference capital.

The results of working for the short period that ensued between the closing of the Grosvenor station and the cessation of supply on November 15th confirms the statement made in the last report, that the concentration of the whole of the generating machinery in one establishment, under the control of the Chief Engineer, would secure material advantages in supervision and economy.

During the past year statutory powers have been acquired over several metropolitan parishes, which have led to a more economical and beneficial disposition of the works. The Board are making no applications for further powers this year, and will limit their Parliamentary business to defending themselves against opposing interests.

Notwithstanding the loss of certain old customers after the fire, new applications for current are coming in from day to day, and large demands are arising in certain portions of the authorised area in which, hitherto, there has practically been none. Works are now in hand with a view to meeting the material extension of the business which may be anticipated. Meanwhile supply of current was resumed on February 15th, and customers are being connected to the new underground mains as rapidly as possible.

The Directors retiring, as provided by the Articles of Association, are Mr. Francis Ince, Mr. Joseph Pyke, and Mr. Arthur F. Wade, all of whom are eligible, and offer themselves for re-election. The auditors, Messrs. Kemp, Ford and Co., who retire in accordance with the Articles of Association, offer themselves for re-election.

#### ENGINEER'S REPORT.

To the Directors of the London Electric Supply Corporation (Limited).

Gentlemen: Since I had the pleasure to report to you a year ago the engineering work of the Corporation has gone through a period of considerable activity under my direction. The concentric mains which you have manufactured under my patents have proved to be a complete success. Four concentric trunk mains have now been laid from Deptford to London, consisting in all of some 25 miles; they are laid in 20ft. lengths, and thus in the above distance there are no less than 6,500 joints. The work of laying was of necessity performed by unskilled labourers, who had neither experience nor training in such work, and I am glad to say that on first testing the mains only some 20 joints out of the entire number proved to be defective; these defective joints are easily found and rapidly replaced. The mains have been thoroughly tested with a pressure of 17,000 volts, and have stood this test perfectly, and as you are aware they are now in daily use at a pressure of 10,000 volts, the normal pressure of your permanent work.

With the sanction of the Board of Trade, earthing arrangements have been made in connection with the mains and other portions of your system, and the working is so satisfactory that no disturbance whatever is caused to the telephone or telegraph systems; in fact, neither the Post Office nor the Telephone Company are able to say when your machinery is working.

During the past year the whole of the machinery from the Grosvenor station has been removed to Deptford. The dynamos, which were designed to give 10,000 lights each, have been found capable of supplying with ease 15,000 lights each, consequently two larger engines for working these machines to their full capacity have been erected at Deptford during the year. These dynamos have been put into a thoroughly efficient state, and with this plant the work is now being done. In addition, two larger engines, each of 1,500-H.P., which had just been erected at the date of my last report, have been got into efficient running condition, and the necessary alterations are being made to the two larger dynamos (each capable of giving 30,000 lights), that will enable you to use them, now that your concentric mains are complete, at a full pressure of 10,000 volts (for which the machines were originally designed), instead of 5,000 volts, the pressure first used. These machines will be working at 10,000 volts pressure within the next three months, and you will then be in a position to generate current for 90,000 lights. It is not, however, proposed to supply more than two-thirds of this number at the same time, in order that a reserve of power sufficient to meet the requirements of the Board of Trade may be always kept in hand.

With these two large machines supplying your circuits the first important stage of your undertaking will be completed.

Great progress has also been made towards the next stage, though this work has not been pressed in view of making more rapid progress with that of the first stage. Nevertheless, more than three-fourths of the work of the next pair of dynamos has already been done. They will each be capable of supplying 200,000 lights; but in the first instance it is intended to supply engine power to each dynamo for 100,000 lights only, and by the end of another year from the completion of what I have called the first stage of your work, I expect to be in a position to report the completion of the second stage. You will then be able to supply 290,000 lights, less a proper reserve. Sufficient mains are already laid between Deptford and London to transmit the current which you will then have to dispose of.

I desire to call attention to the fact that from the commencement of your operations to the present time, no engineering or electrical difficulties whatever have arisen which I have not been able to overcome, and at the present moment I know of no weak point in your system, and consider success to be now assured.

It is a matter of great regret that a fire in your temporary distributing station in November last has caused a loss of the revenue which would otherwise have been earned, and which, owing to the extraordinary severity and darkness of the winter, would have been more than usually profitable. I am glad to say that this fire was not due to any defect of principle in your system, and could not have happened had your permanent distributing station been erected; but as you are aware, it was an impossibility to erect the permanent station, the premises being occupied by the machinery which was then in course of removal to Deptford. The fire has, however, in some sense been beneficial, as it has allowed the permanent work to be pushed forward to an extent which could not otherwise have been possible, progress having been much delayed by the necessity of keeping a running business going during a period of progressive changes in the permanent system. The loss occasioned by the fire was not serious, so far as destruction of apparatus was concerned, but was principally felt in decreased revenue returns. The suspension of supply enabled good progress to be made with the laying of distributing mains, there being at the present time some 18 miles laid and in use.

It was important that this work should be pushed on, as the right to use overhead cables expires in the summer of this year, and the distributing mains being so well advanced, it has been deemed wise to discontinue the use of those cables. Your customers are now being connected to the permanent underground mains with the utmost possible speed.

A most important work has been completed during the past year in erecting at Deptford switching gear, which allows all or any of the machines to be used separately, or in combination. It has been further proved that the various machines can be worked together in parallel, a matter of considerable importance to successful working, as ensuring the maximum of efficiency and economy.

The Corporation has secured sites for three additional distributing stations, and the work of installing them with the necessary apparatus is being proceeded with. The stations will all be in work during the present year, each having two separate sources of supply at 10,000 volts pressure, which is lowered at these stations and distributed at 2,500 volts, being further reduced to 100 volts before entering the wires of the customer, as in the case of the low-pressure system.

At the time of my last report there were many parts of the system which were generally considered doubtful and more or less experimental; I refer more especially to the supposed difficulties of transmitting current from Deptford to London. The fact that current of 10,000 volts pressure is transmitted every day to London is the most complete answer to such doubts.

The great advantage of the high-pressure system is apparent, in that the loss involved in transmission of current from Deptford to the distributing stations is inappreciable, while the facilities for procuring coal and water there, sufficiency of room for machinery and appliances, and freedom from the legal and financial consequences attending the erection of generating stations in crowded neighbourhoods, cannot fail to tell their own tale in the working expenses of the current year.—I am, gentlemen, you obedient servant, S. Z. De Ferranti, Engineer.

3, Adelphi-terrace, W.C., March 3, 1891.

### South of England Telephone Company (Limited).

An extraordinary general meeting of this Company will be held at Winchester House, Old Broad-street, London, E.C., on Monday next, March 16th, at two o'clock in the afternoon, when the subjoined resolutions will be proposed. In the event of such resolutions being passed, they will be submitted to a subsequent general meeting for confirmation as special resolutions, under the Companies Act, 1862, viz.:—

(1.) *That the agreement submitted to this meeting, and expressed to be made between this Company and the National Telephone Company (Limited) for the amalgamation of the two Companies, by a transfer of the business and property of this Company (with certain exceptions) to the National Telephone Company (Limited) be, and the same is hereby, approved.*"

Digitized by Google

"(2.) *That with the view of giving effect to the above-mentioned agreement and in order to enable the Debenture stock and shares to be allotted there, under, as part of the purchase consideration, to be distributed among the members of this Company, this Company be wound up voluntarily under the Companies Acts, and that Mr. Thomas Abercrombie Welton be, and he is hereby, appointed liquidator for the purpose of winding up its affairs and distributing its property.*"

"(3.) *That, pursuant to the 161st section of the Companies Act, 1862, the liquidator be, and he is hereby, authorised to carry the said agreement into effect, and to receive the Debenture stock and shares agreed to be allotted, and the cash payable thereunder, and to distribute the same among the members of this Company.*"

The above-mentioned agreement can be inspected by the shareholders at the offices of the Company.

---

The following circular has been addressed to the shareholders :—

"I beg to call your attention to the enclosed notice convening an extraordinary general meeting of the Company, to be held on the 16th instant, for the purpose of considering an important proposal for the sale of this Company's property to the National Telephone Company (Limited), and to pass the necessary resolutions, if approved, relating thereto.

"Shareholders who have attended the general meetings of this Company for the past few years will not be unprepared for this announcement.

"The terms of the proposed sale are as follows :—

"The National Telephone Company to take over the business of this Company as from November 1, 1890, together with all assets and liabilities. The profits of the business for the six months prior to the above date to be at the disposal of the shareholders of this Company.

"The purchase consideration payable by the National Company consists of :—

"(1.) 12,000 fully paid ordinary shares of the National Company, carrying the dividend accruing on April 30th next.

"(2.) Four and a-Half per Cent. Debenture stock of the National Company for £70,000.

"(3.) Interest at 6 per cent. per annum on the paid up amount of the Preference shares from November 1, 1890, until such date as the Debenture stock is issued.

"(4.) The amounts paid in advance of calls on the Preference shares, with interest, from November 1st last, at 5 per cent. per annum, until date of repayment.

"The Debenture stock is equal to the amount called up (£3. 10s.) on the 20,000 Preference shares, while the 12,000 ordinary shares of the National Company would on a *pro rata* distribution give one share of £5 for 25 ordinary shares of this Company of £1 each.

"The immediate advantage of this arrangement is obvious. The dividend on one £5 ordinary share in the National Telephone Company last year was 6s., as against 2s. 6d. on 25 £1 shares in this Company.

"The Board have the greatest confidence in recommending this proposal for your acceptance. FRED. L. ROBINSON, Secretary."

---

## The British Tanning Company (Limited).

An extraordinary general meeting of the shareholders of this Company was held on Tuesday at Winchester House, Old Broad-street, E.C., (at which Mr. H. Horny presided) for the purpose of considering and, if deemed advisable, approving a Bill in Parliament to render valid certain letters patent for the improved process and apparatus for tanning by electricity.

The SECRETARY (Mr. H. Hodges) read the notice convening the meeting.

The CHAIRMAN said: I regret that our chairman cannot be present to-day, but he is unavoidably prevented. You have heard the reason why we call you together. This is really only a formal meeting ; it is a special meeting required by the Committee of the Houses of Parliament, because, as I shall explain further to you, we have been applying to the Houses of Parliament for a Private Bill. At the last ordinary meeting, which was held on December 17th, you heard that we had a lawsuit going on against parties who had a similar process to our own. This came on in the Courts in the middle of January, and the result was unfavourable to us. The position that we occupy at the present moment is that by the decision of Mr. Justice Romer our patent is not valid in this country. To get this invalidity removed and make our patent again valid, we have taken the opinion of our solicitor and find there are several ways in which we could do it. We found that the best and the cheapest way to do it was to apply to Parliament for a private Bill. In saying the cheapest way, I mean that it will not cost us anything, because we have given notice to the vendors that they are liable to put our patent once more in a valid position. I have been over to Paris to see the vendors, with the result that they agree that this litigation to put your patent in a valid position is to their account, and they have given guarantees that the expense will be borne by them. Therefore, I think the proposal the Board of Directors is going to put before you should meet with your full approval, as it is to your interest to see that your property is in a right and valid condition without costing you anything. I have now to move,—

"*That the Bill now read, entitled, 'An Act for rendering valid certain letters patent to Eugene Worms, of Paris, in the Republic of France, and Jean Balé, of the same place, for improved process and apparatus for tanning by aid of electricity,' be and the same is hereby approved, subject to such additions and variations as Parliament may think fit to make therein.*"

Mr. QUINTIN seconded the motion.

The SOLICITOR (Mr. Birchall) having read the short title of the Bill,

Mr. PARKER-RHODES thought if the patent could be recovered by Act of Parliament, those who sold the worthless patent to them should be at the cost of proving that patent good for the sum they asked, £40,000. Let them go to Parliament and do all that was necessary, and not leave it to the shareholders, who had bought their shares on the understanding that it was a good property. The Chairman had said that he had been to Paris and seen the vendors, who had given him guarantees that they would bear the cost of these proceedings in Parliament. It would, in his opinion, cost the Company some £2,000 or £3,000 to proceed with this Bill, as they must prove that they had some justification for petitioning Parliament, and they must do that through counsel and through special solicitors. Was the vendors' guarantee in cash? He thought the Directors were doing a very serious thing in applying to Parliament over such a small matter as this when the Court of Chancery had decided against them, and he should protest against any action being taken in connection with this proposed Bill before Parliament.

Mr. WATSON asked what would be the result with regard to the shareholders if Parliament did not pass the Bill?

Mr. PARKER-RHODES said if this resolution was carried all those who were in favour of it would be taken as having given their consent to go to Parliament, and would lose their claim against the Directors for having bought a worthless patent. He then moved that the Bill be not approved.

A SHAREHOLDER said, if the Bill is not proceeded with the Company must be left without a patent, and must be wound up, and what little money was left would be thrown away in costs.

In reply to a SHAREHOLDER the CHAIRMAN said the Bill was in the House of Lords within the last day or two. In reply to Mr. Watson's remark, if the Bill was not passed their position would be the same as to-day, because they would have power to go to the higher courts. They could go to the Court of Appeal within a year, and they had already told the vendors in Paris that they held them liable. He hoped, however, that they would be successful in obtaining the passage of the Bill.

---


PATENT

# SILICIUM BRONZE AND SILICIUM COPPER WIRE.

The best for overhead Telephone and Telegraph Lines,

AND ALL ELECTRICAL PURPOSES.

Hard Drawn High Conductivity Copper Wire.

ROLLED AND DRAWN PHOSPHOR BRONZE.

PHOSPHOR BRONZE · VULCAN · PHOSPHOR · DURO METAL

PHOSPHOR BRONZE BEARINGS, BUSHES, AND OTHER PARTS OF ELECTRICAL MACHINERY

*SOLE PROPRIETORS of the British, Indian and Colonial Patents,*

THE PHOSPHOR BRONZE COMPANY (Limited),

*87, Sumner Street, Southwark, London, S.E.*

WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.


Digitized by Google

Mr. QUINTIN said the Directors were so satisfied with the guarantee for the costs, that they had agreed to personally guarantee the shareholders against any expense in this respect.

The CHAIRMAN then put the amendment to the meeting, and it was lost, the original resolution being agreed to *nem. con.*

The proceedings then terminated.

## The Direct Spanish Telegraph Company (Limited).

The following is the report and accounts of the Directors for the half-year ended December 31, 1890, to be presented at the general meeting of shareholders, to be held at Winchester House, E.C., on Tuesday, 17th inst., at 2 o'clock:—

1. The accounts for the half-year ended December 31, 1890, show, after providing for Debenture interest, a balance to the credit of profit and loss of £6,597. 19s. 10d.

2. The traffic receipts show an increase of £1,612. 6s. 7d. as compared with the corresponding half-year of 1889.

3. The working expenses are £221. 3s. 4d. in excess of those for the corresponding period of last year.

4. The Company's cables and the land lines in connection with them have continued in good working order throughout the half-year.

5. The London-Bilbao section of the Company's system has been duplexed with excellent results, and is now able to carry a largely increased traffic. The cost of establishing the Duplex (£886. 15s. 1d.) has been paid out of the revenue for the half-year.

6. Of the balance of profit and loss, £2,500 have been put to reserve fund (which now amounts to £23,051. 14s. 8d.), leaving a balance of £4,097. 19s. 10d. Out of this amount the Directors recommend the payment of the dividend at the rate of 10 per cent. per annum on the Preference Shares, and a dividend at the rate of 6 per cent. per annum, together with a bonus of 1 per cent. (both free of income tax) on the ordinary shares, thus making with the previous half year's dividend a total distribution of 7 per cent. for the year on the ordinary shares. This will admit of a sum of £566. 10s 8d. being carried to the "Contingencies Account." The dividend warrants will be issued on April 1, 1891.

7. Sir James Anderson and Mr. Etlinger are the Directors retiring by rotation and offer themselves for re-election. The auditor, Mr. H. R. Duke, retires and offers himself for re-election.

## NEW COMPANIES REGISTERED.

**ASPINALL'S ENAMEL (LIMITED).**—Registered by Wilson, Bristows, and Co. (Limited), 1, Copthall-buildings, with a capital of £125,000 in £10 shares. Objects: To acquire the business of a paint and enamel manufacturer heretofore carried on at New Cross, Kent, by Henry Edward Aspinall, in accordance with an agreement, made February 24th, between Henry Edward Aspinall of the one part and James Graham, on behalf of the Company, of the other part, and to carry on generally the business of paint and enamel manufacturers, colour grinders, drysalters, &c.

**BURGESS AND CO. (LIMITED).**—Registered with a capital of £15,000, in £10 shares, to be issued as Preference or ordinary shares, as the Directors may determine. Objects: To acquire the business now carried on at Trowbridge, Wiltshire, under the style of Burgess and Co., and to carry on the business of manufacturers of and dealers in electrical apparatus and appliances, &c.

**MOBBS AND CO. (LIMITED).**—Registered with a capital of £13,000, in £10 shares. Objects: To acquire the business now carried on at Northampton by Henry Mobbs, and to carry on the businesses of civil, mechanical and electrical engineers, and general iron and brass founders in all their branches.

**UNITED STATES POWER SYNDICATE (LIMITED).**—Registered with a capital of £50,000 in £10 shares. Objects: To purchase the sole rights of manufacture and sale in the United States of Priestman's and Hume's patents relating to hydro-carbon engines, and to carry on in the United States the business of makers and dealers in electric and motive power and lighting, mechanical engineers, &c.

**NEW COMPANIES REGISTERED DURING FEBRUARY.**—Among the Companies registered at Somerset House during the month of February were the following:—

| | Capital. |
|---|---|
| Aspinall's Enamel, Limited (£10 shares) | £125,000 |
| Burgess and Co., Limited (£10 shares) | 15,000 |
| City of London Electric Lighting (Pioneer) Company, Limited (£50 shares) | 100,000 |
| Mazapil Copper Company, Limited (£10 shares) | 50,000 |
| Mobbs and Co., Limited (£10 shares) | 13,000 |
| Rubber Trust Syndicate, Limited (£100 shares) | 10,000 |
| Tewkesbury Agricultural and General Engineering Company, Limited (£10 shares) | 100,000 |
| United States Power Syndicate, Limited (£10 shares) | 50,000 |

## CITY NOTES, &c.

**BRAZILIAN SUBMARINE TELEGRAPH COMPANY.**—The Directors of this Company have declared an interim dividend of 3s. per share, or at the rate of 6 per cent. per annum free of income tax, for the quarter ended December 31, 1890, and payable on the 25th inst. The books of this Company will be closed from the 18th to the 24th inst., both days inclusive. The traffic receipts of this Company for the week ended March 6th amounted to £6,613.

**CADOGAN ELECTRIC LIGHT COMPANY (LIMITED).**—A meeting of shareholders held on the 2nd inst. confirmed resolutions passed at a meeting on the 13th ult, that the Company be wound up, and that Arthur Greenwood, 16, Great George street, Westminster, mechanical engineer, be liquidator, with authority to sell the business of the Company to the New Cadogan and Belgrave Electric Supply Company (Limited), or to any other company.

**CITY AND SOUTH LONDON RAILWAY COMPANY.**—The receipts of this Company for the week ended March 7th amounted to £731.

**COMMERCIAL CABLE COMPANY.**—This Company announces a quarterly dividend at the rate of 7 per cent per annum, payable on April 1st.

**EASTERN TELEGRAPH COMPANY (LIMITED).**—This Company announce the payment, on the 14th April next, of interest of 3s. per share, less income-tax, being at the rate of 6 per cent. per annum on the Preference shares of the Company for the quarter ending March 31st, and the usual interim dividend of 2s. 6d. per share on the ordinary shares, free of income-tax, in respect of profits for the quarter ended 31st December last. The register of transfers will be closed from the 7th to the 14th April, both days inclusive.

**GREAT NORTHERN TELEGRAPH COMPANY.**—The traffic returns of this Company are as follows:—Receipts in February, 1891, £20,600; 1st January to 28th February, 1891, £41,600; corresponding months, 1890, £39,400; corresponding months, 1889, £42,000.

**LIBIOLA COPPER COMPANY (LIMITED).**—At the third annual general meeting, held on Monday, it was resolved that a dividend of 6s. 6d. per share for the year ended December 31st, be declared, and that the interim dividends paid on 18th June and 15th September of 2s. per share respectively be considered as part thereof, and the balance, 2s. 6d. per share, be paid on and after the 31st inst.

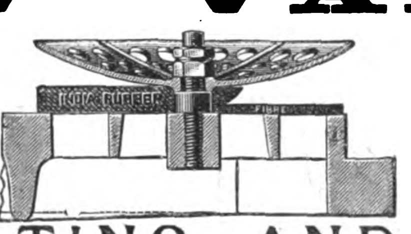
**ORIENTAL TELEPHONE COMPANY.**—The Directors of this Company have resolved, subject to final audit of the accounts, to recommend to the shareholders a dividend at the rate of 2½ per cent. per annum for the past year on the entire paid-up capital of the Company, which dividend, being payable only to the ordinary shareholders, is equal to 3½ per cent. on their shares.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY.**—The traffic receipts of this Company for the week ending March 6, 1891, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £5,349.

**CRICKET.**—The cricket club connected with the firm of Messrs. Girdlestone, Tatham, and Co. will hold its second smoking concert at the Swallow Assembly Rooms, Swallow street, Piccadilly, W., this (Friday) evening. The chair will be taken at eight o'clock by Mr. J. O. Girdlestone. From the programme, with a copy of which we have been favoured, a pleasant evening should result.


NEW VALVE

No Rubber, Percha, or Leather.




One-half the price of Rubber or Metal.

FOR CIRCULATING AND AIR PUMPS.

Unaffected by any Lubricating Oils. Does not Expand in diameter. Feed Water may be worked at any temperature Suitable for any shaped guards. Only one quality manufactured.

"12, John-street, Sunderland, 26th Sept. 1885.

"DEAR SIRS,—In reply to your letter of the 25th inst., the Valves I got from you have done their work well, and ARE AN UNQUALIFIED SUCCESS. I will continue get them from you as required.—Yours faithfully, JAMES WESTOLL."

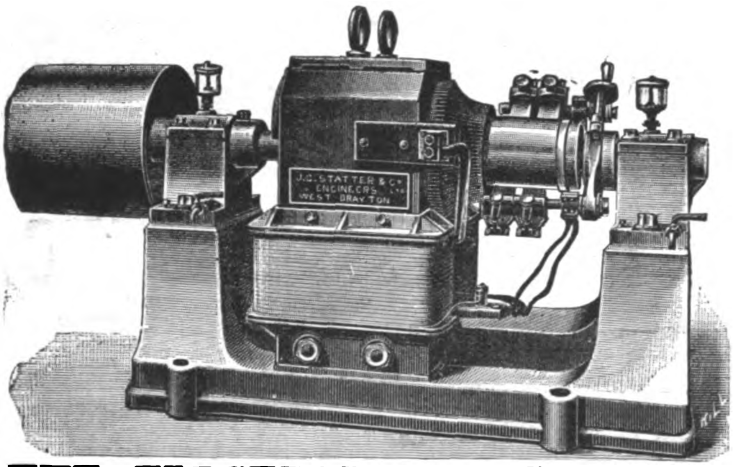
For further Testimony and Prices, apply to MOSSES & MITCHELL, 68-71, Chiswell Street, London.


Digitized by Google

# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name. | Previous Week's Price, March 4. | | Price Wednesday, March 11. | | Rate per Cent. Yielded. | Dividend Due. | Business Done During Week Ending Mar. 11. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **TELEGRAPHS.** | | | | | s. d. | | | |
| £1,381,380 | Stock | 15/0 | Anglo-American | 47 | 48 | 47½ | 48½ | 5 18 7 | Jan., Apr., July, Oct | 48 | 47½ |
| £2,809,310 | Stock | 30/0 | Do. Preferred | 84 | 85 | 84½ | 85½ | 6 14 6 | ,, ,, | 85½ | 84¾ |
| £2,809,310 | Stock | .. | Do. Deferred | 11¼ | 12 | 11½ | 11¾ | .. | .. | .. | .. |
| £250,000 | 100 | 4% | African Direct, Telegraph 4% Debentures | 99 | 102 | 99 | 102 | 3 18 5 | January and July .. | .. | .. |
| 130,000 | £10 | 8/0 | Brazilian Submarine | 11¾ | 12¼ | 11¾ | 12¼ | 6 2 5 | Mar., June, Oct., Dec. | 12 | 11¾ |
| £84,500 | £100 | 5% | Do. 5 per Cent. Bonds | 100 | 103 | 100 | 103 | 4 17 1 | January and July .. | .. | .. |
| £75,000 | £100 | 5% | Do. 5 per Cent. Bonds (2nd Series, 1906) | 103 | 107 | 103 | 107 | 4 13 6 | June and December | .. | .. |
| $7,216,000 | $100 | 7% | Commercial Cable Capital Stock | 108 | 110 | 108 | 110 | 5 18 2 | April and October .. | 110 | 109½ |
| 16,000 | 10 | 8/0 | Cuba Submarine | 10½ | 11½ | 10½ | 11½ | 6 19 2 | February and August | 11½ | 10¾ |
| 6,000 | 10 | 10% | Do. Preference 10% | 16 | 17 | 16½ | 17½ | 5 14 3 | ,, ,, | 17 1/16 | 16⅝ |
| 12,931 | 5 | 7% for '90 | Direct Spanish (£4 paid) | 3¾ | 4¼ | 3¾ | 4¼ | 6 11 9 | April and October .. | .. | .. |
| 6,000 | 5 | 10% | Do. Preference 10% | 9 | 10 | 9½ | 10½ | 4 15 3 | ,, ,, | .. | .. |
| 60,710 | 20 | 3/6 | Direct United States | 10½ | 10⅞ | 10½ | 10⅞ | 6 15 0 | Jan., Apr., July, Oct. | 10⅞ | 10 11/16 |
| 400,000 | 10 | 2/6 | Eastern | 14 | 14½ | 14 | 14½ | 4 11 3 | ,, ,, | 14½ | 14 |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference | 15 | 15½ | 15½ | 15¾ | 3 16 2 | ,, ,, | 15 11/16 | 15 5/16 |
| £1,200,000 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock | 107 | 110 | 107 | 110 | 3 12 9 | May and November | 108 | 107 |
| £800,000 | 100 | 5% | Do. 5 per Cent Debentures, 1899 | 107 | 110 | 107 | 110 | 4 10 11 | February & August | 107 | .. |
| 250,000 | 10 | 2/6 | Eastern Extension | 14¾ | 15½ | 14¾ | 15½ | 4 11 10 | Jan., Apr., July, Oct. | 15 | 14¾ |
| .. | £100 | 4% | Do. 4 per Cent. Debentures Stock | 104 | 107 | 105 | 108 | 3 14 1 | .. | 106½ | 105 |
| £91,800 | 100 | 5% | Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900 | 103 | 106 | 103 | 106 | 4 14 4 | January and July .. | 104 | .. |
| £145,300 | 100 | 5% | Eastern & S. African 5 per Cent. Mor. Deb., 1900 | 103 | 106 | 103 | 106 | 4 14 4 | ,, ,, | 104 | .. |
| 180,227 | 10 | 1/9 | Globe Telegraph and Trust | 9 | 9½ | 9½ | 9¾ | 5 4 0 | Jan., Apr., July, Oct. | 9 5/16 | 9⅛ |
| 180,042 | 10 | 6% | Do. 6 per Cent. Preference | 15 | 15½ | 15 | 15½ | 3 18 8 | ,, ,, | 15 7/16 | 15 1/16 |
| 150,000 | 10 | 5/0 | Great Northern | 17 | 17½ | 16¾ | 17¼ | 4 6 11 | Jan., April, and July | 17⅜ | 17 |
| £230,000 | 100 | 5% | Do. 5 per Cent. Debentures, 1883 | 103 | 106 | 103 | 106 | 5 13 2 | March & September | 105½ | 103½ |
| 17,000 | 25 | 12/6 | Indo-European | 36 | 38 | 37 | 39 | 6 8 2 | May and November | 38½ | 38 |
| 33,348 | 10 | 4/0 | London Platino-Brazilian | 6½ | 7½ | 6½ | 7½ | 5 14 4 | ,, ,, | .. | .. |
| £100,000 | 100 | 6% | Do. 6 per Cent. Debentures | 105 | 108 | 105 | 108 | 5 11 1 | March & September | .. | .. |
| 9,000 | 8 | 4/0 | Reuter's | 8½ | 9 | 8½ | 9 | 5 11 1 | April and October .. | .. | .. |
| 3,381 | £100 Cert. | 6% | Submarine Cables Trust 6% | 115 | 120 | 115 | 120 | 5 0 0 | ,, ,, | .. | .. |
| 15,609 | 10 | 4/0 | West African Telegraph | 8 | 9 | 8 | 9 | 5 11 1 | January and July .. | .. | .. |
| £390,900 | 100 | 5% | Do. 5 per Cent. Debentures | 97 | 100 | 97 | 100 | 5 0 0 | March & September | .. | .. |
| 30,000 | 10 | 3/0 | West Coast of America | 2 | 4 | 2 | 4 | .. | January and July .. | .. | .. |
| £150,000 | 100 | 8% | Do. Debentures 8% 1902 | 94 | 99 | 94 | 99 | 8 1 7 | June and December | 99 | .. |
| 33,321 | 10 | .. | West India and Panama | 2⅝ | 3¼ | 2½ | 3 | .. | .. | 2 11/16 | 2⅝ |
| 34,563 | 10 | 6/0 | Do. 1st Preference 6% | 11½ | 12 | 11½ | 12 | 5 0 0 | May and November | 11 15/16 | 11 13/16 |
| 4,669 | 10 | £3 | Do. 6 p. c. 2nd Pref. | 11 | 12 | 11 | 12 | 5 0 0 | ,, ,, | .. | .. |
| 64,174 | 15 | 6/0 | Western and Brazilian | 12 | 12½ | 12 | 12½ | 4 16 1 | ,, ,, | 12⅝ | 12½ |
| 27,873 | 7½ | 6/0 | Do. 5 per Cent. Cumulative Preferred | 6¾ | 7¼ | 6¾ | 7¼ | .. | — | 6½ | .. |
| 27,873 | 7½ | 4/6 | Do. 5 per Cent. Deferred | 5¼ | 5¾ | 5¼ | 5¾ | .. | .. | 5 1/16 | .. |
| £300,000 | 100 | 6% | Do. 6 per Cent. Debs., Series "A" 1910 | 103 | 106 | 103 | 106 | 5 13 2 | February & August | 105½ | .. |
| £250,000 | 100 | 6% | Do. 6 per Cent. Mort. Debs., Series "B" 1910 | 103 | 106 | 103 | 106 | 5 13 2 | ,, ,, | 105 | 103½ |
| $1,836,000 | $1,000 | 7% | Western Union 7 per Cent. 1st Mortgage | 120 | 125 | 120 | 125 | 5 12 0 | May and November | .. | .. |
| £175,100 | £100 | 6% | Do, 6 per Cent. Sterling Bonds | 100 | 104 | 100 | 104 | 5 15 5 | March & September | .. | .. |
| | | | **TELEPHONES.** | | | | | | | | |
| 224,850 | 14/0 | 0/4½ | Consolidated Telephone Const. & Maintenance. | 7/16 | 9/16 | 7/16 | 9/16 | .. | May and November | .. | .. |
| 280,000 | £1 | 3% | Oriental (11s. paid) | ½ | ⅝ | ½ | ¾ | 4 7 11 | Yearly | .. | .. |
| 438,984 | 5 | 2/6 | National | 4⅝ | 4⅞ | 4⅝ | 5⅛ | 5 12 10 | June and December | 4 15/16 | 4 13/16 |
| 15,000 | 10 | 6/0 | Do. 6 per Cent. Cumulative 1st Pref. | 12¾ | 13¼ | 12¾ | 13¼ | 4 10 7 | ,, ,, | .. | .. |
| 15,000 | 10 | 4/9½ | Do. 6 per Cent. Cumulative 2nd Pref. (£8 pd) | 10¼ | 10¾ | 10¼ | 10¾ | 4 9 7 | ,, ,, | 10½ | .. |
| 209,750 | 1 | ½% | South of England, Ordinary | ¼ | ½ | ¼ | ½ | .. | — | .. | .. |
| 20,000 | 5 | 2/1 | Do. 6 per Cent. Cumulative Pf. (£3 10s. pd) | 2¾ | 3¼ | 2¾ | 3¼ | 6 9 0 | .. | .. | .. |
| 58,000 | 5 | 1/0 | United River Plate | 3 | 4 | 3 | 4 | .. | January and July .. | .. | .. |
| £146,128 | Stock | 5% | Do. 5 per Cent. Debenture Stock | 90 | 95 | 85 | 95 | 5 5 3 | .. | .. | .. |
| £3,200 | 100 | 7% | Do. 7 per Cent. Debentures | .. | | .. | | .. | — | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | | | |
| 111,000 | 5 | .. | London Electric Supply | 2 | 2½ | 1¾ | 2½ | .. | — | .. | .. |
| 43,900 | 10 | .. | Metropolitan Electric Supply (£9 paid) | 8¾ | 9¼ | 8¾ | 9¼ | .. | — | 9½ | 9 1/16 |
| 42,858 | 5 | .. | Westminster Electric Supply (£4 paid) | 3¾ | 4 | 3¾ | 4 | .. | — | 3½ | .. |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | | | |
| 63,416 | 2 | .. | Brush Electrical Engineering | 2¼ | 2⅝ | 1⅞ | 2⅜ | .. | .. | .. | .. |
| 63,416 | 2 | 1/1 | Do. 6 per Cent. Preference | 1½ | 2 | 1½ | 2 | 6 0 0 | June and December | .. | .. |
| 20,009 | 5 | 8/6 | Crompton and Co., 7 per Cent. Pref. Shares | 5 | 5½ | 5 | 5½ | 6 7 3 | January and July .. | .. | .. |
| 17,130 | 5 | .. | Edison and Swan United | .. | | .. | | .. | .. | .. | .. |
| 45,000 | 10 | 6% | Electric Construction | 5½ | 6½ | 5 | 6 | .. | .. | .. | .. |
| 70,000 | 2 | 10/0 | Elmore's Patent Copper Depositing | 2¾ | 3¼ | 2¾ | 3¼ | .. | .. | 3⅛ | 3 |
| 20,000 | 5 | .. | Fowler-Waring Cables (£4 paid) | 2½ | 3½ | 2½ | 3½ | .. | .. | .. | .. |
| 41,600 | 10 | 10/0 | India Rubber, Gutta Percha & Telegraph Works | 18½ | 19½ | 18½ | 19½ | 5 2 7 | February & August | 19⅜ | 19 |
| £200,000 | 100 | 4½% | Do. 4½ per Cent. Debentures, 1896 | 104 | 106 | 104 | 106 | 4 4 11 | March & September | .. | .. |
| 11,834 | £10 | 6/4 | International Okonite Limited Ordinary | 9 | 9½ | 8½ | 9 | .. | .. | .. | .. |
| 11,834 | £10 | 5/0 | Do. Preference | 9½ | 9¾ | 9½ | 9¾ | 8 4 1 | .. | .. | .. |
| 78,949 | 5 | 4/10½ | Swan United (£3. 10s. paid) | 4½ | 5 | 4½ | 5 | 6 19 10 | May and November | 4 9/16 | 4½ |
| 37,350 | 12 | 12/0 | Telegraph Construction and Maintenance | 46 | 48 | 46 | 48 | 5 0 0 | March and July | 47½ | 46½ |
| £150,000 | 100 | 5% | Do. 5 per Cent. Bonds, red. 1894 | 102 | 105 | 102 | 105 | 4 15 3 | January and July . | .. | .. |
| | | | **RAILWAYS.** | | | | | | | | |
| 50,000 | £10 | .. | City and South London Railway | 5½ | 6½ | 5½ | 6½ | .. | .. | 6½ | 5¾ |


# IMPROVEMENTS IN DYNAMOS



# STATTER-BRUNTON

## DYNAMO.

**The latest design in the market, made with all the advantages of the latest scientific knowledge and the highest mechanical skill.**

The woodcut represents our B TYPE DYNAMO. A most efficient machine, working noiselessly, and without sparking or overheating; is highly finished and well proportioned. The output is so rated in our Catalogue that the machines may be worked very much in excess of their stated full output for short periods.

**STOCK SIZES UP TO 77 KILOWATTS.**

**MACHINES BUILT TO 500 KILOWATTS.**

**THE ELECTRICAL ENGINEERING CORPORATION, LIMITED,**
STATTER'S] [UNITED

68, Victoria Street, London, S.W.

WORKS:—ALLIANCE ENGINEERING WORKS, WEST DRAYTON, NEAR LONDON.


Digitized by Google

# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 670.—Vol. XXVI. FRIDAY, MARCH 20, 1891. Price Fourpence.

## NOTES.

The speaking quality of the London and Par s telephone line of which a detailed description will be found in another column, fully justifies the promises of its designers. On Wednesday we had an opportunity of conversing with Paris. Room No. 90, on the second floor of the General Post Office, until recently the office of Mr. J. B. Chapman, is fitted, along one wall, with a number of telephones of different patterns, some selected by the English engineers and some by the French. On first listening, with a receiver at each ear, there was an absolute silence. We naturally supposed that the line was temporarily switched off, and expected to hear a click followed by the usual buzzing and gurgling and then by a faint Punch-and-Judy-like voice. But this silence was the normal state of the line, and a voice was soon heard with the utmost clearness and very fair volume. We inquired whether Mr. H. R. Kempe was there, and he came to the telephone at the Paris end, and during a short conversation the tones of his voice were most faithfully reproduced and perfectly recognizable. The simplicity of the arrangements and the unmistakeable recognition of the voice recalled the electrophonoscope at South Kensington, and Mr. Preece was asked by a visitor whether the line did not terminate in a neighbouring room. Mr. Kempe's voice could not have been more easily distinguished if he had been speaking from the laboratory in No. 8, where we last saw him. It is, indeed, remarkable to think that this grand result is obtained with a battery power of three Leclanché cells.

The daily papers have all been explaining that the design of the cable is based upon the K. R. law. K., we thought, stood for electrostatic capacity. This is also sometimes called inductive capacity, but the daily press unanimously call it capacity for induction. It has been asserted on purely theoretical grounds that self-induction is essential in telephone lines to prevent the higher vibrations from being extinguished to a greater degree than the lower tones. Mr. Preece has most consistently stuck to the principle laid down by him at the Royal Society in February, 1887, and has used every effort to *abolish* self-induction. Whatever may be the scientific explanation, the line is an emphatic success, both as to volume of sound, which probably depends on the resistance, and as to the clear individuality of the tones of the speaker, which is due to the more complex properties of the line.

At the meeting of the London Electric Supply Corporation on Friday the Chairman dealt minutely with the accounts, and urged as a good excuse for their somewhat discouraging aspect the scale and novelty of the Company's operations. The London Company, in common with other new enterprises, has had to buy its experience, and owing to various causes, most of which have been beyond its control, the purchase price has proved abnormally high. With ordinary good fortune Mr. Forbes may reasonably hope to have a more cheerful tale to tell next year, by which time the many obvious advantages attendant on high pressure distribution from an "eccentric" station may be expected to be more apparent in the accounts. It is with great satisfaction that we note the cordial support given to Mr. Ferranti from the Chair. With the bugbear of an unsatisfactory balance-sheet ever before him some impatience on the part of the Chairman would not have been altogether surprising.

The following summary of the financial side of the question may be of interest. The authorised capital of the London Electric Supply Corporation is 1¼ million sterling, of which more than £700,000 has been paid up. The total expenditure since the present Company's formation amounts to nearly £650,000, so that there is an unexpended balance of about £60,000. During the past year no less than £143,000 was spent, the chief items being mains (£77,000), plant at Deptford (£33,000), transformers (£9,000), meters (£3,000). The total expenditure in round figures under these headings is as follows:—Mains £121,000, plant at Deptford £102,000, transformers £36,000, meters £4,800. The revenue account exhibits a remarkable equilibrium, the expenses balancing the receipts to within £19. 14s. 3d. The total receipts for 1890 were £28,704. 9s. 11d., the current sales (by meter and contract) realising just on £26,000, about two-thirds of the current having been sold by meter.

It appears that the difficulties which have arisen in connection with the Boy Messengers Company and the District Messengers Company, and the prominence with which these have been brought before the Press and before Parliament have aroused the Postmaster-General to a sense of the obligation which rests on him, either to allow this most useful service to continue, or to provide a substitute through his department. He promises that by Wednesday next "a large staff of messengers will be always on hand" at "all the principal post-offices in London," and "at a smaller actual cost than

Digitized by Google

would be possible under the schemes of the Boy Messengers and District Messengers Companies."

We have frequently made use of the services of the latter, and realise the great difference between the convenience of being able to summon the messenger by the mere turn of a handle, and of having to go out to the nearest post-office to seek him. Some years ago there was an outcry against the inhumanity of chimney-sweeping by climbing boys, and a philanthropist invented a brush fastened to a rope. On being asked how the rope was to be placed in the chimney, he admitted he had not thought of that difficulty, and suggested that it would be best to send a lad up the chimney with it. Similarly, the subscribers to the Messenger Companies will still need some one to go and fetch the messenger, and will be deprived of the very convenient means now at their disposal for summoning a cab, a policeman, their own doctor, or a fire engine, to say nothing of a special fire extinguishing apparatus, which on one occasion, at least, succeeded in extinguishing the fire before the engine arrived. Will the State undertake any of these useful offices?

THE rejection by Mr. HANBURY'S Committee of what may be called the City and South London Railway Extension Bill was a foregone conclusion from the moment that its promoters persisted in their determination not to make a "physical junction" with the existing line from King William-street to Stockwell. The reasons adduced for this course, namely, the expense and the fact that the trains which it was proposed to run on the new line would not fit the 10ft. tunnel of the City and South London Railway were not likely to weigh against the enormous public disadvantage of a break 150 yards long in the much-wanted line from Islington to Clapham.

THE London County Council's Bill for dealing with overhead wires, a summary of which is to be found in our issue of January 30th, has passed the Select Committee of the House of Commons, but in a very emasculated condition. To put the matter briefly, the Bill in its original form gave the County Council authority to make bye-laws with regard to the erection, supervision, registration, and removal of overhead wires; empowered that body to remove aerial lines into subways where these existed and were convenient; to appoint uniformed inspectors with power of compulsory entrance at reasonable hours on to private property to inspect wires, and to make charges for identification and supervision. In the Bill as it now exists all mention of subways, charges and uniformed inspectors armed with compulsory powers is struck out; drastic excisions due, no doubt, in a large measure to the clever and in many ways convincing arguments of the National Telephone Company.

IN accordance with a resolution of the Chelsea Vestry passed in the autumn, their surveyor, Mr. HIGGENS, has recently drawn up a voluminous report on overhead and underground wires, &c. Mr. HIGGENS'S report forms an excellent epitome of the law on the subject, and contains several useful suggestions. Electricity supply companies are, as a rule, so much more sinned against than sinning, that it is quite a novelty to find that they are entitled to do something which the Vestries cannot prevent, and something which distinctly tends to raise the rates. Mr. HIGGENS points out that the junction boxes, &c., which are now so frequently met within London, are provided with iron covers which only in some few instances are filled in with material similar to that of the surrounding pavement. The result is that asphalte pavements, which *might* last ten years, will probably require renewal in less than five. The surveyor to the Chelsea Vestry not unreasonably wants compulsory powers in this matter.

A MEMORANDUM and précis of correspondence between the Board of Trade, Messrs. Crompton and Co., the Brush Company, and several other firms, on the Overhead Wire Regulations, have been printed by the London Chamber of Commerce, and the subject will be further discussed at the meeting to-day. There appears to be but little doubt that the real difficulty will soon be recognised. Major CARDEW admits that "the material need not possess a high specific resistance. Five megohms is as good for the purpose as 5,000." In case of cracks in the covering, he wants a thickness of insulating material greater than the sparking distance. This he puts at one-sixteenth of an inch for 2,000 volts. Finally, he requires some proper mechanical protection to resist abrasion. Mere piling on of india-rubber seems to be a very poor way of fulfilling these requirements, which ought to be easily met.

SOME months ago we published an important experimental investigation by Prof. RYAN dealing with the character of the variations in current and magnetism which occur in a transformer at different parts of the alternation, the losses due to hysteresis, eddy currents, &c., being shown by curves deduced from the observations. This week, MR. SYDNEY EVERSHED, in continuing his articles on the magnetic circuit of transformers, gives the first of a series of curves which are very similar to those previously published by Prof. RYAN. They were, however, obtained by an entirely different method and without reference to them in any way. We understand that the construction used to obtain the "indicator diagrams" was devised over two years ago. Publication was, however, delayed till the present time, in order that a thorough series of tests on iron might be made, with a view of obtaining data from practice.

A CORRESPONDENT writes us as follows on the Paper read last week before the Society of Arts by Mr. NEWMAN LAWRENCE and Dr. HARRIES, an abstract of which has appeared in our columns:—"I cannot but think that the authors of the Paper were somewhat unfortunate in their choice of the experiment by which they sought to demonstrate the cataphoric action of electrical currents; and that the facts adduced in support of this and other theories put forward by them were crude, even for a Society of Arts audience. The 'indifference, suspicion, and conservatism' of the medical profession was made much of on Wednesday evening; but medical men can hardly be expected to accept without considerably more proof than

Digitized by Google

was forthcoming, the statements that 'very probably life does not exist without electricity,' and that the health of the body is '*to* a large extent dependent upon electricity.'"

**Technical Instruction Bill.**—This Bill, as amended, was considered and read a third time in the House of Commons on Thursday last week.

**The "Electric."**—The accumulators on board this pinnace are by the Electric Construction Corporation, and not, as stated by us last week, of the Epstein type.

**Bradford.**—The question of adopting electric traction on a new tramway line about to be laid down in Bradford is being considered by a committee of the Town Council.

**The Junior Engineering Society.**—A numerously attended excursion of this Society took place on Saturday, 7th inst., when the Boiler Works of Messrs. Maudslay, Sons and Field, at East Greenwich, were visited.

**The Hermite Processes.**—The Hermite processes of electric bleaching and sewage purification are to be worked in France by the Société Française d'Exploitation des Procédés Hermite, whose offices are at 4, Rue Drouot, Paris.

**University College, Bristol.**—The Council of this College will, in May, nominate to one of the science scholarships offered by the Commissioners of the 1851 Exhibition. Further details will be found in our advertisement columns.

**Direct Spanish Telegraph Company.**—We are informed that the telegraph office of this Company, at No. 74, Gracechurch-street, is now again in direct communication with Bilbao and Madrid, and there is no delay in the transmission of telegrams to Spain by that route.

**A Telephone Association for London.**—Steps are being taken to form an Association with the object of securing lower telephone rates and a double-wire system in London. We are informed that the Association has already received an encouraging amount of support.

**Long Distance Electric Lighting.**—The old Breton town of St. Brieux (Côtes du Nord) is to have the first electric lighting station in France on the Thomson-Houston alternate current system. The generating plant is situated at a spot 15½ miles from St. Brieux. The installation will be inaugurated on Easter Sunday.

**Exeter.**—At the last meeting of the Town Council it was decided to obtain a Provisional Order, and lease it to the Exeter Electric Lighting Company with powers of resumption at the end of 21, 28, or 35 years, on special terms, the company's charges to be reduced in proportion to their profits over 5 per cent. per annum.

**International Electrical Exhibition at Toulouse.**—An International Electrical Exhibition will be held at Toulouse during the present year. The exhibition will be open for a period of four months, from the 15th May to the 15th September next. Full particulars may be obtained by applying to the Secretary of the Exhibition at Toulouse.

**Magnetic Meteorology.**—Some few months since the Abbé Fortin announced that he had discovered a system for predicting the weather by the movements of the magnetic needle, and an instrument of his design was, therefore, placed under test at the Observatory in the Parc St. Maur. Since it has been installed at the Observatory no movement whatever of the needle has been observed.

**The Diminution of "Chattering" on Overhead Circuits.**—A grooved washer of vulcanized indiarubber has recently been brought out by Mr. C. Dexter Barker, of Turnmill-street, E.C., to diminish "chattering" on telegraph and telephone wires. The washer is inserted into the groove of an ordinary insulator, and the wire bound round this elastic cushion instead of round the hard surface of the insulator.

**The "Amber."**—We note with satisfaction that the boats of the Eastern Telegraph Company's cable steamer "Amber" did good work in rescuing the drowning emigrants from the "Utopia" when she sank in Gibraltar Bay on Tuesday evening after colliding with H.M.S. "Anson." The electric search lights of the Fleet are also reported to have been employed with great effect, enabling many to be saved who would otherwise have been drowned in the darkness.

**London Chamber of Commerce.**—A meeting of the Electrical Trades Section Committee will be held at Botolph House, Eastcheap, at 1.30 p.m. to-day. The following are the agenda:—(I.) To receive the reports of the sub-committees on:—1. Overhead wires; 2. Telephone clauses; 3. Board of Trade form of accounts. (II.)—To consider the desirability of co-operation between the Telephone and Electric Light Companies, for the purpose of placing wires underground in future.

**An Organ-Blowing Plant.**—A recent issue of the *Electrical World* of New York contained an illustrated description of a motor plant installed in one of the prominent Brooklyn churches for blowing the organ. The motive power is furnished by a small Perret motor, belted directly to the crank shaft that operates the bellows. Attached directly to the body of the bellows is a rod that operates a regulating switch. As the bellows fills, the motor is made to run more and more slowly, and *vice versâ.*

**The Saunderson Arc Lamp.**—Mr. A. Apps informs us that he is no longer connected with the Saunderson patents for arc lighting. We regret to hear this, as Mr. Apps promised us full particulars of the system. Dr. Hopkinson reported that the use of volatile hydro-carbon in the arc was advantageous. Prof. Silvanus Thompson, on the other hand, said in his lecture before the Society of Arts on March 6th, "The introduction of all known foreign substances whatsoever into the carbon pencils of the arc is found to lower the intrinsic brilliancy." Total illumination and intrinsic brilliancy are not the same thing, and we should like to hear if Mr. Saunderson has met with success in his experiments.

**The Edinburgh Exhibition.**—The liquidator of this Exhibition has issued a circular stating that a first dividend of 13s. 4d. per pound will be paid to those creditors whose claims have been admitted. Preferable debts had been paid to the amount of £2,710. 16s. 3d., and the ordinary claims lodged amounted to to £42,215. 4s. 8d. The subscriptions to the guarantee fund amounted to £26,569. 7s., and of that sum there had been received £25,594. 7s. The total receipts, including drafts on cash credit, were £102,539. 18s. 10d.; and the total payment, £101,083. 16s. 5d. There was a balance in hand on November 15th of £1,356. 2s. 5d. The sums received from exhibitors for space amounted to £12,974. 9s. 7d.; music and entertain ment cost £12,053. 2s. 6d.

**The National Telephone Electrical Society.**—This society is still progressing. A short time ago Mr. A. C. Cotterill, the district manager, described his anti-induction apparatus lately patented, and Mr. Wicker, from Sheffield, gave a short lecture on the "The Action of the Transmitter and Receiver." On Friday, February 27th, Mr. P. Loftus, Chief Construction Engineer, gave a very interesting and instructive lecture on "Construction and Renewal of Telephone Lines," illustrated by diagrams. Mr. Loftus also explained an improvement of his own for leading in subscribers' lines. The lecture was very much enjoyed, and there was a large attendance. Last Friday two papers were given by Messrs. Lloyd and Bailey on "Magnetos and their Connections," which led to a very interesting discussion on the different kinds of switch-hooks.

**The Gordon System of Electric Traction.**—The experiments carried out at Messrs. Merryweather and Sons, Tramway Works, Greenwich, on behalf of the Gordon Electric Car Syndicate, are said to have given encouraging preliminary results. The track has closed conduits, and the general idea of the system is a series of contacts actuated by means of an automatic magnet in a box placed in the ground every hundred yards or so—about 16 to a mile. The preliminary trials have been made in all sorts of weather, and with very severe tests, such as flooding the whole track of 70 yards with water, working in snow, fog, and so forth. The working pressure is 250 volts and the current 30 amperes. It is to be hoped that the system will shortly be applied to a complete tramway line in order to verify, under ordinary working conditions, the satisfactory results shown by experiment.

Digitized by Google

**The National Telephone Company and its Border Subscribers.**—With regard to our Note under this heading last week, we are informed that the facts of the case are as follows: —When the National Company came into the Galashiels district, some five years ago, the telephone subscription was fixed at £10, with a verbal understanding that when the patents expired a substantial reduction was to be made. In January last the rentals were reduced all round by 30 shillings. The subscribers, however, expected something more sweeping, and thought £6 a reasonable figure. The result of this difference of opinion, and of negotiations with the Mutual Telephone Company, has been that all the subscribers in the vicinity of Galashiels have, with one or two exceptions, withdrawn from the National Company's system. The Mutual Company have made an offer to introduce an exchange, the subscription to which will be about £6 per annum.

**Adelaide.**—The Brush Electrical Engineering Company, having written to the Adelaide City Council, offering to lend them some electrical plant for the purpose of making experiments with regard to the lighting of the city, the matter was referred to the Electric Lighting Committee. The Committee have reported as follows:—"With reference to the offer of the Brush Electrical Engineering Company to lend the Corporation, for the period of six months, one Brush arc dynamo and 55 arc lamps, free of cost, upon certain conditions, the Committee directed the City Surveyor to place himself in communication with the agent for the Company in Adelaide (Mr. Grant) with a view of obtaining the fullest information as to the number of lamps, engine stations, &c., it would require to light the whole of the streets with electricity. The Town Clerk was also directed to obtain all the information possible from any other company who, it might be thought, might be willing to tender for lighting the streets with electricity."

**Electric Traction on the South Staffordshire Tramways Company's System.**—Speaking at a recent meeting of this Company, the Chairman, Mr. W. J. Carruthers-Wain, stated that he had recently returned from a long tour of inspection in America, where cable and electric tramways were in extensive operation, and he was much satisfied with the way in which things were worked out there. He had one or two letters from shareholders who could not attend but who wished their views to be known, and those views came to this, that they recognised the impracticability of making a steam tramway pay in a district like that worked by the Company, and they urged the adoption of some other mode of traction. For his own part he should like to see a cable tramway, but where the population was so limited, a cable line was no good, so that it would be an excellent thing if the authorities could be made to see the advantage of overhead wires. He trusted the authorities were sufficiently intelligent and liberal-minded to accept the suggestions he had made with regard to this matter. He had inspected the line to see what was possible to be done with regard to electric working, and was in hopes of receiving a favourable proposition from the local authorities in regard to it.

**Telegraphing Extraordinary.**—During the recent unprecedented fall of snow in Devon and Cornwall, the Porthcurno station of the Eastern Telegraph Company found its landline communications with the rest of the island interrupted by a barrier of snow extending over half those counties, and varying in depth from 2 or 3 to 25 feet. The cables, however, remained intact, and by their aid frequent and rapid communication was held with the Company's London station by way of Lisbon, Gibraltar, Malta, and Marseilles, a distance of over 9,000 miles, urgent service messages being frequently exchanged within the space of a few minutes. It fortunately happened that the Eastern Company's direct line from London to Marseilles through France was, notwithstanding the weather, in excellent electrical condition, and by this route wonders of telegraphy were performed. In one working day of 23 hours 24 minutes no fewer than 1,558 messages were exchanged between London and Marseilles, being an average of 67 messages per hour, many of them very lengthy, and the majority composed of difficult code words, or cypher. When it is considered that this was accomplished by hand working only, over a simplex wire nearly 9,000 miles in length, composed of aerial, submarine, and subterranean lengths, it will probably be regarded as one of the most extraordinary feats of telegraphy on record.

**Machine Stoking.**—The following statements are taken from a Paper recently read before the Institution of Civil Engineers by Mr. J. F. Spencer:—The efficiency of a machine stoker as a smoke preventer is due to its uniform careful firing. With regard to economy of fuel, this may result from two distinct causes. First, the use of a cheaper coal, either too dirty for, or the heat units of which cannot be fully utilised by, hand firing. Secondly, the more perfect combustion due to a uniform supply of fuel, and the automatic and progressive manufacture of carbonic acid. With reference to the economy from the use of a cheaper coal than is possible with hand firing, the testimony is overwhelming, and is rarely contested; but it is not so generally known that, owing to the more perfect combustion in machine stoking, the cheaper coal realises also a higher evaporative duty per pound of fuel. Machine stoking also tends generally to an increased and more uniform evaporative duty, and of this there is a large amount of evidence available. Economy of labour may be and is realised by machine stoking, as the system permits the automatic supply of fuel to the hoppers. The approximate total number of furnaces fitted, and now working, with machine stokers is, however, only 15,120. This represents about 8,000 boilers, out of an estimated total in the United Kingdom at the present time of 140,000, or only 5·7 per cent., and it has taken nearly 70 years to achieve this limited success.

**Prof. Elihu Thomson's Pioneer Experiences.**—In his address on "Pioneers' Day" at the recent meeting of the National Electric Association at Providence (R.I.), Prof. Elihu Thomson gave the following interesting account of his early experiences:—Recounting my own experience in electric lighting, I may say that I built a small dynamo about 1876 to run an arc light. It was a success, and it led to the construction of other dynamos. When I came, however, to the commercial part of the business, which began in 1878 or 1879, I found that there were many difficulties to overcome, and not the least of these difficulties was the getting of steady power to run the machines. The first Thomson-Houston three-coil armature machine intended for commercial use was capable of running from four to eight lights in series. I carefully examined every inch of the wire, and insulated the whole thing myself. Our first machine was put up in a bakery in Philadelphia, where it was used all night, and it was rather tenderly nursed by us. Sometimes we were up all night tending to this baby, and under conditions which were not altogether agreeable in the summer, as there is a good deal of waste heat in a bakery. The temperature was sometimes as high as 140 deg. After running these machines some time a Company was organised, which is now the Thomson-Houston Electric Company. It was organised in a modest way in New Britain, Conn. I became electrician of this small Company, and the apparatus was made in New Britain in an old basket shop. This was the beginning of our experiences. We soon got into another shop and began the construction of apparatus for commercial use. After we got into operation our difficulties were not, by any means, over. We had to develop all sorts of devices. We had to overcome conditions constantly arising to discourage us. When one thing was accomplished we were met by other reverses. The Brush Company saw our beginnings of success and tried to buy up a majority interest in our little Company in New Britain, apparently for the purpose of entirely swallowing us. Subsequently, however, in the same year, certain parties in Lynn purchased a majority interest in the stock, and what was the American Electric Company of New Britain started operations in Lynn. The Brush Company, as you are probably aware, has been swallowed up by us, the infant they tried to swallow. Such is fate. We have the firmest confidence in the expansion of the electrical industries. We are absolutely certain that the business is going to be greater and greater as time goes by. We have calls now for machines and dynamos up to 500 and 1,000 H.P., where a few years ago we thought it an unusual thing to have 100 and 200 H.P. machines, and it looks very much as though in the near future machines of much larger capacity would be demanded for the work of installation.

Digitized by Google

## THE MAGNETIC CIRCUIT OF TRANSFORMERS: CLOSED VERSUS OPEN.

BY S. EVERSHED.

(*Continued from page 536.*)

§ 34. Our investigations have led us to the conclusion that in order to compare the merits of two transformers it is practically useless to compare their full load efficiencies, for the worst transformer is reasonably efficient at full load; all we need do is to determine the energy losses, and of these the constant waste constitutes a criterion of efficiency. This, in brief, is the contention advanced originally by Mr. Swinburne in his British Association Paper, read in 1889. Indeed, many of the results independently arrived at in the present articles are stated, or rather concealed, in Mr. Swinburne's Paper, and may be unearthed by those possessed of more patience than the present writer. Most of the tables in the Paper are valueless for purposes of ready comparison, the amount of the drop in volts at full load having apparently been left to chance.

We will now examine a little more closely the nature of the constant losses in transformers, and for this purpose it will be convenient to construct diagrams showing the phase relations and approximate forms of the curves of induction, exciting current, eddy currents, and electromotive forces, when a transformer is run with its secondary circuit open.

§ 35. Before a diagram can be drawn, it is necessary to know the form of the wave of impressed E.M.F. at the terminals of the primary coil. In attempting to treat transformer problems analytically, it has been the invariable practice to assume that the E.M.F. wave followed a simple periodic law. Because, according to Fourier, *any* function whatever can be expressed by an *infinite* series of sine or cosine terms, the mathematical clothiers, alluded to in § 1, after an invocation addressed to the mighty powers of Fourier's theorem, calmly cut down the infinite series to one solitary term, and then find that the primary and secondary current waves (and the induction wave also sometimes) are one and all simple sine functions of the time. Such a trifle as the possible effect of hysteresis in altering the shape of the waves must give way before the powers of analysis, and the theory of transformers resolves itself into transcendental trigonometrical transformations which more or less completely mask the real phenomena involved in electrical transformation.

§ 36. But a new era is dawning, and we are gradually coming to recognise the virtue and necessity of stating the unknown laws connecting such phenomena as magnetic force and induction in iron for example, in the form of a curve which simply gives the observed relation under certain specified conditions. Why attempt to make an empirical formula fit the curve when we have the curve itself? The disastrous effects resulting from the ancient practice of constructing an elaborate formula to fit the observations, and then practically destroying the observations, are familiar to all engineers who refer to their Molesworth. To pack the results of any observations whatever into an empirical formula ought to be statutory offence. Having entered a protest against the Fourier theorem bogey and empirical mathematics, it must be confessed that the sine function is not to be despised, and when kept within proper bounds makes an excellent servant. In drawing transformer diagrams we shall first assume the E.M.F. wave to be a simple sine function of the time; next, that it is a plain zig-zag; and finally, that it is constant in value while alternating periodically in sign.

§ 37. Armed with some squared paper, a slide rule, and the cyclic **B H** curve (Fig. 9) corresponding to a maximum induction of 5,000 gausses, let us draw a "no-load" diagram for the low-induction closed transformer No. 2. It is best in choosing the horizontal scale to make a complete period correspond with some convenient whole number of squares, irrespective of the true length of period, the latter being usually an incommenusrable portion of a second. The maximum value of **B** being known, the curve connecting **B** and time is readily plotted, assuming for the moment that it is a sine function. Next work out the maximum value of the counter E.M.F. in the primary. Since $\mathbf{B}_t = \mathbf{B}' \sin 2\pi F t$; **B'** being the maximum induction, the counter E.M.F. will be $N A \frac{d\mathbf{B}}{dt} = N A \mathbf{B}' 2\pi F \cos 2\pi F t$, and its maximum value is of course $N A \mathbf{B}' 2\pi F$. This value being plotted at the epoch corresponding to $\mathbf{B} = 0$, the remainder of the curve is easily filled in by taking four or five values for $E' \sin \theta$. This is readily done if the slide rule gives sines, and if not the natural sines of, say, 10°, 30°, 50°, 70°, and 80° may be written down from a table and kept at hand. Instead of plotting the counter E curve having a *negative* maximum when **B** is passing through zero from negative to positive, it may be plotted as that component of the impressed E necessary to exactly balance the counter E (Fig. 10). Now, refer to the **B H** curve, and from the known mean length of the induction path in the core and number of turns in the primary coil, calculate the value of the necessary exciting (or magnetising) current for, say 1,000, 2,000, 3,000, 4,000, and 5,000 gausses. Owing to the hysteresis there will natnrally be two values of $C_p$ for each value of **B**, and care must be taken to plot them in the right order—that is to say, plot them as they occur in going round the cyclic **B H** curve counter-clockwise. The curve so obtained is marked X

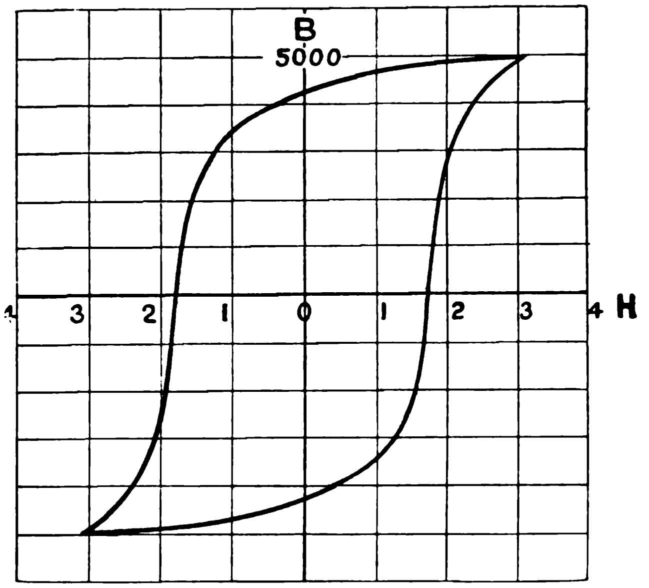



FIG. 9.—Cyclic **B H** curve from charcoal iron, taken between + and − 5,000 gausses. **B** and **H** in C.G.S. units.

in Fig. 10, and we shall in future call it the X component of the exciting current. The vertical scale to which the exciting current is plotted should be large enough to give a bold curve; it is, of course out of all proportion to the scales chosen for E and **B**.

There remains to be found the additional exciting current required to neutralise the demagnetising effect of the eddy currents in the core. As the waste of power due to core eddy currents has already been calculated, we might find the required current by dividing the power by the E.M.F., but this easy way of arriving at the result does not direct attention to the manner in which eddy currents reduce the effective magnetising force, and it will be preferable to give in this place a rough method for ascertaining the average value of the demagnetising effect of eddy currents in thin laminæ.

Referring once more to Fig. 2, and remembering the expressions found for the E.M.F. in and resistance of an elementary path in the section of the lamina, we find the current in it is $\frac{\dot{\mathbf{B}} s^2 x l dx}{\rho r^2}$, and consequently the magnetic force within the element being $\frac{4}{10} \pi C \, d\mathbf{H} = \frac{4\pi}{10} \frac{\dot{\mathbf{B}} s^2 l x dx}{\rho r^2}$, where $\dot{\mathbf{B}}$ must be expressed in volts and $\rho$ in ohms. If this expression is integrated from $x = x$ to $x = r$ we shall have the value of **H** just inside

Digitized by Google

the elementary path P Q due to all the eddy current outside it. Call this $\mathsf{H}_x$ and

$$\mathsf{H}_x = \frac{2\pi \dot{\mathsf{B}} s^2 l (r^2 - x^2)}{10 r^2 \rho}.$$

What is required is the average value of H over the whole section of the lamina, and to get this the surface integral of

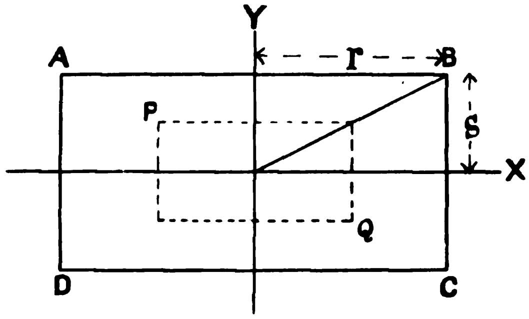



Fig. 2.

H must be taken from $x = 0$ to $x = r$, and the result divided by the whole area of section; we have then an average value of H, which, if applied in the form of a current entirely outside the lamina, would diminish the H due to the current in the primary coil by very nearly the same total amount as does the neutralising current must flow in a circuit round the whole core—in short in the primary coil.

§ 39. On performing the integration mentioned in the last paragraph, we find the average eddy current H over the whole section of a lamina is $\frac{\pi \dot{\mathsf{B}} t^2}{40 \rho}$ per cm. in length of core, and it is a maximum when $\dot{\mathsf{B}}$ is so. $\dot{\mathsf{B}} = 5000 \times 2\pi F \cos 2\pi F t$, as we have already seen, and its maximum is $5000 \times 2\pi F = 2{\cdot}2 \times 10^6$, but as we are throughout working in volts, amperes, and ohms, it must be divided by $10^8$ and maximum $\dot{\mathsf{B}} = \frac{2{\cdot}2}{100}$ volts (per sq. cm. of core).

When this value is inserted in the equation for the average eddy current H, we find that the maximum reached by this average H is ·43. Being so small no great error can be introduced by the fact that we took a rough average value throughout the section of a lamina. The maximum current required in the primary coil to produce a positive H = ·43 is found from the relation $\frac{4\pi N C'}{10} = {\cdot}43 \times 147$, where C′ is the maximum of C, and 147 is the mean length of the induction path in the core. On working out we find

$$C' = {\cdot}0225 \text{ (amperes)}.$$

This value is to be plotted on the diagram at exactly the same epoch as the maximum counter E, and the whole wave of the

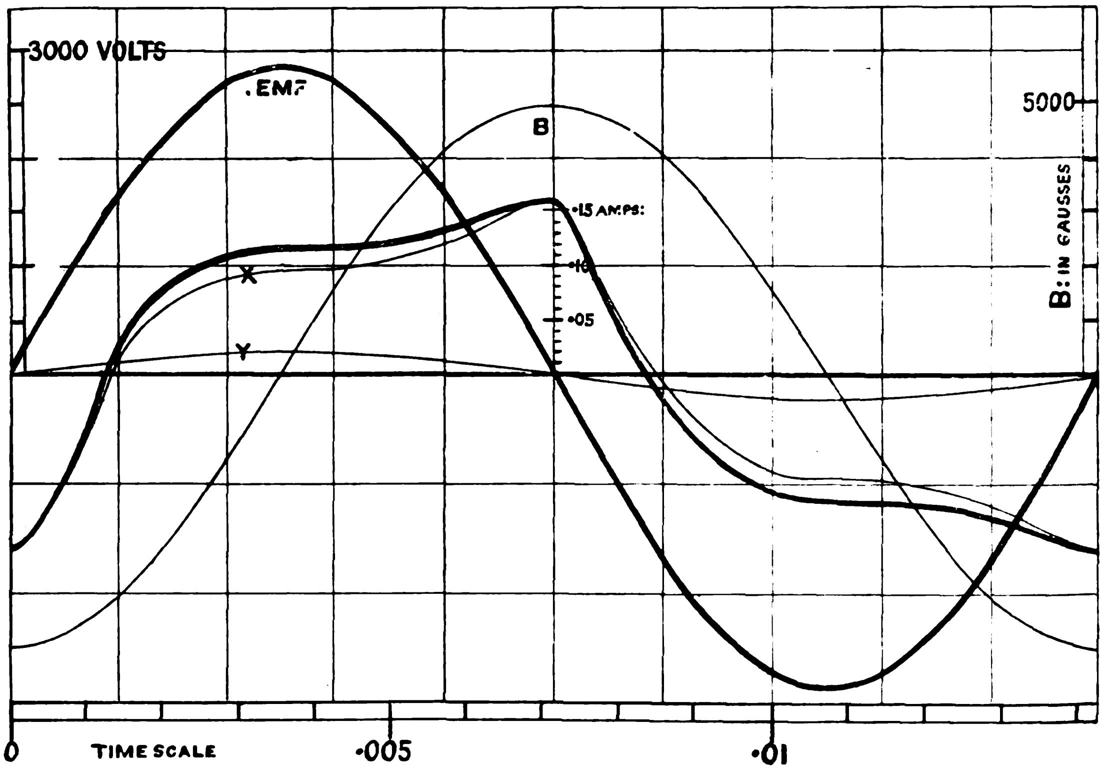



Fig. 10.—No. 2 Closed Transformer, excited by sine E.M.F. Output = 0.

B = Induction density in core.
X = Current in primary coil to magnetise the core.
Y = Current in primary coil to neutralise effect of eddy currents in core.
$c$ = X + Y = total exciting current.

actual distribution of currents in the lamina. In short the lamina may be supposed to be made up of an inner section or core of non-conducting magnetic substance, surrounded by a thin non-magnetic conductor in which all the eddy currents occur. In this simple case it is quite evident that the H due to the eddy current would be uniform over the whole section of the magnetic stuff; and the eddy current would be cophasal with the E.M.F. ($\dot{\mathsf{B}}$), which is its cause; for there is no other changing induction besides that involved in $\dot{\mathsf{B}}$, to throw the current out of step. All that is necessary to annul the effect of the eddy current is to provide an equal total current round the lamina in the opposite direction—that is, in the same direction as the main magnetising current but cophasal with the counter E.M.F. This is true of each lamina in the core, so that the anti-eddy current, as it may be called, is easily filled, is by working out a few values from the current equation C = ·0225 sin $2\pi F t$. The wave is marked Y in Fig. 10, and we may call it the Y component of the exciting current.

§ 40. The diagram now contains a complete account of the whole exciting current considered as two separate currents for distinct purposes; X to carry the core through the requisite cyclic change of induction, and Y to neutralise the demagnetising force of the eddy currents, so that X may have fair play so to speak. In Fig. 10 X and Y are added together to form one curve, C, which is the whole exciting current; it is by no means a sine function of the time nor is it possible in an iron cored transformer to make it so, if the impressed E and B waves are simple sine functions; it is not cophasal with either

Digitized by Google

E or B, so that, although it implies waste of power by reason of its not being in step with B, the power cannot be found by measuring E and C separately and multiplying their product by the so-called cosine of the "angle" of lag. The expression angle of lag, so freely used by writers when treating of alternate currents, has no meaning when applied to the exciting current of transformers there being no point on the wave from which lag is to be measured. If the time between maximum E and maximum C is called the lag, then it is exactly a quarter period, and the result would be *no* power; if, on the contrary, the time between $E=0$ and $C=0$ is taken to be the lag, the formula E C cos (angle of lag) will make the power far larger than it really is. The true waste power can be readily found from the diagram by integrating E C throughout a half-period and dividing the result by $\frac{1}{2}$T. This process will be illustrated after the zig-zag and alternating constant E diagrams have been discussed.

§ 41. The only remaining items to be noticed are the counter E in the primary coil, due to stray induction in the air between the core and the turns of the coil, and the loss of volts due to resistance of the primary coil. The stray induction being wholly confined to an air path wastes no power; it requires work to magnetise air of course, but unlike iron, air gives all the energy put into it back to the circuit again when demagnetised. The stray induction threading the primary coil causes a slight additional counter E.M.F. in it, but it will be understood that the stray B due to the exciting current must be negligible compared with the whole induction in the core. The core being worked at a low induction density will have an average permeability perhaps two thousand times greater than air, so that if the air path had the same area and length as the core the total stray induction and the counter E due to it would only amount to $\frac{1}{2000}$th of the core induction and its counter E; in fact the additional counter E due to stray induction caused by the exciting current might amount to one volt, as against 2,000 due to the core induction. When the transformer is loaded the stray induction is increased of course, and at full load, when the load current is 3·75 amperes, the total current in the primary is 30 or 40 times greater than the exciting current, and the counter E due to stray induction would be 30 or 40 volts, or 1·5 to 2 per cent. of the total E.M.F. It is this loss of volts which is sometimes spoken of as the drop due to "self-induction"; putting aside the negligible one volt drop due to the exciting current the "self-induction" drop is proportional to the load just as the resistance drop is, and the loss of volts due to the two causes together is usually spoken of as *the* drop due to load. The loss of volts due to the resistance of the primary may be just calculated in order to realise how utterly insignificant it is at no load. The diagram (Fig. 10) gives ·162 amperes as the maximum exciting current; the resistance of the primary coil is 7·6 ohms, so that the maximum value of C R is less than 1·25 volts, an amount which is invisible on the diagram. This is an important point to remember in dealing with the effect of the irregular shape of the exciting current wave on the E.M.F. and load current waves, for evidently the wave of C R would be the same shape as C (being only C multiplied by the constant R), and if it were drawn on the diagram and added to the counter E.M.F. wave in order to find the complete impressed E.M.F. wave at no load, the latter would not be a simple sine wave, being distorted by the addition of the irregular C R wave. But the latter is not only absolutely invisible on the diagram, but is really so small that it makes no appreciable distortion in the impressed E wave, and consequently if the counter E is a sine wave the impressed wave must be also.

§ 42. The fact that C R is so exceedingly small shows that for any reasonably well designed transformer having a core of even moderately good iron, the irregular shape of the exciting current wave will not affect the form of the impressed E.M.F. wave which may therefore in every practical case be obtained by differentiating the induction wave, whether the latter is capable of analytical expression or not, and conversely the induction wave may be obtained from integration of the E.M.F. wave. When the curve of impressed E.M.F. is a sine function, the induction wave is of course a cosine which can be expressed as a sine function. If the impressed E.M.F. wave departs ever so little from a simple sine law, the induction wave alters its shape in a corresponding degree but opposite sense. The next two diagrams will afford a good illustration of this remark.

---

NOTE.—If the reader will refer to § 27 (p. 535) he will find a rough method described by which the exciting current for a Hedgehog was calculated, and the statement made that the values so obtained agreed very closely with the currents actually required by Mr. Swinburne's Hedgehogs. The writer congratulated himself a little too soon on the accuracy of an estimate made on the basis of some dimensions for Hedgehog transformers kindly supplied by Mr. Swinburne, for owing to a misunderstanding by which radius of "Hedgehogging," centimetres, diameters, and inches became inextricably mixed, it turns out that a large over-estimate was made; No. 3, as an open transformer (Fig. 7), would only require about 1·4 amperes and not 1·95 as stated. Similarly No. 2 (Fig. 8) would require considerably less than 1 ampere exciting current. The reduced exciting currents would make very little difference to the efficiencies given in tables 12 and 13, but a slight modification of No. 2 will be made in a future article, as its efficiency may be raised to 90·5 per cent. by cutting off nearly half the spherical ends, without increasing the exciting current beyond 1 ampere.

(*To be continued.*)

---

## TRANSFORMER DISTRIBUTION.

BY G. L. ADDENBROOKE.

There has for some time been a general feeling in electrical circles that the celebrated Paper by Mr. Crompton on alternating *versus* continuous current distribution of electrical energy has become a matter of past history, and that the improvements which in the interval have taken place in transformers, and in the means employed for distributing energy by means of alternating currents, warranted the raising of the same issue afresh.

On learning the title, therefore, of Mr. Swinburne's Paper, there was a good deal of curiosity felt as to the manner in which he would treat the question, and what issues he would raise. If Mr. Swinburne has not gone "the whole hog,' in the design of his own transformers, he certainly has done so in the scope of his Paper. This Paper reviews the whole field presented by alternating current distribution, and the different appliances employed in connection with it, and the general effect is to leave a bewildered impression in the mind that there is something generally wrong with the methods pursued at present. Any single one of the sub-headings into which Mr. Swinburne divided his Paper would have been amply sufficient to give scope for an interesting communication raising sufficient points to provide material for an important discussion extending over several evenings.

In the present article it is my intention only to deal with what are called Transformer Sub-stations. This subject is of itself a very extended one, and, therefore, to bring it at all into shape, the best way of treating it will, I think, be to take examples and deal with them separately.

Let us in the first place review briefly the present position of matters, that is to say, the state of things which now exists when a district is served by a Central Station working on the alternating current system and furnishing electrical energy, to be used chiefly in the form of light, the district to consist of shops, public buildings, and private residences in about the average proportions.

The first fundamental fact which we have to take into consideration in such a case is that the number of lamps installed on the circuit will be usually at least double that for which current is demanded at any one time; that is to say, simply, that never more than half the total number of lamps on the circuit will be in use at once. Let us suppose, as is more or

Digitized by Google

less the case at present, that there is a separate transformer in each house. Now, although the number of lamps on the whole circuit alight at once will never be more than half that installed, yet it can never be assumed that the total number of lamps installed in a house, shop, or public building will not be in use at once on some particular occasion. It is therefore necessary to install converters in each house of sufficient capacity to take the total number of lamps for which that house is wired; that is to say, briefly, the maximum capacity of the transformers installed on the central station circuit will be double that in actual use at any one time.

Coming now to the transformers themselves, a great many not by any means accordant tests have been published on the efficiency which such transformers give at their maximum load. The average capacity of transformers installed in English houses will certainly not be, as a rule, less than 2,000 watts; at the same time this is about the smallest size transformer which can be made to work at a high rate of economy. As a rule now, in the class of lighting which is being done in London, the average size of the transformers is considerably above this; but if electric lighting is to be extended into the suburbs and to be used in provincial towns, such an average size of transformer as this would not be greatly exceeded.

In transformers of this size, and of fair design, it is doubtful if an average maximum efficiency of more than 95 per cent. can be assumed, but for the purposes of this article I shall assume that an average maximum efficiency at full load of 96 per cent. is obtained. Further, in order to facilitate dealing with the matter, it will be sufficiently accurate to assume that this loss of 4 per cent. of the maximum efficiency of such transformers is a constant one; that is to say, that 4 per cent. of the maximum efficiency of the transformer is being lost by hysteresis and in resistance in keeping the transformer fully magnetised, whether or not it is doing work on the secondary circuit; and that this loss continues the same as *related to the maximum efficiency* whatever the load on the secondary of the transformer may be.

By dealing with the matter in this way, one arrives at a sufficiently accurate basis for all ordinary calculations, while avoiding the many vexed questions as to the action of transformers which still exercise the minds of those who have experimented and gone most fully into the various actions which take place in them.

Let us suppose that such a Central Station as above indicated has been established on the alternating current system, and is in running order, and that it is necessary to keep the pressure on all its mains during the whole of each 24 hours. During the whole of each day, therefore, four per cent. of the maximum capacity of the total number of transformers installed will be continually wasted, and since the capacity of the transformers installed will be at least double of that for which energy is required at any one time, we shall have during the whole day a continual loss averaging 8 per cent. of the average maximum current sent out from the station.

Now the tabulated returns sent out from Central Stations, which have already been in operation for more than a year, show that their current output does not average much more, taking the whole year through, than about 2½ hours of the average maximum daily output. Comparing the loss in the transformers, which is 8 per cent. spread over the 24 hours with this, it is obvious that the loss in the transformers equals (8 × 24), or 192 per cent. of the average maximum current for one hour. That is to say, there is a loss of current between the switch room and the secondary circuit of the transformers which, on an average, equals the average maximum station output for two hours each day. This is equivalent to saying that, from the losses taking place in the transformers alone, very little more than 50 per cent. of the alternating current generated in the station actually reaches the secondary circuit. In fact, it will hardly be out of order to say that, under such circumstances, the average efficiency of an alternating current system is not much above 50 per cent.

Now this is a very serious state of things; and although, even under such circumstances, it is possible to supply alternating currents profitably, at a fairly low rate of cost per unit, yet it is evident that, even putting on one side all possible improvements in boilers, engines, and alternating current dynamos, which class of improvements may be said to be common not only to alternating currents, but to every other system of electric lighting, there is still great room for improvement in this single item of transformer distribution alone.

Such was the state of things when Mr. Crompton compared the economy of a Central Station on the alternating current system with that to be anticipated from the use of direct currents. It is a state of things to which the advocates of alternating current distribution have not been blind from the very first, however little may have been said by them upon the subject; but, at the same time, it is one that everyone has felt might easily be remedied in a great measure, as soon as the Electric Light was more generally adopted, and when groups of houses, situated within moderate distance of each other, were all being supplied with electric current.

Obviously the first and simplest way in which economy may be effected is by grouping several houses or shops together on the secondary of one transformer of considerable capacity; by this means two electrical advantages are secured. In the first place a large transformer is more economical in working than a smaller one, that is to say, the percentage loss in magnetising it is less. In the next place, it is a practical certainty that the full number of lamps in all the houses supplied from the transformer will never be required alight at once. Consequently, it will be practicable to install a transformer of considerably less size than would be necessary for running all the lamps installed at one time; and so the average loss on the whole circuit will be reduced from, let us say, 8 per cent. to something like 6 per cent., that is by one-quarter, or 25 per cent.

Any little extra expense which might be incurred for longer secondary mains in such a case would be more than counterbalanced by the diminished cost of the single larger transformer, as compared with several small ones, and by the fact that it would be only necessary to install one primary pair of cut-outs, one primary switch, and one earthing device, instead of several. Companies working in London and the provinces have already adopted this improvement in many instances where the conditions were favourable.

But further and still greater economies may be attained by grouping the transformers in what are now called Sub-Transformer Stations. Such Transformer Stations have the immediate advantage over the system last mentioned, that by their means it is possible to reduce the transformer capacity to about that required for the maximum current supplied, which will only be half that of the total number of lamps installed, and operated from each sub-station. The average loss in the transformers is therefore at once reduced from eight per cent. of the average maximum current supplied by the station to four per cent.; and there is this further gain, namely, that with such large transformers as would be required for operating such sub-stations, the losses in magnetising, &c., would probably not average more than two per cent. of the maximum efficiency; while there is good reason to suppose that these losses might with care be reduced to less even than this extremely low figure.

Here, then, at once putting all other considerations on one side, is an enormous theoretical gain, but this is by no means the whole gain which may reasonably be anticipated and calculated upon if such transformer sub-stations are established and properly operated. Since the heavy working load is only on for a few hours each evening, it would not as a rule be necessary for a large transformer to be in circuit with the mains for more than six hours per diem, and probably even this period could be very materially reduced with a little care. At other times a transformer with a capacity of not more than about one-tenth that of the large transformer would be amply sufficient for all the lighting done on the secondary circuit. The losses in such small transformers established in sub-stations situated at moderate distances from each other over the area of supply would be so small that, for our present purpose, it is hardly necessary to estimate them.

Consequently, by this method of using Sub-Transformer Stations, and by employing small transformers to do the work during the day and night when the load is light, and a large one for the evening hours when it is heaviest, what may be

Digitized by Google

called the transformer efficiency of an alternating current system of distribution will be raised from not much above 50 per cent. to at least 85 and probably 90 per cent. Such being the theoretical aspect of the question, it now remains to consider how such a system could be carried out in practice, and how in first cost, and subsequent maintenance, it compares with the present methods, either of using high-tension alternating currents and establishing transformers in each house, or in using continuous currents, supplemented by secondary batteries, or any of the other means with which electricians are familiar.

*(To be continued.)*

## ELECTRO-MAGNETIC REPULSION.*

BY PROFESSOR J. A. FLEMING, M.A., D.SC., M.R.I.

*(Concluded from page 571.)*

§ 10. We must now pass on to study shortly another class of actions, namely, deflections and rotations produced by electro-magnetic repulsion on highly conducting discs or rings. If the conducting ring or disc which is presented to the alternating pole is constrained by being fixed to an axis around which it can rotate, the action may reduce to a deflective force. Here, for instance, is a flat disc fixed on a transverse axis. On presenting this disc to the pole, the disc is prevented by its constraint from being repelled bodily; so it does the next best thing it can, it sets its plane parallel to the lines of magnetic force, and gets into such a position that the induced currents in it are reduced to a minimum. On this principle, before becoming acquainted with Prof. Elihu Thomson's original work, I devised a little copper disc galvanometer for detecting small alternating currents.

§ 11. More interesting than the deflective actions are those which result in the production of continuous rotation in highly conducting bodies placed in an alternating field. This electro-magnet in front of me, and which has come from Prof. Elihu Thomson for the purposes of this lecture, consists, as you see, of a nearly closed circuit divided iron core wound over with a coil (Fig. 10). The ends of the iron circuit are provided with copper bars, which embrace and cover portions of the polar terminations of the magnet. When the magnet is excited by a

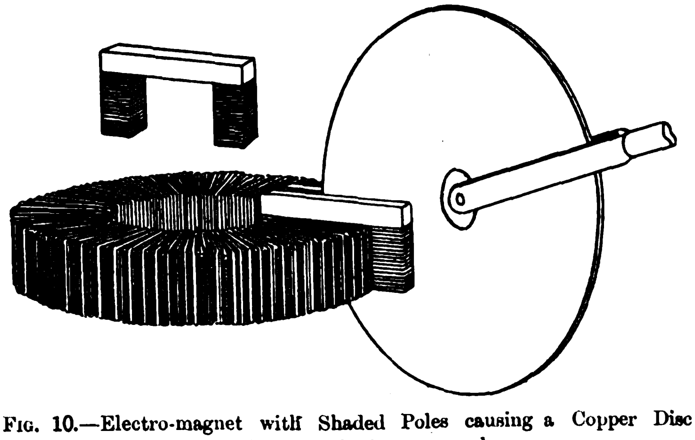


FIG. 10.—Electro-magnet with Shaded Poles causing a Copper Disc placed between the jaws to revolve.

periodic current, these secondary circuits become the seat of powerful induced secondary currents. Taking in hand a large copper disc pivoted at the centre and held in a fork, we hold this wheel so that part of the disc is inserted between the jaws of the electro-magnet. Immediately, rapid rotation is produced. The reason is not far to seek. The alternating field induces, both in the closed coils and in the neighbouring portions of the disc, induced currents; these tend to cause the parts of the conductors in which they flow to be pulled into parallelism, and if the polar coils are so placed as to partly shield the poles these attractive actions act unsymmetrically on the disc and pull it continuously round. The action is, perhaps, better illustrated by a simpler experiment. If we hold a pivoted copper disc (Fig. 11) symmetrically over an alternating pole, the action of the pole is one of pure repulsion on the disc, which, however, causes no rotation in it. When a copper sheet is so placed as to shield or "shade," as Prof. Thomson calls it, part of the magnetic pole, currents are induced both in the fixed plate and in the movable one. The fixed disc shields part of the other from the induction of the pole, and hence causes the induced currents in that plate and disc to be so located that they are in positions to cause continual attraction between one another and continuously pull round the movable disc into fresh positions, so creating regular rotation. This principle of "shading" a pole is employed in constructing the polar coils of the magnet used in our experiment a moment ago, and the experiments present us with a form of self-starting alternating-current motor, although not perhaps a very efficient one in the technical sense. This principle of "shading" a portion of a conductor from the inductive action of the pole, and so causing the eddy currents in it to be located in a portion of its surface, and to cause attraction between that conductor and the shading conductor, is capable of being exhibited in various ways. We place on this copper plate a light hollow copper ball, and support it in a little depression in a copper plate. Holding the arrangement over the alternating magnet, the ball begins to spin round rapidly when the magnet is excited. This rotation is caused by the continual attraction of the eddy currents induced in the fixed plate and in that part of the ball which is not shielded from the pole by the plate. We may vary the experiment, and exhibit many more or less curious and amusing illustrations of it. If we float these copper balls in water (Fig. 12), and place the glass bowl containing them over the alternating pole, the interposition of a copper sheet between the pole and the balls causes the latter to begin to spin in a highly energetic manner.

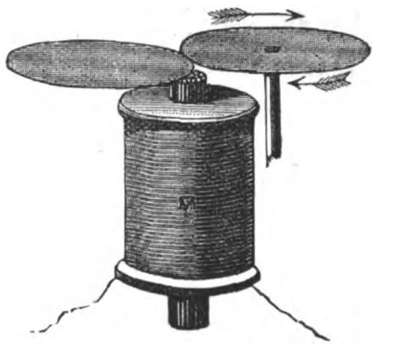


FIG. 11.—Revolution of a Shaded Copper Plate held over an Alternate Current Magnetic Pole.

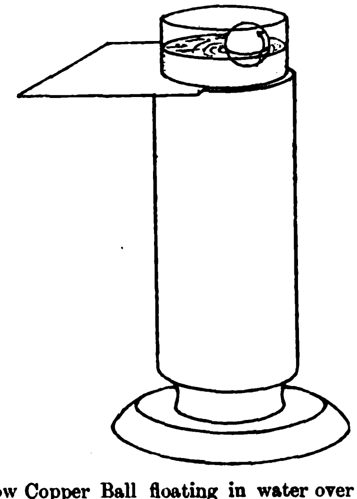


FIG. 12.—Hollow Copper Ball floating in water over an Alternate Current Electro-magnet, and caused to revolve by the interposition of a "shading" plate.

* A discourse delivered at the Royal Institution of Great Britain on Friday evening, March 6, 1891.

Digitized by Google

§ 12. Prof. Elihu Thomson has invented a novel form of electro-magnetic gyroscope (Fig. 13). We have now suspended over the alternating magnet a gyroscope of the usual form. The wheel of the gyroscope is made of iron, and the tyre of the wheel is a thick copper band. Immediately the magnet is energised, the gyroscope begins to rotate with great rapidity over the pole. In this case the unsymmetrical disposition of the eddy currents in the copper band around the wheel is sufficient by itself to cause the rotation to occur. The phenomenon which, however, lies at the bottom of all these effects is that the self-induction of the secondary circuit causes the eddy currents to be delayed in phase behind the magnetising field, and hence to persist into the period of reversal of that field, and so produce the repulsion between the primary conducting circuit and that part of the secondary conducting circuit in which the eddy currents are set up.

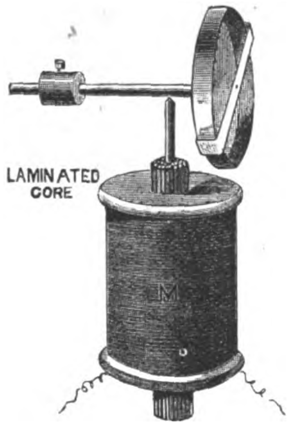



Fig. 13.—Electro-magnetic Gyroscope revolving over the pole of an Alternate Current Electro-magnet.

One more experiment in this part of the subject, before we pass on to some other developments of it, shall be placed under your notice. Returning to the use of the electro-magnet, in which the iron circuit is all but complete, we find that when a highly-conducting disc is put between the closely approximated half-shielded jaws of this electro-magnet, and an alternating current employed to excite it, the conducting disc is held up in

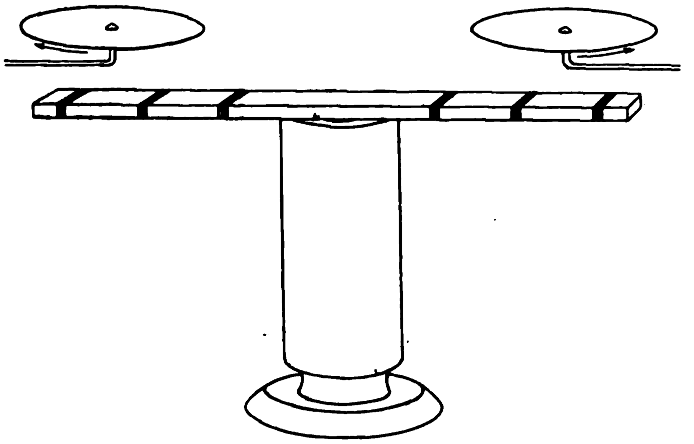


Fig. 14.—Alternating Magnetised Iron Bar causing revolution of two iron discs held near its extremities.

the air gap by reason of the electro-magnetic attraction set up between the disc and the shielding polar plates. If, however, the disc has a relatively poor conductivity the attraction is not nearly so marked. A good or bad silver coin can be discriminated thereby, because the good silver coin has conductivity enough to be the seat of powerful induced currents but the bad coin has not.

§ 13. Closely akin to the foregoing, but rather less easy to explain, are the rotations in copper and iron discs which can be caused by the approximation to them of a laminated iron bar alternately magnetised. These actions have been carefully studied by Prof. Elihu Thomson, and applied by him and others in many practical devices. Across the top of this electro-magnet we place a long bar of laminated iron with the plane of the lamination vertical (Fig. 14). This bar is throttled at intervals by copper bands, which form small closed secondary circuits upon it. We excite the magnet, and hold near the bar an iron disc capable of free rotation; it begins to rotate rapidly, as you now see. Not only can this be done with a laminated bar throttled by conducting circuits, but even a solid bar of hard steel will serve the same purpose, and a couple of steel

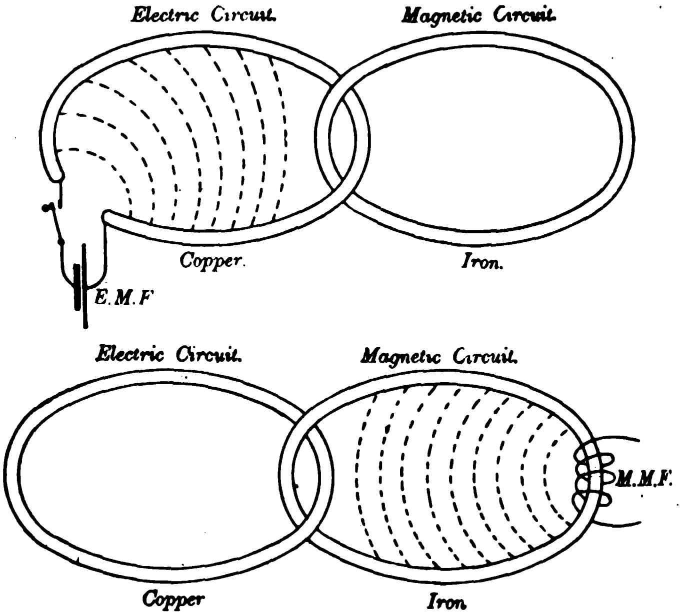



Fig. 15.—Diagrams illustrating the symmetry in relation between Electro-motive Force and Electric Current, and Magneto-motive Force and Magnetic Induction.

files placed across the poles can cause rapid rotation in pivoted discs of copper or of iron held with their edges close to the bars so alternately magnetised. To elucidate this remarkable action, we must revert for a moment to some fundamental facts. Here are two paper rings interlinked, one red, the other of blue paper (Fig. 15). Let the red ring stand as a symbol for a copper or conductive circuit. Let the blue ring stand for an iron or magnetic circuit. If we introduce into the conductive circuit an impulsive or alternating *electromotive*

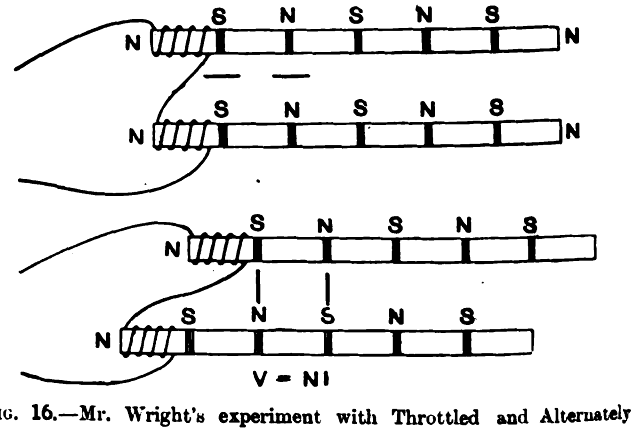


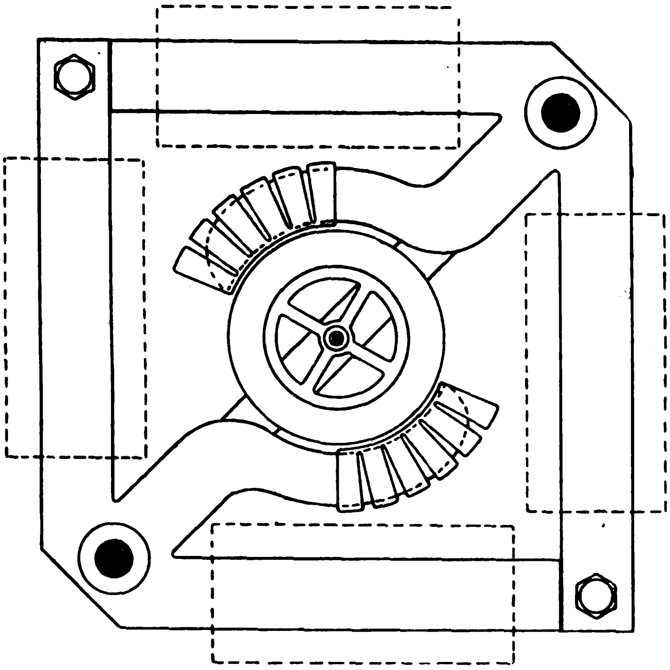

Fig. 16.—Mr. Wright's experiment with Throttled and Alternately Magnetised Bars.

*force*, we are well aware that the interlinked iron circuit, by increasing the self-induction of the conductive circuit, hinders the change of current strength in it by introducing a *back electromotive force* of self-induction. Consider now the iron circuit. If we introduce into that magnetic circuit an impulsive or alternating *magnetomotive force* by interlinking it with some turns of a magnetising current, the effect of the copper or conductive circuit, which is linked with the iron or magnetic circuit, is similarly to introduce a *back magnetomotive force* into the magnetic circuit by reason of the magnetic field set up by the secondary current generated in that copper or conducting circuit. In other words, the secondary current induced in the copper circuit by any change in the magneto-

Digitized by Google

motive in the iron circuit is in such a direction that it operates to oppose that primary magnetomotive force, chiefly, however, at the spot where the copper circuit passes round the iron. The general result may be stated to be that the action of the interlinked copper circuit is to cause the magnetic induction in the iron circuit to leak across through the air and partly to escape passing through the secondary circuit. This escape of induction is called magnetic leakage, and the induced current set up in the closed secondary circuit is the cause of this magnetic leakage. There is a symmetry in the relations of magneto-motive force and the magnetic induction and electromotive force and electric current, and we can, as Faraday pointed out long ago, make the symmetry complete, if we suppose the two interlinked magnetic and electric circuits immersed in an imperfectly conducting medium. If, then, we throttle a magnetic circuit such as a laminated iron bar with copper coils closed upon themselves, and place a magnetising coil at one end, the closed conducting circuits hinder the rise of magnetic induction in the bar; in other words, they give it what may be called *magnetic self-induction.* If the source of magnetism is a rapidly-reversed pole, the consequences of this delay or " lag " in the induction is that a series of alternating magnetic poles are always travelling with retarded speed up the bar, and these may be considered to be represented by tufts of lines of magnetic force which spring out from and move laterally up the bar. If the bar is not laminated and not throttled, the eddy currents set up in the mass of the bar itself act in the same way, and operate to resist the rise of induction in the bar and to delay the propagation of magnetism along it. Hence we must think of such a throttled bar when embraced by a magnetising coil at one end as surrounded by laterally moving bunches of lines of magnetic force, which move up the bar. Each reversal of current in the magnetising coil calls into existence a fresh magnetic pole at the one end of the bar which is, as it were, pushed along the bar to make room for the pole of opposite name, which appears the next instant behind it. When an iron disc is held near such a laminated and throttled bar, these laterally moving lines of force induce poles in the disc which travel after the inducing poles, and hence the disc is continually pulled round. If the disc is a copper disc the laterally moving lines of magnetic force induce eddy currents in the disc, and these, by the principle already explained, create a repulsion between the pole and the part of the disc in which the eddy currents are set up.

§ 14. The progression of alternate poles along a bar can be investigated by means of an experiment due to Mr. A. Wright. Two laminated straight iron bars (Fig. 16) are throttled at intervals with secondary circuits, and have wound on one extremity a magnetising coil. The two bars are placed near each other and parallel. The coils are so connected that the poles at any instant in the ends of the two bars are of similar name. An alternate current is sent through the coils joined in series. Under these circumstances a series of alternate poles of similar names run up the bar parallel with one another. A small, soft iron needle hung at any place between the bars sets itself parallel to the bars because at any instant poles of similar names are abreast of one another at any spot in the length of the bars. If, however, we shift one bar lengthways backwards or forwards through a certain distance so as to bring opposite poles abreast of each other throughout their journey up the bars, we shall find a position such that the soft iron needle will set at right angles to the bars when hung at any point in the space between them. The distance by which we have to shift the one bar backwards of the other to effect the change is evidently half a magnetic wave length, and knowing the frequency of the alternations we can readily arrive at a measure of the velocity of propagation of these alternate poles in the bar. This velocity is evidently numerically equal to the product of the frequency and wave length so obtained.



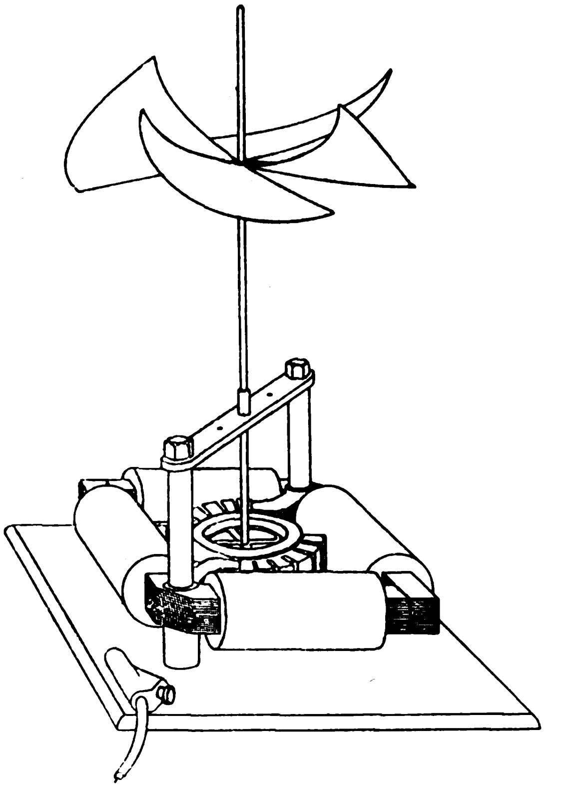


Fig. 17.—Plan and General View of Ferranti-Wright Self-starting Alternating Motor working a Fan.

§ 15. A very pretty application of the above principle has been made in the electric meter of Messrs. Ferranti and Wright for measuring alternating currents. Before me stands one of these meters. It consists of a pair of vertical electromagnets, with laminated iron cores, and each magnet bears at the top a curved horn of laminated iron which is throttled by copper rings. These curved horns, springing from the magnets, embrace and nearly touch a light iron-rimmed wheel, free to turn in the centre. The actions just explained drive the wheel round, when the magnet coils are traversed by an alternating current. The iron wheel carries on its shaft a set of mica vanes, which retard the wheel by air friction. Under the opposing influences of this retardation and the electro-magnetic rotation forces, the wheel takes a certain speed corresponding to different current strengths in the magnetic coils, and hence the total number of revolutions of the wheel in a given time, as recorded by a counter, serves to determine the total quantity of alternating current which has passed through the meter. A motor (Fig. 17) working a fan is also here exhibited, the operation of which depends on the same facts. In the case of

Digitized by Google

the motor the iron-rimmed wheel has its tyre clothed with copper sheet to aid the action.

§ 16. The rotation of iron discs can be shown also by means of a badly designed transformer. If a closed laminated iron ring (Fig. 18) like the one before me is wound with a couple of conducting circuits, such an arrangement constitutes a transformer. If these two circuits are wound on opposite sides of the iron ring, the previous explanations will enable you to perceive that the arrangement will be productive of great magnetic leakage across the iron circuit. In designing transformers for practical work, one condition amongst others which must be held in view is to so arrange the conductive and magnetic circuits that a great magnetic leakage of lines of force across the air does not take place. If, however, this leakage exists, it indicates that the secondary circuit is not getting the full benefit

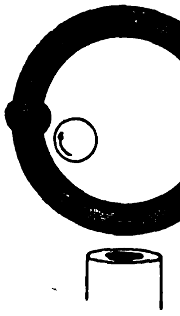


FIG. 18.—Magnetic Leakage across a Throttled Iron Ring, causing rotation of an iron disc placed near the Secondary Coil.

of the induction created by the primary. To detect it we have merely to hold near the iron circuit a little balanced or pivotted iron disc, and if it is set in rapid rotation, as you observe in this case, it indicates that there are laterally moving lines of magnetic force outside the iron, which have escaped from the iron in consequence of the back-magneto-force of the secondary circuit.

§ 17. Time would fail me if I were to attempt to enlarge on the practical applications of the scientific principles which these experiments disclose to us. They are a fertile field both for the investigator seeking to add to the sum total of existing knowledge, or to the inventor in search of applications in elec-

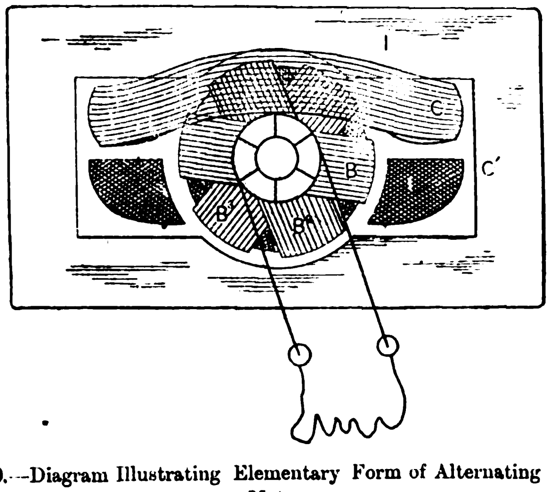



FIG. 19.—Diagram Illustrating Elementary Form of Alternating Current Motor.

trical technology for such acquired facts. Ingenious minds, and that of Prof. Elihu Thomson foremost amongst them, are busy in seeking to turn these facts to account in the construction of alternating current motors.

One of the simplest of these is shown in principle in the diagram now on the screen (Fig. 19). The coils C are traversed by an alternating current, and are placed on either side of a drum armature wound over with three sets of insulated wire coils, the terminals of the coils coming to insulated sections of a commutator. The functions of this commutator are to keep one coil, B, on short circuit during the time when it is in such positions relatively to the field coils C that the induced current in the closed coil causes it to be repelled by the field coils, and as each successive coil on the armature becomes in turn the active coil, rotation is kept up. A motor, made by Prof. Thomson, based on these principles, but with some additions, is on the table, and on turning the current into it it speedily starts and gets up considerable speed. The details of the actual construction are a little less simple than in the diagram shown, because the motor is made to start by sending the external current into the armature by means of a commutator and brushes. When, however, the proper speed is attained, the armature coils are automatically short-circuited, and the motor continues to run in virtue of the current induced by the field magnet in the armature coils. This is by no means, however, the last word said on this portion of the applications, and I think we may shortly look to Prof. Thomson to give us further and more perfect methods of utilising these facts in the construction of self-starting alternating motors.

§ 18. For the opportunity of exhibiting to you this evening these remarkable experiments, I am personally indebted to Prof. Elihu Thomson, both for constructing and sending the apparatus we have used. Part of these appliances have now an historical value, and have been presented by him to the Royal Institution. For the use of the rest, I desire to record my obligations and thanks. Illustrative as these experiments are of important facts in connection with the use of alternating currents, they have a special value at the present time. In the opening year of next century, when we celebrate the centenary of the first practical production by Volta, in 1801, of the electric current, we shall find ourselves in the presence of the fact that almost every large city is ramified by a subterranean network of copper conductors for the distribution of electric energy as a necessary of modern life; and although it may be dangerous to express too confident a view on the direction which the progress of electrical invention may take, yet it does not seem improbable that the alternating current will be doing a considerable share of that work. It is, therefore, not only as a contribution to a comprehension of the vagaries of these alternating currents that the phenomena we have shortly studied are worthy of attention, but also as being, perhaps, the avenue of approach to a further possession of valuable knowledge, enlarging our views, and capable, without doubt, of being minted into the current coin of useful and ingenious applications.

ERRATA.—On page 570, Fig. 7, of our last issue, the words *attractive impulses* and *repulsive impulses* should be interchanged, the large shaded hummocks representing the repulsive impulses.

## THE LONDON-PARIS TELEPHONE LINE.

The establishment of telephonic communication between London and Paris, the progress of which has been recorded from time to time in our columns, is now an accomplished fact, and has proved a most unqualified success, highly creditable to all concerned.

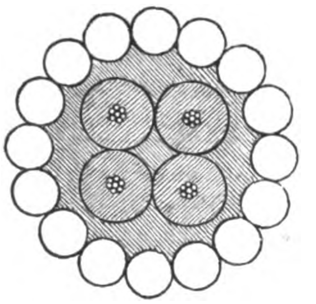
The route for the English landline runs along the South Eastern Railway to a point near Sidcup, and thence by road and rail through Swanley, Maidstone, and Ashford to the cable-house on the beach at St. Margaret's Bay, between Dover and Deal. The English landline is of copper, and weighs 400lb. to the mile. It has a resistance of about 2·25 ohms per mile at 60 deg. Fahr. It is supported on creosoted wooden poles, 70 yardsa part, by means of double-shed porcelain insulators about 25 feet above the ground. The going and returning wires of each circuit are twisted spirally round each other all the way, exchanging places at each cross-arm, the spiral being completed by each wire regaining its normal position at every fourth pole—that is to say, every 280 yards. The buzzing effect of induction has been reduced to a minimum. A Wheatstone automatic transmitter, working at fast speed on one of the circuits, can just be heard in the telephone upon the other circuit. The telephone at present employed is the Post Office form of the Gower-Bell apparatus, but Hunnings, Berliner, Ader and other instruments are being tried. The French landline is similar in construction to the English

Digitized by Google

line, except that only one circuit is run at present, and the copper wire weighs about 600lb. a mile. Its length is about 204 miles, and the speaking with the D'Arsonval apparatus employed in France is also excellent. There are, unfortunately, no less than seven kilometres of underground line in Paris. This is constructed on the Fortin-Hermann system, and is insulated by wooden beads impregnated with paraffin.

The connecting cable, which is the joint property of the two Governments, was designed by Mr. Preece, and contains four separate conductors (*see* Figure), two for each circuit. Each conductor is a strand of seven pure copper wires, weighing 160lb. per nautical mile, with a resistance of 7·478 to 7·632 ohms per knot at the testing temperature of 75deg. Fahr. It is covered with three alternate layers of Chatterton's compound and guttapercha, weighing 300lb. per knot. The total weight of each core is, therefore, 460lb. to the knot. Its insulation resistance from the wire to the water is not less than 500 megohms per knot after lying in water at a temperature of 75deg. Fahr. for 24 hours before the test, and after the conductor has been electrified for a minute. The capacity does not exceed 0·3045 microfarads per knot. The cores are twisted spirally round each other in a strand, so as to change places like the land wires; and to silence the cross talk as much as possible the opposite wires are meant to form part of the same circuit. The stranded cores are served with tanned hemp, and on this cushion is laid a spiral sheathing of 16 galvanised iron wires, each 0·28in. thick, with a breaking stress of 3,500lb. Clark's coating of mineral pitch and sand protects the whole.

The K.R. or product of the capacity into the resistance of the entire line from London to Paris is estimated at 5,300. Theory shows that good articulation begins to fail when the K.R. exceeds 10,000 for an overhead copper wire and 8,000 for



Section of the London-Paris Telephone Cable.

an underground or underwater line. The cable was manufactured by Messrs. Siemens Brothers, under the supervision of Mr. Mittelhausen, general manager of their works, and Mr. F. Jacob, their chief electrician, as well as the Post Office engineers.

On Monday, the 9th inst., as we informed our readers last week, the laying was begun. Preparations were made early in the morning for landing the shore end at Sangatte, where the "Monarch" had been lying for several days. The shore end being landed, the "Monarch" immediately started paying out towards St. Margaret's Bay. At first there were no signs of an approaching storm. A drizzling rain, however, soon began to fall, and the breeze freshened, but it was not until towards three o'clock, when ten miles of cable had been paid out, that the gale came on, and the water became rough, and a blinding snowstorm swept over the vessel. At length it was decided to anchor until a lull in the storm should reveal the land. The cable was fastened and the anchor rattled out soon after 4 o'clock. The snow cleared about 5 o'clock, and it was then discovered that the "Monarch" was lying off St. Margaret's Bay, about a mile from the shore, and eastward of the cable hut. An attempt was made to lift the anchor and pay out all the cable, but the strong tide, aided by the wind, had driven the cable foul of the anchor, and after a fruitless attempt to clear, the anchor was slipped with 14 fathoms of chain. It was now a quarter past 8 at night, and very dark, but the "Monarch" paid out the rest of the cable to avoid cutting it, and buoyed the end well off the shore to the east of St. Margaret's Bay, about 20 minutes past nine. She then ran for the Downs, where she anchored soon after 10 o'clock. Next morning a strong easterly gale prevented further operations. Wednesday was not much better. Thursday was fine, and after picking up the cable from the buoy, as we mentioned last week, she proceeded to clear it from the lost anchor. The cable was coiled four times round the anchor, and could only be released by cutting out the damaged part. This was done, the anchor and chain being recovered, and the end of the cable buoyed. On Friday nothing could be done owing to the high wind and sea; but on Saturday morning the cable was picked up and some five miles re-laid, so as to clear a bight in the Calais-Dover line. The "Monarch" finally arrived off St. Margaret's Bay about twenty minutes past three in the afternoon, where she anchored 1,000 yards away from the landing-place. A raft was speedily formed with the lifeboats, and the shore end landed. The end was hauled ashore by the sailors at ten minutes past six, and twelve minutes later brought into the cable hut. St. Martin's-le-Grand was immediately called up, and the good news announced. Three cheers were given at the Post Office and in the hut, and those from London sounded so lustily that it was declared they had split the drum of the telephone. The end of the cable was then stripped and the sheathing filed off, the rasping of the file being plainly heard in London. The cores were then pared, and the cable connected to a Morse apparatus, by which the hut was put in communication with Sangatte. The French electricians there telegraphed a "hurrah for the telephone," and the work was done.

It was arranged that no telephonic communication should be held between London and Paris until the French engineers arrived in London, and on Tuesday the first words were spoken by M. Amiot. At 4.15 p.m. he addressed his colleagues in Paris, his first words being "Hallo, hallo!" Mr. Graves, Mr Preece, and others afterwards spoke through the line. A formal inauguration took place on Wednesday, when the first message transmitted was one from the Prince of Wales to M. Carnot. An exchange of congratulations then passed between Mr. Raikes and M. Jules Roche. At the Paris Central Telegraph Office, Lord Lytton, Mme. Roche, M. Reinach, M. Broquisse, and M. de Selves were present with M. Roche. Mr. Raikes spoke from his room at the Post Office. Finally, in the afternoon the members of the Press conversed with Paris.

## MEETINGS OF SCIENTIFIC SOCIETIES, &c.

**FRIDAY, March 20th.**

LONDON CHAMBER OF COMMERCE.

*1.30 p.m.* Meeting at Botolph House, Eastcheap, of the Electrical Trades Section Committee.

PHYSICAL SOCIETY.

*5 p.m.* Ordinary Meeting. Papers to be read: (1) "The Theory of Dissociation into Ions and its Consequences," by Mr. S. U. PICKERING, F.R.S. (2) "Some Points in Electrolysis," by J. SWINBURNE. (3) "The Variation of Surface Tension with Temperature," by A. L. SELBY, M.A. (4) "On Magnetic Proof Pieces and Proof Planes," by Prof. S. P. THOMPSON.

INSTITUTION OF MECHANICAL ENGINEERS.

*7.30 p.m.* Ordinary General Meeting.

**SATURDAY, March 21st.**

ROYAL INSTITUTION.

*3 p.m.* Afternoon Lecture: "The Forces of Cohesion," by Lord RAYLEIGH, F.R.S.

**MONDAY, March 23rd.**

SOCIETY OF ARTS.

*8 p.m.* Cantor Lecture IV. 3. "Photographic Chemistry," by Prof. R. MELDOLA, F.R.S.

**TUESDAY, March 24th.**

INSTITUTION OF CIVIL ENGINEERS.

*8 p.m.* Ordinary Meeting. Paper to be read and discussed: "On the Reception and Storage of Petroleum Oil in Bulk," by W. T. H. CARRINGTON, M. Inst. C.E.

**WEDNESDAY, March 25th.**

CHEMICAL SOCIETY.

*8 p.m.* Anniversary Meeting.

OLD STUDENTS' ASSOCIATION.

*8 p.m.* Ordinary General Meeting. Paper to be read: "Coals, Coalmines, and Coalmining," by ALBION T. SNELL, Member,

Digitized by Google

# The Electrician.

**Published every Friday, Price Fourpence; Post Free, Fourpence Halfpenny**
**Editorial, Publishing, and Printing Offices:**
**SALISBURY COURT, FLEET ST., LONDON, E.C.**
*Telephone No.* 2714. *Telegrams:* "ELECTRICIAN NEWSPAPER, LONDON."

*All Letters relating to Subscriptions, Advertisements and other business matters should be addressed to the Publisher,* "THE ELECTRICIAN," *Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to* "THE ELECTRICIAN" *Printing and Publishing Company, Limited, and be crossed* "Coutts and Co" *All other letters to be addressed to the Editor.*

*All letters intended for insertion in* "THE ELECTRICIAN," *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

"THE ELECTRICIAN" *is published every Friday morning, in time for the morning mails. Subscribers should receive their copies by the first post on Friday morning.*

"THE ELECTRICIAN" *is on sale at the railway bookstalls throughout the Kingdom on Friday morning, and can be obtained of all Booksellers and Newsvendors; or direct from the Publishing Offices as above.*

*New Volumes of* "THE ELECTRICIAN" *commence in May and November.*

## SUBSCRIPTION RATES

The rates for Subscriptions to "THE ELECTRICIAN" are as follows:—

| | 3 months s. d. | 6 months. s. d. | 12 months. s. d. |
|---|---|---|---|
| For the United Kingdom | 5 0 | 10 0 | 19 6 |
| For Foreign Parts and Colonies:— Within Postal Union | 6 6 | 12 6 | 24 0 |
| For Aden, Borneo, Ceylon, China, India, Japan, Java, Labuan, Mozambique, New Caledonia, Persia, Philippine Islands, Siam, Transvaal, and Zanzibar | 7 6 | 14 6 | 28 0 |



## TO ADVERTISERS.

"THE ELECTRICIAN" *offers exceptional advantages to Advertisers.* **It has by far the largest circulation of any English Electrical paper, and circulates all over the World.**

*Particulars relating to Advertisements will be promptly forwarded on application to the Offices as above.*

TRADE ADVERTISEMENTS *intended for the current issue must reach the Offices not later than First Post on Thursday morning. Renewals of expiring advertisement orders and alterations to standing advertisements should be in the Publisher's hands by Wednesday at latest. No alteration can be made in Wrapper advertisements after Wednesday evening.*

SMALL PREPAID ADVERTISEMENTS *(for Rates see page xvii.) are accepted up to 4 p.m. on Thursday.*

## TECHNICAL PRINTING.

"THE ELECTRICIAN" PRINTING AND PUBLISHING COMPANY (LIMITED) *inform Electricians, Electric Light Engineers, &c., that they make a specialty of Technical Printing, and have a large Staff thoroughly acquainted with Electro-Technology. They can, therefore, promise Accuracy and Despatch in the Printing of Electro-Technical Literature, &c.*

## "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. (Royal 8vo.)

*Early in each year is issued* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. *The* DIRECTORY *was established in 1883, and the 1891 Edition, published on the 23rd February, consists of 900 pages of printed matter. The names and addresses of all persons engaged in the Electrical Industries at home and abroad may be relied upon as accurate. Useful Tables and Electrical Formulæ, and information specially compiled for this work are given, together with popularly-written Biographical Notices of the leading Electricians, Electrical Engineers, &c., accompanied in many cases by Portraits.*

*The issue for 1891 is ready, and should be ordered at once. Price 5s., post free 5s. 9d. Abroad postage extra. Full particulars on application.*

## ELECTRICAL BOOKS AND PUBLICATIONS

*All Books, Newspapers, and other publications, dealing with Electrical and kindred subjects, can be ordered direct of* "THE ELECTRICIAN" *Printing and Publishing Company, who are proprietors of the well-known* "ELECTRICIAN" *Series of Standard Electrical Works, and are agents for all the leading publishing houses at home and abroad.*


## CONTENTS OF THE CURRENT NUMBER.


NOTES ... 593
The Magnetic Circuit of Transformers: Closed versus Open. By S. Evershed. Continued. Illustrated ... 597
Transformer Distribution. By G. L. Addenbrooke ... 599
Electro-magnetic Repulsion. By Prof. J. A. Fleming, M.A., D.Sc. M.R.I. Illustrated. Concluded ... 601
The London and Paris Telephone Line. Illustrated ... 604
Meetings of Scientific Societies 605
"EXACT" SCIENCE ... 606
The Electric Current and its Laws.—IV. By John T. Sprague. Illus. Continued. 608
Nalder's Ballistic Galvanometer. Illustrated ... 610
The Kingdon Inductor Dynamo 610
St. Pancras Vestry Electrical Exhibition. Illustrated ... 610
Richard Frère's Electricity Meter. Illustrated ... 612
Institution of Electrical Engineers—Transformer Distribution. *Discussion.* Illustrated ... 612
Notes on Alternating Currents of Very High Frequency. By Elihu Thompson ... 615
Parliamentary Intelligence ... 616
American Notes ... 619
CORRESPONDENCE—
Barking Road Cars—T. Frazer 619
Trade Notes and Notices ... 620
PATENT RECORD ... 620
COMPANIES' MEETINGS, &c.—
London Electric Supply Corporation (Limited) ... 621
Direct Spanish Telegraph Company (Limited) ... 623
South of England Telephone Company (Limited) ... 625
The Telephone Company of Egypt (Limited) ... 627
New Companies registered ... 627
City Notes, &c. ... 627
Companies' Share List ... 628


## GOOD FRIDAY.

**In Good Friday Week "THE ELECTRICIAN" will be published on Thursday Morning (March 26th) instead of on Friday (March 27th).**

**Contributors, Correspondents, and Advertisers are requested to take note, and to forward their communications as early as possible, but not later than Tuesday night in Good Friday week.**

## "EXACT" SCIENCE.

Two statements were made in the course of the discussion on Mr. SWINBURNE'S Paper at the Institution of Electrical Engineers last week which were more epigrammatic than is usual on such occasions. Mr. KAPP said that no mathematical assertion was of much use without a practical application underlying it; and the author of the Paper remarked in the course of his reply that nothing was so misleading as experiments carried out with a view of proving a theory. There is a temptation, in attempting to convey a good deal in a few words, to use expressions which, instead of being merely comprehensive, are rather too strong or too sweeping. The first speaker would of course readily admit the great intrinsic value of analytical reasoning, and the immense ultimate value to engineers of the powerful methods which it supplies. Pure science does not seek to be utilitarian; its disciples take up a physical problem now and then as a peg on which to hang their wondrous web of symbols, but its purity is their pride. The other speaker would of course qualify his statement if pressed, for a very large proportion of all experimental work is carried on to investigate or to support some assumption or hypothesis; and the exact difference between supporting a hypothesis and proving a theory is difficult to define.

From one aspect these two statements may be taken as being opposed to each other. The one deprecating abstract theorising if not attended by tangible results, and the other slighting objective evidence as untrustworthy support for sound reasoning. But the author of the first remark is better known for his mathematical work than for any extensive records of experiments; while the other is daily engaged with tests, and on this particular occasion was dealing largely with the results of his own experiments and with those of other

Digitized by Google

manufacturers. On the other hand, it would be conceded at once that a mere record of a phenomenon, or, indeed, of a fact—if we may make the distinction—with no theory or explanation to accompany it, is but a very meagre contribution to knowledge, and cannot be admitted as having any scientific import. The value of experiments can hardly be over-estimated, though it is well to bear in mind the errors into which it may lead anybody who has preconceived notions and who is rather attached to them.

Bacon made a distinction between learning and knowledge, though we do not know if he gave an exact definition. "Let us seek the dignity of knowledge, . . . we may not seek it by the name of learning; for all learning is knowledge acquired." Learning in fact is the higher and wider, and knowledge, included in it, is the particular. Speaking of Mathematic in the Advancement of Learning, he says, "For it being the nature of the mind of man, to the extreme prejudice of knowledge, to delight in the spacious liberty of generalities, as in a champain region, and not in the inclosures of particularity; the mathematics of all other knowledge were the goodliest fields to satisfy that appetite." Generalisation is the first step as a rule from knowledge to science. Galvani's first observation of the stimulation of the frog's limb was an isolated fact. It merely roused his interest; he experimented at first blindly and then systematically, and thus started the great science of dynamic electricity. There are many mere calculators who can wield the potent tools of their subtle art and can attack a knotty problem without perhaps having seen one of its kind before, and by sheer skill in their trade they will crack its shell and serve up the kernel of fact, with perhaps a garnish of formulæ, but sometimes, happily, in such a shape that the plain man may have some chance of making use of it. And there are not a few experimentalists who potter on and poke about in their particular corner of science with all the industry and with all the aimlessness of the ant. Now and again they light on something interesting or useful, but for the most part their work will have to be overhauled by an abler hand, or perhaps some keener mind will re-discover and develope the truths that they have half observed.

Difficulties begin when a combination is effected, and two of the prominent stumbling-blocks are imperfect data and erroneous reasoning. Edison, for example, observed some tiny sparks many years ago and described how they could be produced between wires in a darkened box. No known electrical theory would explain them. Speculations were made about an etheric or odic force. The unfortunate names were repellant to most minds, for we are chary of welcoming to "new forces"; they are generally associated in our minds with table-turning. But there is no doubt now, that Edison had accidently made a Hertz resonator, his keen eye detected the sparks, but the reason for them lay too deep, and the precise nature of the circumstances were not understood. Several unhappy inventors, on the other hand, have observed that a glow lamp is not instantaneously extinguished when the current is broken, and have proposed to light a number of lamps in rapid succession with the current required for one, taking, as every engineer strives to take, a mean advantage of the laws of nature. These men were guided by reasoning which, unfortunately for them, was false reasoning.

A sad amount of time is wasted by these two stumbling-blocks. Where a man is working alone, he may thus waste years like Jacobi with his crude motors. But the scientific societies of to-day undoubtedly do a great service, both by bringing to light work that is actually in progress, and by encouraging discussion. Faults of reasoning do not often meet with criticism until the results to which they lead are found to clash with others, and then comes the value of discussion. A case of this kind is before us at present in connection with the losses in transformers. In the course of his series of articles on Magnetism, Prof. Ewing alluded (*Electrician*, vol. xxv., p. 169) to the influence of speed on magnetic hysteresis. He says that experiments are wanting to show whether speed has in general any material effect. For very small cyclic changes the magnetic changes depend largely on the speed, but "there does not appear to be anything like so serious a dependence on speed when the magnetic changes are considerable." With small changes there is magnetic viscosity. He quotes the calorimetric measurements of Warburg and Hönig, showing two-thirds the heating effect for reversed magnetism. Tanakadaté found the heating for quick cycles to be equivalent to about 80 per cent. of the slow cycle value. "He observed, further, that the heating effect was practically independent of the frequency of the reversals when that was varied between the limits of 28 and 400 cycles per second."

One of the topics of conversation in the electrical community to-day is the simple statement which has been put forward as to the decrease of hysteresis in the iron core of a transformer when the load increases. As far as we are aware, the explanation was not concealed in the mathematics of the Paper in which it was published. The first Paper at the Physical Society on February 27th contained a mysterious sentence which hints that the authors "have reason to believe that the magnetising value of an ampere-turn varies." This would appear to be connected with the other statement, but it cannot be said to explain it. The Vice-President of the Institution, who was in the chair last week, firmly declined to afford the smallest clue to an explanation. He alluded to the work of Prof. Roiti and others to the probable diminution of hysteresis with high frequencies, and to the conclusion which they had arrived at, viz., that the iron losses in transformers were negligible. But the point of peculiar interest, as to the relation between the loss and the load, still remains as an assertion. The course is unusual, but it has this to be said for it. Prof. Ayrton's Paper was presented to the Physical Society, and it is obviously there that it should be discussed. This loss, hitherto unaccounted for, was predicted by Mr. Mordey some years back, and was thought by him to be revealed in experiments made nine or ten months ago. He, too, modestly disclaims any obligation to offer an explanation. "Give you a reason on compulsion? If reasons were as plenty as blackberries, I would give no man a reason on compulsion." After the meeting came explanations. Differences of phase of currents, demagnetisation by the primary, waves of magnetism running round the core and neutralising each other, sheets of magnetism soaking inwards one after the other, but no very sound or confident proof. In Prof. Ryan's Paper (*Electrician* vol. xxiv., p. 264) a table is given, showing a decrease of hysteresis loss from 96·1 to 69·7. An accompanying diagram shows "loss by hysteresis, &c," apparently falling with these limits. A determination of the hysteresis on a slow cycle, by Dr. Sumpner's modification of Prof. Ewing's method, gave a *smaller* loss. Prof. Ryan suggests that the hysteresis falls off on account of the mechanical vibration of the iron. If this be so, there should be less loss in a noisy transformer than in a silent one. If this be the explanation, it is at the same time satisfactory and disappointing. Satisfactory, because it is well known that mechanical shocks decrease hysteresis, and we need not throw over any theory of magnetism; and disappointing, because some new scientific truth was expected. The matter

Digitized by Google

is like the "Ferranti effect," of trifling importance practically, but of great interest theoretically, if it is to affect magnetic theories. Hysteresis is treated as a residuum, and is, after all, of nearly the same order as the errors of observation. It is, in fact, the petty cash of the balance-sheet.

This one item must surely be cleared up soon; in its present stage the matter is very incomplete. Recent Papers have raised many perplexities. The alternate-current transformer has not been long with us. JABLOCHKOFF hinted at it, GAULARD-GIBBS gave it to us, FERRANTI tried it, somebody proposed putting them in parallel instead of in series, manufacturers experimented with some caution and no little secrecy, and here we are to-day in the midst of a conflict which touches the very root of the matter.

## THE ELECTRIC CURRENT AND ITS LAWS.—IV.

BY JOHN T. SPRAGUE.

(*Continued from p. 577.*)

§ 30. If we were examining the electric current systematically, it would be natural to commence at the "source;" but for present purposes it may be better to consider first the phenomena of the "variable" periods at closing and opening the circuit. It is from these that the new notions about the current itself take their rise.

Fig. 3 represents what occurs. The horizontal line A G is the period of a current's duration. The vertical line A E may

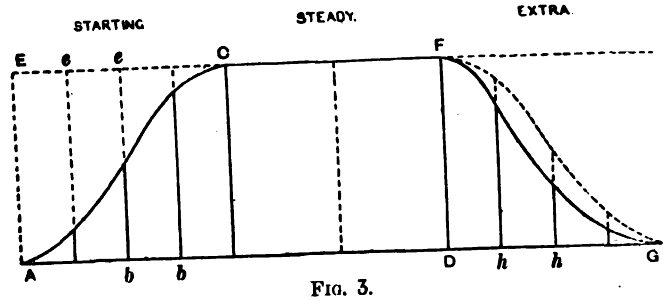



FIG. 3.

have several relations; it may be the E.M.F or "voltage" of the source; or (which is the thing which underlies voltage) it may be "energy." The other vertical lines are the measures of "current," the ordinates which give the curve of current A C F G; c C and D F being the full current due to the voltage of the source and the ohmic resistance of the circuit; b b the ordinates of the initial variable period, and h h those of the terminal variable period. This latter period is the "extra" current period, the true circuit being supposed to be broken at the time D.

§ 31. Any process which takes time, however short, must necessarily be developed gradually, and be describable by a curve. The curve A C is that of the growth of the current up to its full strength; the form of this curve and its length depend upon the conditions which favour or retard the generation of the full current. In the case of electric currents the retarding conditions are found in § 17, p. 576. They are due to certain stresses which must be produced before current can be set up at all, and which involve an absorption of energy from the source. I will defer their special examination till each comes before us in turn, and only indicate them now, viz., static electric stress (§ 17 *d*) and pressure (*e*), these being really the charging of a condenser; (*d*) the magnetance of the circuit, which has some analogies to the charge of a condenser, in that it is a storage of energy in producing some kind of stress. There is another temporary call upon energy, in the "inertia" of the conductor. Think what we may of the nature of current, it can hardly be doubted that it involves a motion of some kind in the molecules of matter; something accompanies it of the nature of friction, which results in the production of heat. This involves inertia, the same thing which resists every mechanical motion, and needs a temporary greater energy to produce than is required to sustain action; and this does not produce heat, but momentum.

§ 32. It will be necessary later on to include all these in one conception of the initial "stress storage" of energy which retards the development of current. Looking at Fig. 3 we may now consider the lines *b b* as representing energy expended *in the conductor*, while their dotted continuations *e e* represent the energy stored in producing stresses, chiefly *outside* the conductor.

§ 33. Inertia implies momentum, and stresses can do work. When the supply of energy from the source is stopped at D, this stored energy returns into the conductor, from which the stresses were created and sustained by the constant stress within it which produces the current; as a consequence identical with what we find in mechanics. This energy appears as momentum, replaces the "source," and maintains a continued current till it is gradually exhausted, when the circuit is opened.

It now becomes internal energy and heat. But the space within the curve F G can never be equal to that outside the curve A C, because all the energy cannot return; some is always retained in magnetism, which results in "hysteresis," Foucault currents, and so on; and even an electric stress in any medium dissipates some energy. I have shown this by the dotted curve F G, which corresponds to A C. The space between the two curves represents this wasted or lost energy; but it should be clearly understood that my curves are ideal and arbitrary. I use this representation to convey ideas, not the exact facts of any particular case.

§ 34. The kind of curve is familiar enough of late; but I wish now to turn it to a purpose that I do not remember to have been utilised before.

*Frequency* is a very useful term for the periodicity of make and break, or of alternation of current, which has now established itself; and if the reader will make a copy of Fig. 3, fold it on itself at the middle dotted line, and slip this into a slit in a card, he will see all that is concealed in a good many pages of mathematical symbols in various papers about variable periods, oscillations, and electrical wave transmission.

By drawing in, and so eliminating the middle part, we alter the "frequency" of the current shown; and when we make the lines C c and F D coincide, we come to a pure wave, the crest or amplitude of which equals the full power of the source. Now this is the lowest proper frequency to be used when the alternating effects are wanted, and the proper frequency when it is intended to fully saturate a magnet.

§ 35. But continue the process, *increase the frequency* without altering the conditions of inductance and magnetance. Now we have the very results before us, which are described by Dr. O. Lodge in his admirable experiments about lightning conductors; we have a lower and lower "current" in the conductor; but we have a higher discharge of energy into the external space, with less facility for its return into the circuit. Here, I think, we may find the truth about the Hertz experiments. They involve successive impulses of energy into space outside the conductors, in such manner and time as to produce waves of induction (not waves of electric transmission), and these find an outlet for the energy which is not given the opportunity of return to the circuit, an action different from, but comparable with, that of the condenser of an induction coil.

§ 36. It is a digression, but I must here explain what I mean about these so-called electric waves. Every musical note has its rythmic interval, which we call its wave length, its periodicity. Take a church bell, for instance, and let us suppose its vibrations to be 400 per second. This is its sound wave period, which we may call A. Now let that bell be struck four times a minute; at each blow a wave of sound will issue, at a periodicity of 15 seconds. Now this may be called a wave of sound, but it is not a sound wave length or period. We may call it B; in this case it is really a recurrent addition to the amplitude of the true sound waves, but no one would complain of the fact being described as successive waves of sound.

Digitized by Google

Perhaps the true combination of the two would be a wave of 15 seconds, with its outline broken into ripples of $\frac{1}{400}$ of a second, each ripple being a true sound wave with rising and falling amplitudes generating the wave of impulse. Now what I mean is, that the electrical waves, of which we have heard so much lately, are not electrical waves analogous to the sound waves A. They have nothing to do with the nature of electric transmission. But they may be called waves of electricity, if we only knew what that means, or, more truly, waves of electric induction. They are analogous to the waves of sound B, merely mechanical incidents, produced not by electricity, but by an artificial periodicity controlled by the conditions of the experiments—mechanical, not electrical waves.

§ 37. Returning now to Fig. 3 and the interpretation of § 35, we may find at once the explanation of the phenomena discussed on several occasions by Sir W. Thomson, and particularly in Papers "On Alternate Currents in Parallel Conductors," abstracted *Electrician*, XXV., pp. 510 and 512. He says (§ 7, II.) :—"When the period is very small compared with 400 times the square of the smallest diameter (400 times the sectional area is more consistent with questions of conductance) multiplied by its magnetic permeability and divided by its electric resistivity, the current is confined to an exceedingly thin surface stratum of the conductors." At all events, it is so small that a very thin stratum will conduct it. Fig. 3 shows why it is small.

§ 38. The statement that it is confined to the surface stratum is, I think, derived from mathematical considerations; but by-and-bye I will give a physical reason why it should be expected to be so. Meanwhile, this is one of the reasons given to show that the energy comes from outside, and under these conditions only just enters the skin of the conductor to propagate the current there. Well, the reasons I will give will show why only this skin current is produced by energy transmitted *within* the conductor.

§ 39. Mr. Heaviside, speaking, p. 388, of the phenomena of a commencing current, and the theory that its origin is from outside the skin of the conductor, says "very few (if any) non-mathematical electricians can understand this fact; many of them neither understand nor believe it." Well, I believe it, and think I understand it, and had already said in reference to it, p. 340, that I would try "to show that there is a better way" to explain it than inventing an action from outside the conductor. My views as to the relation of electricity to the structure of matter and that energy becomes electrical energy only by the agency of a completely closed circuit involve the commencement of the process at the surface of the conductor, and action first externally; the propagation of current in the conductor, being a gradual progressive action in both directions in the conductor, of course "gradual" relates here to time in millionths of seconds. All the facts are as readily explained in this view as on Mr. Heaviside's, and I have no doubt mathematicians would be able to show that either theory is equally adaptable, like the action at a distance, or by a medium which Clark Maxwell says are the same as to mathematical treatment.

Both views of necessity must work from the facts, but in the opposite way. According to the new views, as explained by Mr. Heaviside, p. 389, "the battery or other source of energy" (to save words I shall always speak of "the source") "acts upon the dielectric primarily—that electrical conductors act rather as obstructors, except that they guide the electromagnetic waves along definite paths in space." I maintain that the source transmits energy only into the conductor, but the conductor exerts forces all around, as well as along it; that the characteristic of the force called electricity (which is the marriage of matter and energy, neither alone) involves the setting up of two actions, induction or stress and conduction or transfer of energy.

§ 40. *Induction* precedes *conduction* in genesis. This is not an assumption or hypothesis, nor is it an explanation of any thing in itself, though its consequences may explain much. It is purely a statement of a general fact in nature, for induction is a *stress*, conduction is a *flux*, and of necessity, a flux must be preceded by a stress.

We separate substances into classes, as possessing inductive and conductive capacities; but no such absolute distinction really exists, except as to degree. Induction must occur in copper as well as in gutta-percha, only it breaks down and becomes a conductor (as, indeed, gutta percha does) directly sufficient energy is available. But still the distinction does exist, and is enormous practically; and it is quite clear that the distinction is one of "structure" of matter. Good conductors are elements, metal and carbon, and of simple molecular structure. The next great stage in classification, electrolytes, though more complex in ultimate structure, are still very simple in primary structure, they can break up into two radicals, which to the chemist's mind correspond with the atoms of elements.

Inductors are much more complex in structure, or, as sulphur, are capable of taking variable molecular structures.

Now we know that, given a sufficient stress, that is E.M.F. or voltage, every inductor breaks down; we can generalise from this, and see that until stress rises to a fixed degree, and until all possible stress-bearing matter is charged to that degree, the energy of a "source" will be wholly expended in producing stresses.

§ 41. Current will only be propagated when, and so far as, all stresses are satisfied; therefore, of necessity, the current in a conducting wire can only rise to its normal degree gradually, and reach that degree gradually along the length of the conductor. In fact, if we look at the conditions of Fig. 3, we shall see that there will be a current curve travelling along the wire A G, which will be like the curve A C turned over, and producing gradually the full current strength.

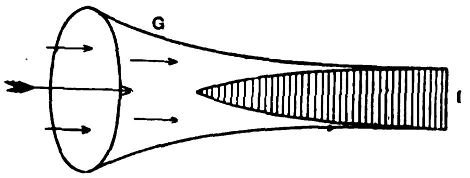



FIG. 4.

Common sense, without the aid of mathematics, will see at once that this progressive wave of propagation must begin at the surface of the conduits, because the leakage of energy is from the conductor into outer substances in which stress is to be set up; it is also evident that a corresponding internal curve of current must exist within the conductor, its elements turned towards the surface, to reach the outer induction circuit, and only taking up the whole of the conductor when the energy is left free to act wholly within it.

Putting these two self-evident ideas together, we see the advancing current must be at first confined wholly to the mere skin of the conductor; and when the frequency is great, we have of necessity no other current generated, as shown §§ 34 and 35. Fig. 4 will show this idea, though prepared for another use later on.

(*To be continued.*)

**The Action of Electric Currents on the Human Eye.**—Prof. Dubois, of Berne, says *Nature*, has been lately studying the physiological action of electric currents and discharges, and he has some interesting observations on the human eye, which, it is known, has luminous sensations under the action of galvanic currents. Sudden variations of current strength, especially at making and breaking the circuit, produce flashes. With a moistened plate at the nape of the neck, and a pad on the eye, a slight flash was distinctly perceived even with a Leclanché cell, giving about 1·20 volt and ·04 milliampere. Raising the current to ·5 milliampere, the observer could tell which pole was applied to the eye. On the other hand, the retina responds much less readily to discharges from condensers or induction coils. Not till a capacity of 0·037 microfarad and a pressure of 21 volts was reached, was a true retinal flash perceived; and not even with 10 microfarads were the durable sensations characteristic of the two poles produced.

Digitized by Google

## NALDER'S BALLISTIC GALVANOMETER.

A good deal of inconvenience sometimes attends the use of the ordinary form of control magnet in a galvanometer This arises from its being really required to perform two distinct

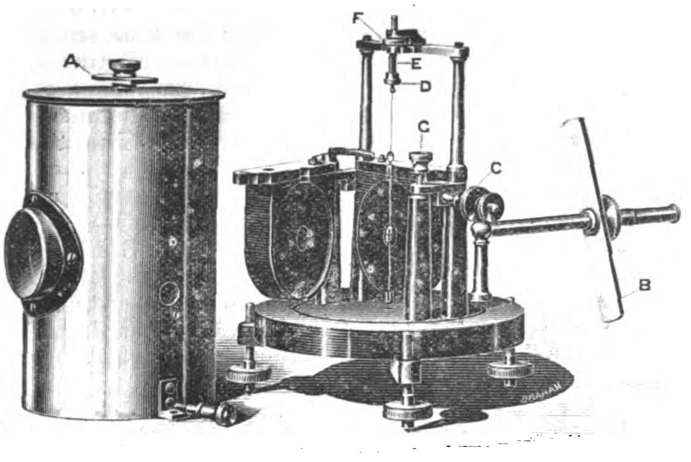



FIG. 1.—Nalder Ballistic Galvanometer. General view, with case removed

functions; first, to alter the strength of the field acting on the needle system; and, secondly, its direction, the former determining the sensitiveness of the instrument and the latter the zero position of the needle. When altering the one it is difficult to avoid altering the other, and the inconvenience becomes the greater the slower the swing. The form of control we illustrate above (*see* Fig. 1) was suggested by Dr. R. Mullineux Walmsley, of the Heriot-Watt College, Edinburgh, who wished to more or less avoid this double effect of the magnet. The usual one is replaced by the much smaller one, A, as fixed on the top of the case, and which can be turned round, but not raised or lowered. By it the spot is first brought to zero. The combined field of the earth and A are then diminished (or increased if a quick swing is required) by turning the tail magnet B on its shaft, or bringing it nearer or further off; but it will be observed that, from the symmetrical position of this magnet with respect to the needle system, when thus moved or turned, it merely alters the intensity of the field without interfering with its direction. Any slight shifting of zero which may occur, due to want of absolute symmetry, is adjusted by a very slight movement of A.

FIG. 2.—Nalder Ballistic Galvanometer. Details of Needle System.

Messrs. Nalder Brothers and Co, of 16, Red Lion-street, Clerkenwell, have applied this method of control to ballistic galvanometers. There are one or two details about this pattern that may be noted. The whole coil is supported on ebonite pillars, and the terminals screw into plates in these after the cover is on, passing through holes in the latter, which are closed by sliding ebonite plugs, C, to keep the dust out when the instrument is not in use. The front coil is hinged so that the needle system is left clear in case a new fibre is required. The attachment for the fibre, D, is free to turn on the end of the rod, E, so that torsion can be taken out; D itself is threaded, and raised or lowered by the nut F, but has a longitudinal slot in it in which a pin works, so that the rod cannot turn round. The second connection to the front coil is through the clamping screw G, which holds the coil in place when closed. In Fig. 2 the needle system with its heavy bell-shaped magnets is shown in detail.

## THE KINGDON INDUCTOR DYNAMO.

This machine is one of the revolving keeper type. The coils, which correspond both to the armature coils and to the field magnet coils of an ordinary alternating current dynamo are fixed, while the revolving wheel carries a number of laminated masses of iron or keepers, which, by their motion, continually change the direction of the lines of force in the iron cores of the armature or secondary coils. The magnets of the dynamo are built up of a number of stamped iron plates of the shape shown in the diagram, and bolted between two stout circular cast-iron frames divided horizontally along the centre line, so that the top can be lifted off and the wheel taken out. The lower frames are bolted to a stout cast-iron bed-plate. The keeper wheel is of exceptionally strong mechanical construction, and consists of 16 keepers, which are constructed of a number of soft iron plates, insulated from one another, and bolted between two stout steel plates mounted on a hub, keyed on to the main driving shaft. Between the keepers and steel plates are two brass rings, which tend to magnetically insulate the keepers from one another. The field magnet or primary poles are permanently magnetised by the current from a small exciter. The intermediate poles have their polarities constantly changed as the keeper wheel rotates. When the keeper wheel or (inductor wheel, as the inventor calls it) has rotated through one thirty second of a revolution the secondary poles will all have their polarities changed, and alternating currents are accordingly generated in the coils with which they are wound. There are no brushes or rubbing contacts, all the coils being fixed.

This dynamo, designed by Mr. J. A. Kingdon, is in use at the Kidsgrove Works of Messrs. Woodhouse and Rawson United, and is wound with one set of coils for supplying incandescent lamps direct at 105 volts; another set is wound with high potential coils for transformer circuits; while a third set is used for arc lamps.

Two machines of similar though slightly different design have been supplied by the Company, and erected at the Woking Central Station. These are wound for 30 amperes at 2,000 volts, and are coupled direct to triple expansion engines. Their periodicity is 70; the inductor wheel is 4ft. 6in. in diameter. The resistance of the eight primary coils connected in series is 2·7 ohms, and of the eight secondary coils 1·8 ohm. The total weight of each is about $7\frac{1}{2}$ tons.

## ST. PANCRAS VESTRY ELECTRICAL EXHIBITION.

The Electrical Exhibition now being held at the St. Pancras Vestry Hall is intended to afford an opportunity to the inhabitants of that district to inspect fittings and switches, &c., and thus enable them to judge of the effective appearance and many other advantages of the electric light which their enterprising local authority will soon be in a position to supply. The Exhibition is of a very complete character, and the large number of lamps at the prettily decorated stalls form an attractive *tout ensemble*.

The current is supplied from a temporary plant erected in a shed near the hall, and consists of a 100 H.P. Marshall semi-portable boiler with extra long fire-box, working under 140lbs. pressure, and provided with a feed-water heater with copper tubes and Worthington pump, and a 80 H.P. Willans engine, coupled direct to a 48 unit Goolden dynamo. This machine was intended to run 400 amperes, at 120 volts, but has been delivering close on 500 amperes very comfortably, without a sign of sparking. There is in addition to the above plant a 20 H.P. Parson's steam turbine. The whole of the plant was erected in four days by Messrs. Sharp and Kent, in the midst of the severe snowstorm of last week. Although it is greatly to the credit of this firm that work of so substantial a character should have been accomplished in such a short time, it is to be regretted that the promoters of the Exhibition should have allowed such a short time for the erection of the plant.

Digitized by Google

One of the first objects of interest in the exhibition is a sample of the mains which are to be laid in the St. Pancras district. These consist of copper strip, as used by the St. James Company and others, supported on wide porcelain blocks, mounted on galvanised iron fittings. Distance pieces of porcelain are bolted at intervals, keeping the strips parallel and straight. Designers of central stations have already shown some originality in the construction of chimney shafts, and here we find a remarkable water-cooling apparatus, constructed of corrugated iron sheets, slung on to the chimney at a height of about 40 feet from the ground. Stand No. 3 is occupied by the recently established firm of Messrs. Miller and Woods, of Gray's-inn-road. Mr. Miller

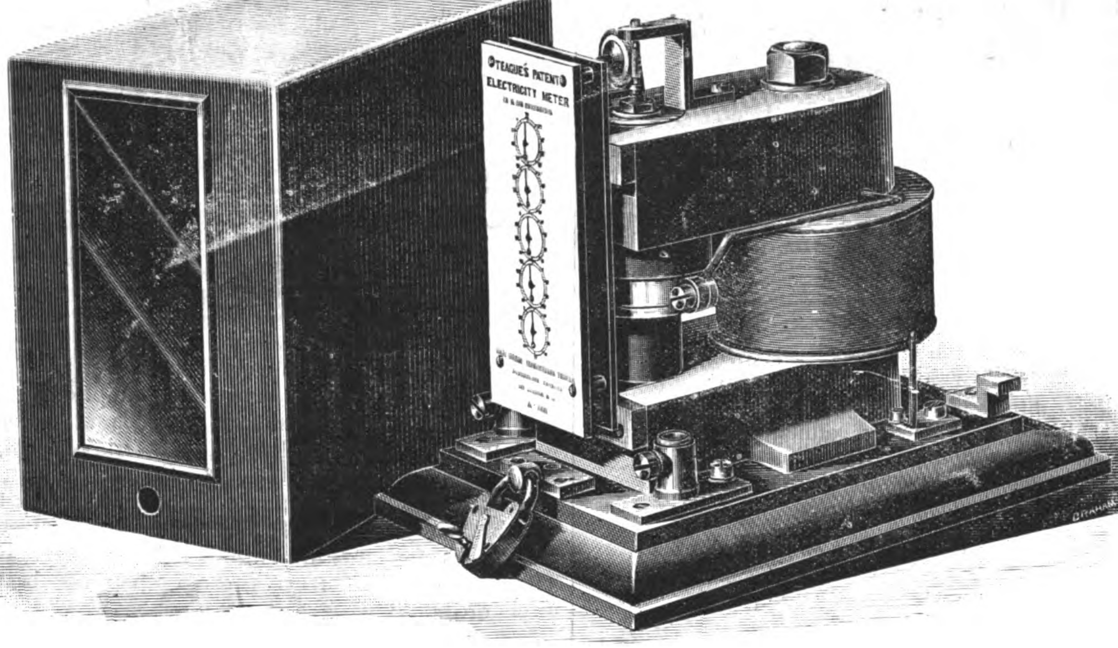



Fig. 1.—The Teague Meter

has a capital ammeter and voltmeter, containing but a very few grains of iron, and the internal arrangements are such that the scale may be either uniform or spread out, the former being used for ammeters and the latter for voltmeters. This firm show an Oerlikon arc lamp, which is one of the very few which will run, if necessary, direct upon a storage battery without the intervention of a resistance. An effective fitting is shown at this stall, hung by a short length of the new flexible metallic tubing, which seems very well adapted for this purpose, being much more substantial than a ball and socket joint. A good assortment of instruments, keys, &c., is exhibited by John Muirhead and Co. The Acme Electric Works make an excellent show, including the Teague watt meter, the Perry twisted strip voltmeter, Ayrton and Perry

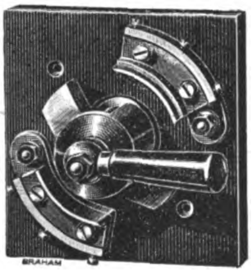


Fig. 2.

combined magnifying spring voltmeters and ammeters, and a number of improved Cockburn quick break lock switches. The Teague meter (Fig. 1) consists of a horse-shoe electromagnet and a hollow revolving cylinder or drum inserted in an annular space bored near the pole. The series current enters at the bottom by the axis of the cylinder, which projects into a mercury trough, passes thence to the top, radiates by the cap of the cylinder to the exterior, and passes down to another mercury trough. The improved Cockburn quick break lock switches are now constructed on an entirely new principle, the amount of spring necessary to ensure the ends of contact brush bedding firmly on the terminal plates being obtained by the flexibility of the brush itself (Fig. 2), which is constructed of extremely thin rolled copper. The terminal plates are segments of a circle, being made adjustable, and by means of screws can be so arranged as to compensate for considerable wear on the brush. At the end of the room the General Electric Company have a number of Aron meters and other fittings, and next to them is the stall of Messrs. Rashleigh, Phipps and Dawson, who show a collection of fittings and give a prominent place to their patent glass bead ray diffuser. This consists of a number of strings of glass beads, threaded on a wire. The beads are in graduated sizes, tapering upwards, and enclose

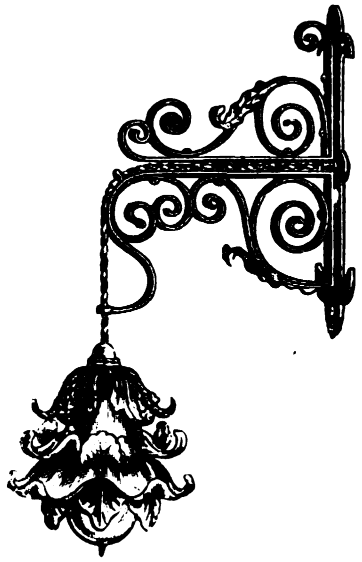


Fig. 3.—Bracket Pendant for Incandescent Lamp (Benham and Froud).

an ordinary electric lamp in a flexible sheath. The arrangement will be admired by those who like clear cut glass on a lamp. Fitting, as the diffuser does, close to the bulb, it takes very much less space than the ordinary cut-glass shade of the preserve jar type. The idea, however, is not altogether new, as we saw something of the kind nine years ago. The new Ferranti meters are shown on an adjoining stand, together with a double

Digitized by Google

pole switch adapted for 2,400 volts. This has a parallel sliding motion, the distance of the break being six inches and the distance between the mains being the same. Messrs. Wake and Sanders have a very fine show of specimens of mica, including large sheets of the quality termed "ruby," and some exceptionally large and clear specimens from Australia and Madras. Messrs. Osler and Co., Strode and Co., Benham and Froud (*see* Fig. 3), Paterson and Cooper, Woodhouse and Rawson, and other well-known firms, are also exhibiting fittings and accessories. One of the most attractive stands is that of the comparatively new firm of Mr. Richard Crittell, of Baker-street, W. Amongst the metallic work shown by them are some very handsome specimens of iron work. Messrs. Drake and Gorham show some specimens of their new D.P. battery plates, both formed and unformed. This plate consists of narrow strips of lead placed horizontally and burned together at the ends, and formed in the old Planté style. At the same stall clear moulded glass cut-outs are shown.

The General Electric Power and Traction Company, which has a prominent stall in the centre of the room, the Keys' Company, and Messrs. A. B. Gill and Co., make a praiseworthy attempt to fulfil the request of the promoters in supplying examples of the domestic applications of electric power, and show washing machines, mangles, air-fans, and hat brushing machines driven by miniature motors. The Keys' Company show a number of switches of a pattern which we understand is largely used in Germany (Fig. 4). The moving part is constructed like an ordinary door bolt. The bar is pressed back by a spring, but may be held forward by a catch. When pressed forward it makes contact between the two lugs on a split copper ring. This ring encloses an ordinary Edison screw

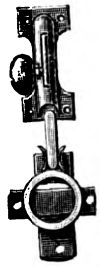


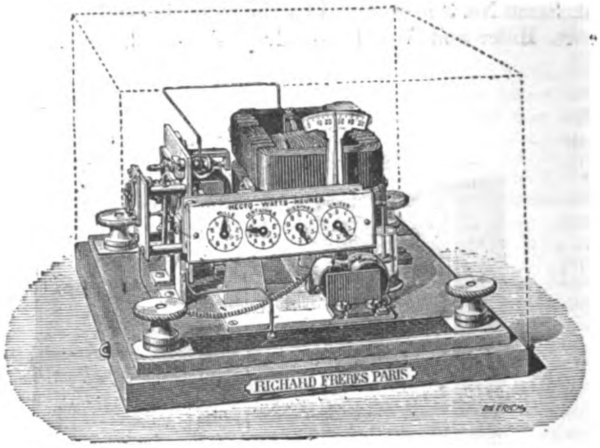
Fig. 4.—Bayonet Bolt Switch.

cut-out. The contact would not be very good, except for the fact that there is both a sliding and a turning motion. It takes up very little space and looks neat. Finally, the Executive Committee have not forgotten to provide something in the nature of mild amusement, such as telephonic "auditions," and a far-reaching, ever-moving search-light on the roof.

The promoters and the Executive Committee of the Exhibition have succeeded in getting together a decidedly creditable display, and we are not surprised to learn that the Exhibition has proved sufficiently attractive to warrant it being kept open beyond the originally fixed period of one week.

## RICHARD FRÈRE'S ELECTRICITY METER.

Richard's meter belongs to the class of intermittent integrating apparatus. The meter is composed of four principal parts —a clock, a wattmeter, an integrating mechanism, and a counter train. The clockwork is entirely independant of the instrument, can be removed and replaced without in any way interfering with the lighting, or giving trouble to the consumer. The clock is wound up at regular intervals of 15 seconds, by a shunt current passing for $\frac{2}{100}$ of a second. The wattmeter consists of a dynamometer composed of a coil of wire or ribbon; inside this a fine wire coil is mounted on a spindle, and the pull is balanced by means of a counter weight. The spindle is provided with a clutch, and is allowed an end play of 2mm. The clockwork makes a contact, which allows the shunt-current to pass through the fine wire coil and an electro-magnet in series with it. The inertia of the armature, being less than that of the fine wire coil, the armature acts first, and disengages the clutch, then the fine wire coil adjusts itself, and a hand upon the spindle indicates the watts passing. Five seconds later the clockwork is automatically rewound, and the wattmeter circuit being interrupted, the clutch engages, and the wattmeter in returning to zero turns it through a certain angle. Ten seconds later, the wattmeter being disengaged, another measurement is made. The counter train, therefore, shows the sum of all the measurements.




The power expended in these meters is said to be less than 20 watts, and they start with a consumption equal to $\frac{2}{100}$ of their capacity. Such meters may be used for measuring both the charge and discharge of batteries, a polarised armature being arranged to cut a resistance in or out, this resistance being proportional to the difference between the charging and discharging in volts. The meter then registers differentially, going forwards in charging and backwards in discharging. The index ought to return to zero when the battery is fully discharged.

## TRANSFORMER DISTRIBUTION.*

BY J. SWINBURNE.

DISCUSSION.—AUTHORISED ABSTRACT.

Before the commencement of the discussion Mr. SWINBURNE showed three of his Hedgehog transformers, having outputs of 2,000, 3,000, and 120 watts respectively. The primary of the first was wound for a pressure of 1,000 volts at a frequency of 130, that of the second for 2,480 volts at 70 periods. The third was intended for street lighting. He said he anticipated a lively discussion on the subject of open *v.* closed-circuit transformers, and in order that a better comparison might be made he hoped speakers would give all details of the patterns to which they referred. As a word of warning to those who intended to criticise the "Hedgehog," he remarked that, like the Scotch thistle, its motto was "*Nemo me impune lacessit.*"

Mr. ESSON said the Paper would be regarded as a most important one, for it served to rectify certain errors which had recently crept into the

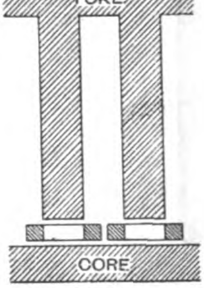



Fig. 1.

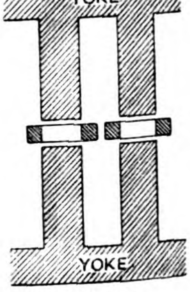



Fig. 2.

consideration of alternating-current machines. The discussion on Mr. Mordey's Paper left things in a very unsatisfactory state, for no figures were given by which the offered explanation of the experiments could be confirmed or confuted, and at the close of the discussion the author himself admitted that some self-induction was necessary for successful parallel working.

* Paper read before the Institution of Electrical Engineers, February 19, 1891.

Digitized by Google

The question of how much was needed was not at all clearly understood, for Mr. Swinburne said that coreless armatures had not sufficient, and Mr. Mordey thought that because his armature had no iron core it had practically no self-induction. Now it is known that both were wrong, and that armatures without iron may have self-inductions quite comparable with those of cored armatures. He then pointed out that the classification of armatures into those having iron cores and those without had led to misconception, and showed that the chief differences between, say, a Siemens or Ferranti alternator and those of the Lowrie-Parker or Westinghouse form are, first, in the position of the air gap, and, second, that in the cored armatures part of the iron forming the magnetic circuit moves, or is utilised to lay the generating coils on. Diagrams 1 and 2 were shown to illustrate these differences. Speaking of Mr. Swinburne's armature-reaction theory, he said Dr. Hopkinson included armature reactions in his term "self-induction," and remarked that it would be difficult to deal with self-induction as exhibited by alternators without including these reactions. Dr. Hopkinson had also stated what should be the value of this self-induction. Mr. Swinburne, however, objected to the treatment on the ground that the harmonic law did not hold, yet he gave no hint as to how the magnitude of the reaction-effect was to be estimated, nor any indication of a law that did hold. With the author's objections to complicated high-pressure networks he heartily agreed, having himself made similar observations in the discussion on Mr. Crompton's Paper three years ago. He also believed it better to use 1,000 volts instead of 2,000, but failed to see any advantage in feeding parallel machines into common bars, and then isolating the supply circuits by feeding them through transformers. On the subject of transformers he remarked that the true efficiency was the ratio of the useful energy supplied by the secondary during lighting hours to that put into the primary in the 24 hours, and that upon this ratio the efficiency of the system mainly depended. Coming to the examination of Mr. Swinburne's figures for the efficiency of the closed-circuit type, he found this efficiency rather understated. Taking a 50 lighter tested by Prof. Ayrton some three years ago, its efficiency at half load was 90 per cent., whilst the loss with open secondary was 53 watts. Now supposing this to work at half load for only four hours out of the 24, its all-day efficiency comes out 69 per cent.; whereas Mr. Swinburne made out the efficiency of a modern closed-circuit transformer to be only 51 per cent. He thought all would

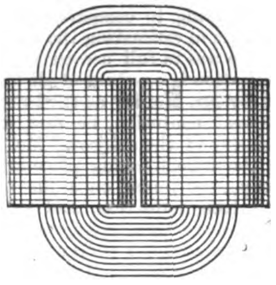


FIG. 3.

agree that it was of great importance to make the "all-day efficiency" as high as possible, but doubted whether Mr. Swinburne took the best way of doing this. For if the Hedgehog transformer be cut in two and made into a closed-circuit one resembling Fig. 3, the watts spent in hysteresis would not increase by more than 66 per cent., and if the loss in the Hedgehog is only 13·5 per cent., the 66 per cent. increase would give 22·5 for the loss in the closed-circuit transformer, instead of 120 as given in the Paper. Making this correction, the "all-day efficiency" of the closed-circuit converter came up to 80 per cent., and by redesigning it this could be further increased. It therefore appeared that there was little to choose between them. In conclusion he pointed out that in 1885 Messrs. Gaulard and Gibbs, at his suggestion, closed the magnetic circuits of their transformers, thus making them resemble Fig. 3. Messrs. Ganz and Co. experimented on a similar form in 1884, and after trying several types had again returned to it, thus showing that no great advance had been made on the shape he suggested some six years ago.

Mr. MORDEY said he did not propose to touch upon the first part of the Paper, as he thought he could best utilise the time at his disposal by confining himself to one definite subject. On alternators he did not at present wish to add anything to the practical contribution that two years ago he had given on the subject. On many of the minor points of distribution he agreed with Mr. Swinburne's conclusions; but from its present interest he thought the design of transformers was the most important subject dealt with in the Paper, and to that he would confine himself. It was interesting to notice that the author had arrived at his present conclusions by a zigzag path, as was seen by a reference to the *Journal* for 1888 where in the discussion of a Paper by Prof. Forbes, Mr. Swinburne said:—"I notice a slip where Prof. Forbes said that some transformers would be more efficient if the iron circuit were open. As I fell into the same error myself, I may point out that the waste of energy is $\int I\,d\,H$," and so on. He (Mr. Mordey) would first sum up the author's present grounds for preferring open circuit transformers. They were (1), that iron was wasteful, hysteresis loss heavy and continuous; (2) that losses were easily ascertainable by calculation only, from $C^2R$ in the conductor, and by Ewing's or Hopkinson's curves for hysteresis (which the author said was constant for all loads), and by calculation for the eddies; (3) that these phenomena in iron and the action of transformers being understood fully—that only "phenomenal iron" could improve closed circuit transformers; (4) that tests of closed-circuit transformers by various observers, showing high efficiency, were wrong, as such efficiencies did not agree with the author's calculations; (5) that the magnetising current was large even in the closed-circuit type. He thought all these conclusions were wrong. On the question of these losses, Mr. Mordey said that careful tests were needed to decide the points, rather than calculations. Many independent observations on closed, circuit transformers by various methods, such as the Calorimeter method used by Prof. Ayrton and others, the "Split Dynamometer" method devised by Mr. Blakesley, &c., had shown the efficiency to be very high. The method he had himself devised and alluded to in 1889, viz., finding the steady temperature to which the transformer was raised when working at a known output, and then determining the loss by applying, with direct currents, sufficient power to maintain this temperature, led to similar results. Recent tests of a 6 kilowatt transformer of his own design by the latter method gave the loss on open circuit as 110 watts, and at full load 206 watts, of which 176 are accounted for by $C^2R$ in the copper. This left only 29 watts for the iron losses at full load, whereas at no load they amounted to 110. On calculating the theoretical iron loss from Ewing's curves it came out at 180 watts at the magnetisation employed. These results showed that as the loss in the copper increased the iron losses diminished, and that conclusions based on the assumption that the iron losses were constant, and could be calculated from Ewing's curves were erroneous. On the basis of the above tests, the efficiencies at various loads of the particular transformer were calculated to be as follows, the first and last being determined by experiment, the intermediate filled in by calculation:—

**Table I.**—Mordey Transformer.

| | Efficiency. |
|---|---|
| Full load. | 96·7 |
| ¾ | 96·2 |
| ½ | 95·1 |
| ¼ | 92·1 |
| ⅛ | 86·7 |
| 0 | 1·8 % loss. |

At no load the total loss was 1·8 per cent. of the full output, and the apparent loss (viz. C × V) 3·1 per cent. the lag between E.M.F. and current (determined simply from the ratio of the true to the apparent waste), which gave the cosine of the angle of lag therefore being 53deg. and 54deg. On the important subject of "all-day efficiency," which Mr. Swinburne stated to be very low in closed-circuit transformers, Mr. Mordey gave the following numbers as relating to the transformer above mentioned, which was one of the Brush Company's ordinary type.

**Table II.**

| Full load for 4 hours (20 hours idle). | | | All day efficiency. |
|---|---|---|---|
| ¾ | " | " | 86 |
| ½ | " | " | 82·7 |
| ¼ | " | " | 68·6 |
| ⅛ | " | " | 52·6 |

He remarked that the small difference between the steady temperature of some of his transformers working at no load and at full load was noticed by him in 1889. For instance, in one case this rise of temperature was 43°F. at no load, whilst at full load it was 48°F. only. From this observation one could infer that either the transformer was very inefficient, or that the loss in the copper was very small, or that some other explanation was needed. Now he knew that neither of the first two suppositions was correct, hence the necessity for some other explanation. Just before the meeting Prof. Ayrton had shown him some tests of one of his transformers, made by Blakesley's method. These tests, conducted by Prof. Ayrton, confirmed his own, and as an instance of this he gave the following numbers, which he said were taken from several pages of concordant figures.

**Table III.**

| Frequency. ∿ | Watts. | Iron losses (watts). | Efficiency. |
|---|---|---|---|
| 210 | 2,363 | 3 | 94·1 |
| " | 907 | 69 | 90·4 |
| 100 | 2,638 | 21 | 93 |
| " | 2,425 | 18 | 93·8 |
| " | 849 | 69 | 90 |

These tests, together with many others made by disinterested observers, all pointed to the conclusion to which he had been led, viz., that the losses in the iron decreased with the load. He submitted that these results, if correct, upset every one of the author's conclusions. But even if Mr. Swinburne's contentions were true, the low "plant efficiency" obtained would seriously interfere to prevent the practical use of transformers constructed in accordance with his views. The author confessed to three-tenths of the plant being required to supply the magnetising current, but said that closed-circuit transformers required two-thirds as much, which latter was by no means the case. The use of condensers would reduce this great disadvantage of open-circuit transformers, but it must be remembered that condensers would also reduce the small disadvantage of closed-circuit transformers. If satisfactory condensers could be obtained (and he congratulated the author on the progress he seemed to have made in that direction) he thought the outlook for closed magnetic circuits was better than ever. The best plan of all, however, was to make apparatus, so that it could be left to work in its simplest form.

Mr. CROMPTON thought the results of his own tests on transformers would confirm Mr. Mordey's observations, but they also enabled him to

Digitized by Google

contradict some of the statements made by that gentleman. In the first place the number of hours required for transformers to attain a steady temperature was much greater than Mr. Mordey would have us believe, for he (Mr. Crompton) had kept them running 30 hours, and still the temperature was not constant. He had also kept both a "Hedgehog" and a closed-circuit transformer of equal output on for 20 hours, the final temperature of the former being 120°F., whilst that of the latter was 212°F. His experience with the Hedgehog type in the lighting of Chelmsford had been satisfactory. Referring to "all-day efficiency," he said most people speak of the efficiency of transformers being 90 per cent. at half load, as if this was their normal working condition. This load was far above the average, even during lighting hours. It might be approximately right for shops and other places where the probable load was readily ascertained, but for private houses it was much too high. Taking the case of a customer whose lighting bill, at 8d. per unit, amounts to £20 a year, he said such a house would require a 50 to 60 light transformer, and the average consumption throughout the year would be 70 watts. The transformer would thus be working on an average at one-sixteenth its full load. It was curious to notice that in the transformer mentioned by Mr. Mordey (*see* Table III.) the iron losses at light loads were about 69 watts, and thus the yearly efficiency would come very near indeed to 50 per cent., the number he gave three years ago. He would have been glad if Mr. Mordey had given the statistics of some of the transformer stations with which he was connected in the shape of the ratio of energy paid for to energy sent out from the station. This, he said, was the important point, and at present it appeared that transformer plants were using about two and a-half times as much coal per unit sold as direct systems. All this extra coal, he submitted, was spent in heating the transformers. Banking transformers and distributing at low pressure would diminish this loss; but after all, what did this come to? Simply that you put down a high-pressure line, with its expensive insulation and a transformer at the end of it, whereas with continuous currents a rather heavy feeder with cheap insulation was all that was required. Transformers, he said, were not so easy to manage as was imagined, and were in this respect not much better than secondary batteries. On the question of "storage," he could not agree with Mr. Swinburne's opinions, for in stations subject to uncertain load, the employment of accumulators to the extent of 20 or 30 per cent. of the total output enabled the working expenses to be reduced immensely. In his opinion, the reason why storage is not used in America was that the loads were fairly steady, and a satisfactory storage cell was not to be had there.

Mr. ADDENBROOKE remarked that Mr. Swinburne was under a wrong impression when he stated that probably no existing company intended changing their system of supply, for he (Mr. Addenbrooke) well remembered that when Mr. Ferranti took out his first patents for transformers the subject of sub-stations and low-pressure distribution was thoroughly appreciated by the inventor. At that time, however, it was impossible to found sub-stations, but it had always been the intention of Mr. Ferranti, as well as of the House-to-House Company, to adopt this system whenever they could. The cutting out or in of transformers at such stations could be effected either automatically or by hand on the lamplighter principle, and with either method a difference of 1 or 2 per cent. in the efficiency of the transformers would be a matter of little importance.

Mr. EVERSHED regretted that the diagrams belonging to the Paper were not issued with the proofs, for without them it was very difficult to follow the reasoning. He described as admirable the explanation of how alternating dynamos act as motors, and said the action was much easier to understand on the armature-reaction theory than by the older ideas about self-induction. Referring to the compound machines mentioned on slip 7, where the magnets are excited by a redressed alternating current, he inquired how the sparking could be got over? On slip 8 the author said cast-iron magnets would not respond quickly to armatured reactions; but he (Mr. Evershed) failed to see why this should be so, for the high specific resistance of the iron would prevent Foucault currents almost as well as laminated wrought iron. In conjunction with Mr. Vignoles he had made many experiments on the loss by hysteresis in different samples of iron, and had never found a sample give more than 25 per cent. more loss than Ewing's specimen; only one sample gave this value, and it was an ordinary bar taken out of a smith's shop. In most cases the losses are about 5 per cent. more than that found by Ewing. On the subject of efficiency of transformers, he said Mr. Swinburne had not taken a good design of closed circuit converter with which to compare his "Hedgehog." [Mr. Swinburne here remarked that in his British Association Paper he had given the best proportions of copper and iron for the closed-circuit form; but in this Paper he had taken an average of the various forms in the market.] Mr. Evershed said that to be anything like a good design there should be much more copper in it, about 2,000 turns in the primary instead of the 400 given. This would reduce the iron loss to 40 watts instead of 120, and the exciting current would be reduced to ·08 instead of ·3 amperes required by the open circuit-type. Nevertheless, if good condensers could be obtained, the large exciting current would not be a serious defect. The subject of open *versus* closed-circuit transformers had occupied his attention for some time, and he found that if you cut the iron circuit of one of the latter form its efficiency was increased. Such being invariably the case, he said, Why not "go the whole hog or none," and do away altogether with the iron core? Recently he had worked out the dimensions of a ten horse-power transformer made on this plan, and found that at a frequency of 70 it would require two tons of copper. If, however, the frequency was raised to 210, the weight was reduced to 200 lbs., and the saving resulting from the absence of a core amounts to 20 per cent. per annum on the cost of the transformer. Difficulties might be experienced in making alternators for such high frequencies, but so far as coreless transformers were concerned high frequency was decidedly advantageous.

The discussion was then adjourned until Thursday, March 12.

THURSDAY MARCH 12TH.

Mr. A. P. TROTTER said the author had been criticised for giving figures instead of facts. This criticism he considered unfair, for it was better to give figures early enough to prevent serious mistakes being made. Had Mr. Swinburne's Paper on Armature Reactions in Direct Current Dynamos appeared sooner, it might have saved others from falling into error in making large Gramme armatures for constant current machines. On the subject of transformer tests, he said the calorimeter method, to be at all accurate, involved many troublesome corrections, and would require very large vessels. The electrostatic wattmeter methods need to be tried; split dynamometers neglected leakage, and as the stray fields are quite different to what one would expect, serious errors may be introduced. Dr. Fleming's experiments at the Royal Institution illustrated how the stray fields of alternating magnets were different from those of ordinary electro magnets. In such fields copper behaved very much like iron in ordinary fields, and possibly copper filings might prove useful for exploring the waste fields of transformers. Mr. Mordey's thermometer method would, he thought, involve considerable trouble if anything like accurate results were to be obtained, for since the heat was in one case generated in the iron, and in the other in the copper, the fact that a thermometer on the iron gave the same reading did not necessarily show that the energy dissipated in the two cases were identical. To obtain reliable results the distribution of temperature should be uniform, and the isothermal surfaces parallel to a casing surrounding the transformer under test. The two latter methods curiously enough led to the result that the losses in hysteresis become less as the load increases. This he could not understand, for if, as is generally assumed, the induction is constant at all loads, he failed to see what goes on in the transformer which would explain the new fact. Since the last meeting, two valuable contributions to our knowledge of transformers had been read before the Physical Society. On the subject of the diminished iron losses at large loads referred to in one of these Papers, he would ask whether such a result was consistent with Ewing's theory of magnetism. To him it appeared possible, and even probable, that the losses with rapidly alternating currents may be quite different from those existing for slow cycles. In order to illustrate the fact that physical properties of materials depend on the rapidity of the changes influencing them, he showed by experiment that a piece or pitch, which was quite soft and viscous to steady pressures, yet transmitted the rapid vibrations of a tuning-fork like a perfectly elastic rigid body.

Mr. G. C. FRICKER, referring to comparisons of closed and of open circuit transformers, said that in estimating the loss in a closed circuit one as 120 watts, Mr. Swinburne was in full accord with writers and teachers who hold that the magnetisation is constant at all loads. This assumption was, however, challenged by Mr. Mordey at the last meeting, and he himself doubted its truth. Great confusion, he said, existed amongst recognised authorities in the theory of the subject. Mr. Kapp, for instance, in his diagram illustrating the actions taking place in a closed circuit transformer, builds up his component forces on a line drawn to represent the maximum value of the resulting induction, and in the speaker's opinion thereby begs the whole question. He also asserts that the resulting induction is in quadrature with the secondary current because this current is in consonance with the impressed E.M.F. Mr. Blakesley, starting from a different standpoint, viz., the impressed primary force, and assuming the necessary adjustment of primary and secondary currents, arrives at the conclusion that the secondary impressed force is in quadrature with the primary current. If, therefore, both Mr. Kapp and Mr. Blakesley are right, the phase difference between the primary and secondary currents is always 90deg. He (Mr. Fricker) thought one of the statements must be wrong, and asked Mr. Swinburne to point out which was correct or to reconcile the two. In view of the contradictions between recognised authorities on the theory of transformers, he thought the experimental facts brought forward by Mr. Mordey should not be lightly set aside. So far as these results would affect the comparison of closed and open circuit transformers, Mr. Swinburne might say that the open form would be equally benefited if the new view be correct. He, however, could not agree to this, for the Hedgehog required a very large exciting current, and hence the plant efficiency would be materially lower even during the hours of full load. It was difficult, he said, to conceive the mechanism which must exist within the transformer if Mr. Mordey's and Prof. Ayrton's figures be true; but, nevertheless, their confirmation would be one of the most interesting developments of electrical science. Speaking of calculations based on the sine law, he remarked that several months ago he arrived at conclusions similar to those proved analytically by Prof. Ayrton, viz., that harmonic variations were not essential to the accuracy of the resulting formulæ, and would give the considerations which led him to the conclusions in the *Journal*.

Dr. FLEMING said Mr. Swinburne had ventilated his opinions against the orthodox view of parallel working, but so far as he (Dr. Fleming) could see, he merely put forward old views under a new name. Armature reactions really meant mutual induction between armature and magnets, and, as such, their existence had always been recognised. Considerable attention, he thought, should be paid to the state of a system at a given instant, and a distinction drawn between the instantaneous inductance and the mean inductance of a circuit. Referring to Prof. Ryan's indicator diagrams for transformers, where the E.M.F. and current curves are plotted in correct relative positions, he showed how the inductance at any instant could be obtained, and expressed it by the formula

$$I = \frac{e - r\,i}{\frac{d\,i}{d\,t}},$$

$e$ being the E.M.F., $i$ the current, and $\frac{d\,i}{d\,t}$ the slope of the current curve

at the point corresponding to the instant considered. Inductances so found were, he said, periodic functions of time. On the subject of parallel working he thought little or no advance had been made since Mr. Mordey's Paper was read. Parallel working was then shown to be quite practicable, and is now largely employed on the Continent. At Leghorn several 150 H.P. alternators were perfectly in parallel. These machines have high resistance, small time-constant, and stiff field, the conditions which, according to orthodox views, are desirable. He could not agree with Mr. Swinburne that 1,000 volts station pressure was preferable to 2,000, for the cost of the mains in the latter case was only about half that in the former. The employment of 2,000 volts did not seem to be any more dangerous, for Messrs. Ganz and Co. and the Thomson-Houston Company had many stations working at this pressure, and, so far as he had observed, the 2,000 volt alternators required no more care in working than their low-pressure exciters. He doubted whether the use of low-pressure alternators and step-up transformers would be safer or more economical, for the waste in the transformers would be considerable, and their cost would probably far exceed the figure quoted by Mr. Swinburne. The chief claim made for the Hedgehog form of transformer was that it gave a more square-shouldered efficiency curve than the closed type. Whether this was so or not was, he said, not a question of calculation, but one on which experiment alone could decide. Such experiments should not be made by a wattmeter, where a fine coil and non-inductive resistance were employed, for considerable error may be introduced. Although Mr. Swinburne admitted that the Hedgehog transformer required a large exciting current, he seemed to underrate the effect of this, when a number of small transformers were connected up, for it would entail a great waste of coal and lower the plant efficiency. As regards sub-centres and low-pressure distribution, he said nothing could be more charming when writing a Paper, but when one came to devise a practical system to work under present conditions great difficulties presented themselves. Care should, however, be taken to run the feeders for supplying high-pressure distributors so that they terminate at points where sub-stations may subsequently be conveniently placed.

Mr. KAPP thought the efficiency of the Hedgehog transformer would be increased by closing its magnetic circuit, for this would reduce the exciting current, and by diminishing the magnetic resistance the lag would be increased; therefore the power would be less and the plant efficiency greater. He could not see how it was possible for an open circuit transformer, which required a large exciting current all the day, to be more efficient than a closed circuit one. The matter could not be settled by argument, and experiments must be appealed to. Speaking of sub-stations, he said he was disappointed with Dr. Fleming's view, for the system had taken great hold upon engineers. At present, however, it would be futile to build large sub-stations. Eventually a leaf might be taken out of the book of direct-current engineers, and stations to supply limited districts established; but instead of carrying coal to these stations they would convey electric energy. Distribution could then be effected much more economically, for large or small transformers could be put in or out according to the demand. He called attention to a drawing of an automatic apparatus for performing these operations which he had designed, and said a copy would appear in the *Journal*.

Mr. F. KING agreed with Mr. Swinburne about the defects of the house transformer system, but thought his estimate that the average comsumption amounted to half-load for four hours per day was rather too high; three hours half-load would be nearer the truth. Making this correction, the all-day efficiency becomes considerably less than the least figure given in the Paper. Referring to the advantages of storage, he said secondary batteries were now satisfactory things, and believed that when transformer systems could use storage, then alternate current engineers would appreciate its importance in reducing working expenses.

Mr. S. JOYCE, jun., asked whether the iron losses in transformers obtained from Mr. Mordey's and Prof. Ayrton's experiments continued to decrease with increase of load, and if they ever became zero or negative?

Major CARDEW said people's opinions differed considerably as to what was meant by sub-stations. Mr. Kapp's system was expensive, but he saw no reason why transformers should not be placed in small lean-to buildings, and used to supply several houses in the neighbourhood.

Prof. S. P. THOMPSON hailed with satisfaction Mr. Swinburne's opinion about 1,000 volts being generally preferable to 2,000. Dr. Fleming had said that the cost of the mains varied inversely as the volts. As far as copper was concerned this might be correct, but it was not so for insulation. This, he thought, varied as the square of the volts, whilst compensations, &c., might be as the fifth or sixth power.

Mr. MORDEY, replying to Mr. Joyce, said the efficiency curve rises and then falls again, whereas the iron losses fall to a minimum, and then rise with further increase of load. Many tests show the same result. On the subject of armature reactions he had experimented by isolating one coil of a 50 H.P. armature from the rest, and connecting it with a voltmeter. On varying the load from 0 to 20 amperes this voltmeter remained quite stationary, whilst the pressure of the active coils fell six or seven per cent. Referring to Mr. Trotter's objections to his thermometer method of testing transformers, he said magnetic leakage could not affect the result at all, and with care there was no difficulty in obtaining correct results.

Prof. AYRTON did not agree with the author's remarks on slip 4 about the word "self-induction" being meaningless when applied to an armature, and pointed out that the self-induction of a coil was not affected merely by its being interlinked with lines due to other magnetising forces. The self-induction of a coil meant the change of lines threading the coil due to unit current in that coil; and although its value would be affected by the presence of iron, yet under given conditions its meaning was quite definite. The transformer tests made by Mr. Taylor and himself had, he said, been attacked both because they gave a point of maximum efficiency and because they showed the loss in iron to be small at full load. No doubt Prof. Ewing and Dr. Hopkinson had shown what the losses were when iron was subjected to slow changes of magnetism; but, so far as he knew, there was no proof that the same losses occur with rapid reversals. In a number of *La Lumière Electrique* for March, 1890, Prof. Roiti had given results of transformer tests made by different methods to those employed by Mr. Mordey and himself, and had been led to the same conclusion, viz., that at moderate loads the iron losses in transformers were negligible. Three independent observers, using different methods, had thus been led to the same conclusion. Speaking of measuring power, he said Dr. Sumpner and himself had communicated to the Royal Society a new and simple method, quite independent of any assumptions as to harmonic variations or leakage, and at an early date he proposed making tests on both closed and open circuit transformers by this method.

Mr. SWINBURNE, in replying to Mr. Esson, said Dr. Hopkinson had worked out the best condition for parallel working by getting the greatest control for a small change in the lead or lag angle, on the assumption that two equal machines were in parallel; this, he pointed out, was not the condition which holds in practice. To Mr. Evershed he pointed out that there was no difficulty in redressing the main current for series excitation of an alternator, for this was done daily both by Thomson-Houston and Ganz. He then observed that though it was said that his representative closed circuit transformer was not good enough, he had repeatedly asked for particulars of a better one, but they had not been produced. Though he had done so in his British Association Paper, he was not now called upon to design closed circuit transformers for his opponents, and in his present Paper he had taken a commercial "Hedgehog" and had compared it with a commercial closed-circuit transformer. His "freezing mixture" statement, he said, was not based on Ewing's curves, for he found that, according to Ferrari's tests, the loss in the whole transformer was less than the loss by resistance, and so the iron must have actually supplied power to the circuit. The readings were taken by the "split" dynamometer method, and proved its worthlessness. Mr. Mordey's figures were, he said, shown to be inaccurate by their agreement with those of Prof. Ayrton and Mr. Taylor, which were taken by the split dynamometer method, and thus gave too high efficiency, especially at full load. Whether the iron losses become small or not at full load was, he said, of little importance to his contention, for if it be admitted that they are large at no load, his point as to the superiority of the open circuit type was proved. Any wattmeter would not give accurate results in transformer measurements, and before one is used it should be carefully checked both with direct and alternating currents on resistances and choking coils. As it was very important that people should have confidence in transformer tests, his firm would provide all apparatus for different tests to be carried out on the same transformers by all the well known methods, and he hoped a good closed circuit transformer would be forthcoming to undergo the same tests. He would be glad if Profs. Fleming or Thompson would make the tests, everything being provided for them. Mr. Kapp's and Mr. Esson's argument that a "Hedgehog" would be improved by closing the iron circuit was, he said, bad, for that would double the iron loss. The large exciting current was not a serious matter, for, although speakers had overlooked the fact, this could be supplied by condensers or by a dynamo running loose. On the subject of sub-stations, he pointed out that there was no need for buildings, for transformers might be sunk in the roadway where needed. Neither was there any necessity for automatic switches to cut transformers in and out, for, if properly designed, they could always be left on without appreciable waste.

## NOTES ON ALTERNATING CURRENTS OF VERY HIGH FREQUENCY.*

BY ELIHU THOMSON.

The interesting account of the novel experiments given by Mr. Nikola Tesla in the *Electrical World* of February 21, 1891 (see also *The Electrician*, March 6, p. 549), relating to the phenomena of alternating currents of very high frequency, leads me to make a statement of some of my own observations while working in similar directions. The highest number of alternations which I have had at my disposal up to the present is 8,000 per second, a rate somewhat below that which Mr. Tesla has obtained, but which, nevertheless, shows properties and brings about actions and results similar to those which he describes. The physiological actions of these rapidly alternating currents have been very ably investigated by Dr. Edward Tatum, some of the results of whose work I have presented in a separate communication. Mr. Tesla's experiences in relation to the static effects of these currents of high frequency are similar to those noted by myself, particularly the small surface of the condenser, which is able to transfer, or permit to be transferred, a considerable amount of energy through a dielectric, owing to the exceedingly high rate at which the changes of direction of charge are made.

The following experiment, which was tried by me some months ago, is interesting in this connection: An incandescent lamp bulb was constructed in which only a single platinum leading-in wire was used, on the end of which, inside the bulb, was mounted a single slip of carbon of two or three inches in length, it being one leg of a broken incandescent lamp filament. Two-thirds of the

* From the *Electrical World* of New York.

Digitized by Google

lamp bulb was now immersed in an outer vessel of water, leaving the single wire above the water for attachment to the source of alternating currents at one terminal, and the other terminal was connected with the outside water, which was rendered slightly conducting by salt dissolved therein. The water surrounding the lamp bulb formed, of course, an outer condenser coating, while the vacuous space and straight slip of carbon were the means for the conveyance of a charge to and from the inside surface of the bulb, which was, of course, exhausted to the ordinary vacuous condition, as found in an incandescent lamp. When an alternating potential of about 1,000 volts, and with a rate of alternations up to 5,000 per second, was applied to the carbon strip, the filament was brought to bright incandescence simply by the bombarding action of the residual gas, as in the Crooke's tubes, while, of course, no complete circuit existed, but only the condenser action of the lamp bulb allowing sufficient current to flow. At the same time the glass of the lamp bulb not immersed in the water became rapidly heated, indicating that that portion which was immersed in the water would have become equally heated had it not been subjected to the cooling action of the water itself.

The retention of the arc, as with direct currents, and the high note evolved by it have been noted from the beginning of my experiments with these high-period currents. Mr. Tesla expresses surprise that he was enabled to hear the note from an arc in which the alternations of current were more than 10,000 per second. Mr. Tesla will pardon me for calling his attention to the fact that he is taking as the limit of audition in this case sounds of from 5,000 to 10,000 complete waves per second, which is far below the limit at which sounds become inaudible to ordinary ears, cases existing in which a pitch corresponding to over 30,000 per second has been heard, according to some authorities. The cause of the persistence of the arc with very high-period alternations, as stated by Mr. Tesla, is undoubtedly the correct one, *i.e.*, that the gas stream has no time to cool between the alternations, and its variations of temperature must therefore be quite slight. The conductivity of the vapour or gas stream constituting the arc therefore remains nearly constant when the rapidity of alternations is sufficiently great.

The characteristics stated by Mr. Tesla as requisite to be possessed by machines suitable for obtaining constant current for the working of arc lights are, of course, connected with the fact that in such machines the characteristic curve indicates a drop or fall in the electromotive force developed on a slight excess of current above the normal, and on a decrease of current arising of the electromotive force to a point above the normal. It is not, however, in accordance with my experience that the undulation of the current is almost essential to the success of an arc-light system; nor do I think that properly constructed clutch lamps depend for their success, any more than do finely constructed clock-work lamps, on the presence of a rapidly varying current due to a small number of armature coils and correspondingly small number of segments in the commutator. In fact, I have run with perfect success clutch lamps in circuit with coils of such large self-induction that any but very slight fluctuations were wiped out and without introducing any particular difference in the behaviour of the lamps. It probably is true, however, that slight gentle fluctuations occurring at very moderate intervals may be of benefit in the working of clutch lamps by keeping the clutch mechanism in a state of vibration or tendency to open or close; but it can scarcely be doubted that if this benefit exists for such lamps a similar benefit would exist on the operation of clockwork lamps, as a similar fluctuation would give rise to a continual tendency in such lamps to keep the detent or escapement free enough for delicately letting go teeth for the feed; but the fact that large numbers of lamps are in use in which the feeding of the carbon either by clutch or by clockwork is under the control of a derived circuit magnet only, and that such lamps operate with the greatest satisfaction, shows that the undulations mentioned by Mr. Tesla are not necessarily a factor to be considered. In such cases the self-induction of the arc branch is negligible as compared with that of the derived circuit magnet controlling mechanism, and the fluctuations, therefore, would pass through the arc without affecting the said magnet to a perceptible degree, particularly as the potential around the arc with slightly different current strengths flowing is nearly constant. I may add that the experiments of Mr. Tesla in relation to the action of the condenser and the elevation of potential brought about by it are decidedly interesting, and point to the possibility of obtaining a pure resonance effect. This would require, however, that the periodicity of the alternations be preserved very rigidly during the experiments, and involves the production of an unvarying or perfectly constant speed in driving the generating machine, a condition not easily obtained in practice.

In making the above notes on the highly interesting and valuable account given by Mr. Tesla, I desire to state that, in whatever way my notes may appear as criticism of Mr. Tesla's views, they are not made in any unfriendly spirit, but with the desire of reaching the exact facts which it is the object of scientific investigation and discussion to ascertain.

## PARLIAMENTARY INTELLIGENCE.

### The City and South London Railway Extension Scheme.

BILL BEFORE THE SELECT COMMITTEE OF THE HOUSE OF COMMONS.

The City and South London Railway Bill, which proposes to extend the electric railway system from King William-street to Islington, came (on Friday last) before a Select Committee of the House of Commons, consisting of Mr. Hanbury (Chairman), Sir G. Campbell, Mr. F. Parker, and Mr. H. Stewart.

Mr. Pembroke Stephens, Q.C., and Mr. Rigg, appeared for the promoters, while the opponents were represented as follows:—The Gas Light and Coke Company, Mr. Pope, Q.C., and Mr. Danckwerts; Lord Calthorpe, Mr. Sanders, Q.C., and Mr. Lewis Coward; the Corporation of London, Mr. Littler, Q.C., and Mr. L. Monk; the Commissioners of Sewers, Mr. Russell Griffiths; Messrs. Rothschild and Sons, Mr. Bidder, Q.C., and Mr. Lewis Coward; the Metropolitan Railway Company, Mr. Littler, Q.C., and Mr. Worsley Taylor, Q.C. Counsel were reserved by the Vestry of St. Luke's, the Regent's Canal Company, the City and Docks Railway Company, Messrs. Cooper Brothers and Co., the Metropolitan District Railway Company, and the Union Bank of London.

Mr. PEMBROKE STEPHENS, in opening the case for the promoters, said the City and South London Railway Company were the pioneers of the system of underground electric railways in London. The proposed extension line would start from a point in King William-street, about 150 yards from the Company's Monument station, and would pass under Moorgate-street, Old-street, City-road, to the Angel at Islington.

The CHAIRMAN: It is not an actual continuation of the present line?

Mr. PEMBROKE STEPHENS said it had been thought better not to carry the proposed line into the existing terminus, but there would be a sub-way leading from the Monument Station to the proposed station in King William-street to enable passengers to pass under cover from one station to the other. The mode of construction in the case of the proposed line would be similar to that adopted on the existing line. The length of the proposed line was two miles, and there would be stations in King William-street, near Moorgate-street, in Old-street, in City road, near the Regent's Canal, and at a point a little short of the Angel at Islington. The Committee would see that the proposed line was clear away from any other line of railway, and, except for the fact that it would pass under the Metropolitan Company's railway at Moorgate-street, it would not touch any other line at all.

The CHAIRMAN: You have no provision in the Bill for workmen's trains.

Mr. PEMBROKE STEPHENS replied in the negative. They were all workmen's trains. The additional capital to be raised in order to carry out the proposed extension was £660,000 of share capital and £220,000 borrowing powers, making together £880,000.

The CHAIRMAN: Have you any clause asking for the subsoil for nothing?

Mr. PEMBROKE STEPHEN: No, sir. The Metropolitan Railway Company, in their petition, went so far as to allege that the working of the proposed line could not be effectually accomplished by electricity as a motive power. The application of electricity as a motive power, they said, was at present in its infancy, and although experiments had been made, the practical results had been uncertain and unsatisfactory; in fact, they had shown that electricity was inadequate as a sole means of efficiently working a line of railway. He (the learned counsel) was afraid that the Metropolitan Company had failed to recognise the various uses to which electricity had been put during the past few years. Certainly, the Company said, "Your petitioners are advised that the cost of working railways or subways by electricity is proportionately very much greater than the cost of the ordinary method of working the traffic of railways, and that although it is true that the South London Railway has been worked since its opening by electricity, such working has been frequently unreliable, and it will be found that the cost is far too great to permit of railways being worked by this system, even though they carry an enormous Metropolitan traffic, to be a commercially remunerative concern." What right had the Metropolitan Railway Company to trouble themselves about the success or failure of the proposed scheme? It was no business of theirs whether the Company did or did not make the line pay. Further, the Metropolitan Railway Company said in their petition: "The promoters of the Bill have inserted the provision for working the line by electricity in order to secure for the Bill a measure of public favour, and to facilitate its passing into law; and the probability is that, in the event of the line being sanctioned, the promoters, having obtained powers for the construction of their railway, will come to Parliament in a future Session for power to make use of steam, which is the only motive power that at present can with efficiency and economy be used upon railways." That was a very curious statement for the Metropolitan Railway Company, seeing last year they themselves considered whether they would not throw over steam and take to electricity.

Mr. GREATHEAD, one of the engineers of the City and South London Railway Company, said the object of the Bill was to afford to the very populous districts north of the City better facilities for travelling to the City. The generating station would be in Duncan-terrace, near the Angel.

The CHAIRMAN: Will it in any sense be a nuisance?

WITNESS: No; there are no houses near. Continuing, the witness said. the generating station at Islington would only supply the extension, and not the whole system. There would be two generating stations—one for each section.

The CHAIRMAN: If the two sections joined you would only want one generating station.

Digitized by Google

WITNESS: Well, there is an advantage in having two, because, if one failed, you will be able to use the other. The conductor will pass through the subway.

What is the distance from the Angel to the present generating station?—About five miles.

On the Central London Railway one generating station will work the whole six miles?—Yes, it is quite possible to work the proposed extension and the existing line with one generating station. It is simply a question of costs.

The CHAIRMAN: The site for the proposed generating station at Islington appears to me to be in a crowded district.

Mr. LEWIS COWARD: So it is, sir.

WITNESS, continuing, said it was proposed to work the new line in the same way as the existing line was worked. The trains, however, would be rather larger, and would accommodate more passengers. The proposed line would cause no interference with the public thoroughfares, and the excavated soil would be collected at and removed from the sites of the various stations. The total cost of the works, including the purchase of land and contingencies, would be about £458,402, and to that sum must be added £110,C00 for equipment. That equipment would enable the Company to run a three minutes' service. A two minutes' service would involve an additional outlay of £40.000 for equipment. The distance from Islington to King William-street would take from 7½ to 8 minutes. There would be no serious competition between the proposed line and the Metropolitan Company; in fact, he could not see that there would be any competition at all. The ground underlying the petition of that company was that they were afraid of further extensions.

Cross-examined by Mr. RUSSELL GRIFFITHS: The tunnels of the proposed Islington extension, the proposed Central London line, and the existing City and South London line varied in diameter.

Would not that be objectionable if you wanted to amalgamate the lines at any time?—No.

The CHAIRMAN: You will have the same gauge on these lines?—Yes.

Mr. POPE, who had just entered the room, rose to cross-examine the witness on behalf of the Gas Light and Coke Company.

The CHAIRMAN said as he was not present during the examination of the witness they could not allow him to cross-examine the witness, unless some special reason could be shown for granting him an indulgence.

After some argument between the Chairman and the members of the Bar, Mr. Pope, Mr. Littler, and the other opposing counsel left the room.

Shortly afterwards Mr. Danckwerts, who was with Mr. Pope, for the Gas Light and Coke Company, entered the room, and attempted to cross-examine the witness, but the Chairman at once stopped him.

Mr. DANCKWERTS: In the name of the members of the Bar of England I protest against such a course.

Mr. Danckwerts then withdrew.

Sir BENJAMIN BAKER, consulting engineer with Sir J. Fowler, stated that he gave evidence in support of the original Bill.

Sir G. CAMPBELL: What are the advantages of two small tunnels over one large one?—The cost of construction is about one-half less.

Then the saving of cost is the great advantage?—Yes; but you also get better ventilation. There are no serious disadvantages attached to the small tunnels, while there are a great many advantages.

Were you consulted about the break of line and the construction of a subway?—There are difficulties in the way of carrying the existing line through.

What are they?—The very great expense and the necessity of making some rearrangement of the City station, probably.

There are no physical difficulties—it is merely a question of expense?—Yes; no doubt you could do it.

The further consideration of the Bill was adjourned till Monday.

### Monday, March 16th.

The CHAIRMAN said, in the opinion of the Committee the weakest point of the promoters' case was the awkward break between the existingand the proposed lines. The Committee would require to be satisfied onthe point.

Mr. RIGG said he would bear the Chairman's statement in mind.

Mr. DOUGLAS YOUNG, land valuer and surveyor, gave evidence to the effect that, allowing for certain improvements, lands required for the service of the railway would cost £198,992. He had had experience of the depôt at Stockwell, and he was in a position to say that the working of the machinery of the depôt proposed to be established at Islington would cause no injury.

Mr. VENNER, Secretary of the Agricultural Hall Company, stated that Islington required more direct means of communication with the City, and that the proposed line would be of great advantage to those persons in the City who desired to visit the Agricultural Hall.

Mr. GRAY MOTT, the Chairman of the City and South London Railway Company, stated that the subway for foot passengers connecting the existing Monument Station with the proposed King William-street Station would be about 150 yards in length. It was not proposed to make a physical junction, so that passengers might be carried direct from Islington to the south side of the Thames. There were several serious obstacles in the way of such a junction, one being the great outlay which would be required to buy up most expensive property in King William-street. The carriages on the Islington extension would be larger than those on the existing line, so that the Islington carriages could not run over the Stockwell line, though of course the Stockwell carriages could run over the Islington line, the gauge being the same on both lines.

The CHAIRMAN: I should like to know a little more as to why you do not propose a physical junction, so that passengers might be carried right through from north to south. It strikes me that the Company are deliberately adopting a style of carriage which will make any junction in the future impossible.

WITNESS replied that they had found the carriages on the South London line rather small, and that therefore they were anxious to make those on the proposed line larger. In addition to the great cost of acquiring property in King William-street, the running of through carriages would not pay. The great bulk of the traffic was to and from the City, and not from north to south.

Mr. H. STEWART: Have you any future intentions in the way of extending your line, say from the Angel towards Highbury in the north, or westwards to King's Cross?—There is no such intention at present. Of course we cannot say what the future may bring forth, but the further you go the less likely is the traffic to prove remunerative. We anticipate a very large traffic on the Islington extension.

Mr. LITTLER asked the witness whether he had not stated that the object of the Company in promoting the Bill was not to make the line but to occupy the ground?

WITNESS replied that the promoters of the Central London Railway Company deposited a Bill in Parliament last year to take up the ground in King William-street, and it was true he had said one of the objects of the City and South London Company was to occupy the ground. Their desire, however, was to make the line, and if they got the Bill they would make it. He believed that the existing line would pay.

By RUSSELL GRIFFITHS: He hoped the proposed line would be constructed for less than £440,000 per mile. It would cost more than £225,000—the cost of the existing line—because property was very expensive in the City.

Re examined by Mr. RIGG: The existing line was not opened for traffic until December 18th, and therefore they had barely had three months' experience of its working.

You have not worked the line to its full capacity?—We have not done so yet.

Have you the means of increasing your train service without any great additional expenditure?—Yes. We do not run any trains as yet on Sundays.

You hope to do very much better by the end of the year than you have done up to the present?—Yes. We are doing better every week.

Supposing there was no subway, that the line was simply from the Angel to King William-street, would it afford valuable facilities to the public?—Yes. I do not know any district which requires such facilities more than Islington.

Sir G. CAMPBELL: Have we the least security that the line will ever be made?—You have more security than you often have.

Mr. PEMBROKE STEPHENS: Parliament has no absolute security that any line will be made. The City and South London Company, who are promoting this Bill, have paid the necessary deposit.

Sir G. CAMPBELL: This is very different from an ordinary railway. The proposal of the Company is that they shall be permitted to occupy a certain main line of streets in the City, and if we pass the Bill we prevent other people from using the ground as long as the powers last.

Mr. H. STEWART (to witness): If Parliament sanctioned it, another Company could run either above or below your line?—Certainly. We do not occupy the whole of the ground.

Mr. GREATHEAD, the Engineer, was recalled, and stated that last year the Central London Railway promoters proposed to make a physical junction with the existing City and South London Railway. The estimate for the junction was £70,000. That estimate was based on the assumption that the promoters would be able to take easements under the property. They did not contemplate having to purchase the whole of the property. Mr. Viger's estimate for purchasing the necessary property was £440,000

The CHAIRMAN: Then your main objection to having a physical junction between the two lines is the expense?—Yes.

The CHAIRMAN: Therefore your evidence is in conflict with that of Mr. Mott.

Mr. RIGG: But Mr. Mott has to find the money.

The CHAIRMAN: Mr. Mott certainly said he would not like a physical junction if he could get it at a small cost.

Mr. RIGG (to witness): If you had to make a physical junction would the cost be such as to make the line financially impossible?—I think so.

Sir JOHN FOWLER said he had no doubt the proposed line could be carried out successfully. It would, undoubtedly, carry a large number of passengers. There was no engineering difficulty in the way of the construction of the proposed line.

Do you approve of the substitution of a subway between King William-street and the Monument for a physical junction?—I do not think that a physical junction should be made, at least for the present.

Do you consider that the subway ought to be made as a temporary arrangement?—It is quite impossible to come to a decision on the point now as to whether or not there should be a junction connecting the two lines. In addition to the question of expense, there is the important point as to where the station should be made.

Do you think this line must be a continuous line ultimately?—I am not so sure of that. With the expience I have had I am not prepared to suggest anything to the Committee with regard to a junction. I would not take the responsibility of suggesting anything at the present time. I think it would be wiser to let things develop themselves.

This closed the evidence for the promoters, and the Chairman ordered the room to be cleared. On the public being readmitted the Chairman said the Committee proposed to hear the evidence against the Bill on the following day. The proceedings were accordingly adjourned.

### Tuesday, March 17th.

On the Chairman taking his seat, the counsel for the leading opponents were absent from the room. Mr. Littler, Q.C. (who, with Mr. Worsley Taylor, Q.C., appeared for the Metropolitan Railway Company), was eventually sent for, and on the learned counsel entering the room,

Digitized by Google

The CHAIRMAN said the Committee intended to adhere to their ruling with regard to counsel cross-examining witnesses. That ruling is in accordance with a resolution passed in 1861 by the General Committee on Railway and Canal Bills, which remained the standing authority on the subject. The resolution ran as follows :—" Counsel shall not cross-examine a witness, unless he has been present during the entire examination-in-chief ; and counsel shall not re-examine unless he has been present during the entire cross-examination." The Committee would regulate their procedure by the spirit, and, if necessary, by the strict letter of that authoritative resolution.

After a formal protest against the ruling of the chair, the learned counsel then retired from the room.

Mr. BIDDER announced that Messrs. Rothschild had arranged clauses for the protection of their property in the City with the promoters.

Mr. DANCKWERTS made a similar announcement on behalf of the Gas Light and Coke Company.

Mr. J. WOLFE BARRY, C.E., was then examined on behalf of the Corporation of the City of London. He stated that a physical connection between the existing line and the proposed line at King William-street was perfectly practicable from an engineering point of view, and that he thought the line ought not to be sanctioned by Parliament without such a connection. No underground railway ought to be authorised in London which did not communicate with external lines. The tunnels of the proposed line ought to be 11ft. 6in.—size of the proposed tunnels on the Central London Railway. If the tunnels on both lines were the same size there might be a junction between the two lines at a future date.

Mr. RUSSELL GRIFFITHS having addressed the Committee on behalf of the Corporation of London,

Mr. PEMBROKE STEPHENS summed up the case for the promoters. He said the scheme put forward by the promoters was admittedly a good one, and therefore he asked the Committee not to reject it because it did not include a general connection of the various systems. The Committee had passed the preamble of the Central London Railway Bill, and he did not see why they should not sanction the scheme now before them. He asked the Committee to bear in mind the enormous boon the proposed line would confer on both the districts traversed and the City itself. With electric lines from the Angel to the City and from the Monument to Stockwell he ventured to think that sooner or later science and the logic of events would bring about the desired solution.

At the conclusion of the learned counsel's speech the room was cleared. On the public being readmitted, the Chairman said the promoters had failed to make out a case for the passing of the scheme, and therefore the Bill would be thrown out.

The Bill was accordingly rejected.

## Overhead Wires Bill.*

### HOUSE OF COMMONS SELECT COMMITTEE.

On Friday last a Select Committee of the House of Commons, presided over by Mr. S. Williamson, had before them the Overhead Wires Bill, promoted by the London County Council for the control and regulation of overhead wires in the administrative County of London. There were several petitions against the Bill.

Mr. Pope, Q.C., and Mr. Freeman appeared for the promoters of the Bill, while the opponents were represented as follows :—Mr. Pember, Q.C., Mr. Moulton, Q.C., and Mr. Erskine Pollock for the National Telephone Company ; and Mr. Littler, Q.C., and Mr. Russell Griffiths for the four Inns of Court.

Mr. POPE, in opening the case for the promoters, said the Bill was one of the results of the report of the Committee appointed by the House of Commons in 1885 to consider the law relating to the control of telephone, telegraph, and overhead wires. That Committee consisted of influential and experienced members of the House, including the late Chairman of the Metropolitan Board of Works. While the Committee came to the conclusion that the risk of danger to the public from overhead wires had been very greatly exaggerated, they also expressed the opinion that the probable development of the telephonic system made it desirable that there should be some change in the law relating to the control over such wires. After dealing with the present state of the law and making certain suggestions, the Committee concluded their report as follows :—" Bye-laws for the regulation of all wires as to substance, length of span, durability and other matters for their identification and inspection should be made for the whole of London by the Metropolitan Board of Works, for provincial towns by the corporations, and for rural districts by the local authorities, in each case subject to the sanction of the Board of Trade. * * * * For the protection of the public it is necessary that there should be a ready means of dealing with every wire. For this purpose every wire should be identified, and the bye-laws should provide for the best method of identification by registration or otherwise, and for the removal of all ownerless wires. The Committee believe that such regulations as they have recommended will be abundantly sufficient." To carry out the recommendations of that Committee so far as the administrative County of London was concerned, the London County Council had promoted this bill.

Mr. HENRY LAWRANCE CRIPPS, Parliamentary Agent, stated that he had assisted the County Council in preparing the Bill. Clause 3 provided that where the Council had a subway in any street it should be lawful for the Council at any time to require the Telephone Company by notice in writing to remove into the subway any then existing wire of the Company over the street which could be conveniently placed in it, and that if any question should arise between the Council and the Company as to whether the subway was in fact convenient for the reception of the wire, or whether, having regard to the purpose for which the wire was used, it could under the circumstances be conveniently placed in the subway, the matter should be settled by an arbitrator. It was a necessary clause, and he hoped it would commend itself to the Committee. To obtain uniformity it was necessary to give to the County Council a certain control over the bye-laws and other local authorities.

Mr. RICHARD MELVILL BEACHCROFT, Solicitor, and a member of the London County Council, was then examined.

In the present Bill do you accept the decision of Parliament that the local authorities should themselves carry out the bye-laws which you and the Board of Trade finally decide ?—That is so.

One of the objects of this Bill is to prevent as far as possible wires from being taken overhead ? We hope to see the day when there will be subways through which all the wires will go.

The further consideration of the Bill was adjourned till Tuesday.

TUESDAY, MARCH 17TH.

Mr. J. WOLFE BARRY, Civil Engineer, was called on behalf of the County Council. He stated that he had advised the London County Council with regard to this Bill. The circumstances of London were special and peculiar, and therefore London required careful legislation. He thought it was necessary that the definition of the word "wire" should include "any wire, conductor, or cable, and any support or attachment thereto, any part of which is placed, or shall hereafter be placed, over any street or any part of any street." With that addition it was made perfectly clear that the words "support and attachment" enabled the County Council to deal with the posts or any other fixture to which the wires were attached. He approved of the provisions of the Bill, which enabled the County Council to call upon the various companies to remove their overhead wires and place them into the subways, and to bear the cost of registration and inspection.

By Mr. E. POLLOCK : The Bill of last year contained a general power to construct subways throughout London, but that power was withdrawn before the Bill was considered in Committee. There was no power in this Bill to make subways.

Do you think it reasonable to ask for powers to compel telephone companies to place their wires in subways when you do not ask for power to construct the necessary subways ?—Yes. I assume that they can be conveniently placed into subways.

Don't you think it would be better to postpone asking for such power until the subways have been constructed ?—No. We are dealing with overhead wires, and we say wherever they can be conveniently placed into a subway, subject to a reference to an arbitrator, then the wires shall be placed there.

Until the County Council have constructed the subways I suppose the telephone companies must go on constructing lines overhead ?—Yes, if they want to go on with their business.

Then after they have done this you ask for power to call upon them to place their wires into subways ?—Yes.

And you think it is reasonable to ask for such power now ?—Yes.

Mr. WINTERBOTTOM, Solicitor to the National Telephone Company, stated that the application of the County Council for power to call upon his Company to place their wires into subways was premature. At present the Company used copper wires, similar to telegraph wires ; but if they were compelled to place their wires into subways, they would have to incur an enormous expense. The single wire which they now used would be of no use in a subway alongside an electric wire. It would be necessary to have two wires, and these would have to be covered with an insulating material ; in fact the whole system would have to be reconstructed.

With regard to the cost of registration and supervision. However small the fees are you will be serious affected ?—Certainly. We have at present 12,000 miles of wire representing about 12,000 wires, and the wires passed through four different districts.

At a registration fee of a shilling it would cost you £2,400 ?—Yes.

Mr. COLLINS : That is supposing they have to be registered in each district ?—Yes.

Mr. PEMBER : And they will have to be.

WITNESS, continuing, said if the County Council of London had the power to send inspectors into private houses, the business of his Company would be greatly hampered.

By Mr. POPE : He did not think the wires of his Company were in any sense dangerous.

Would you represent that no bye-laws are necessary for the protection of the public against the wires of the Company ?—Yes.

Therefore Parliament passed an unnecessary provision in the Public Health Act, 1890 ?—Not at all. Every company may not be as careful as we are.

Then your Company ought to have been exempted from the Act ?—No ; we do not wish to be exempted.

WITNESS, in further cross-examination, said the County Council were trying to take away the common law rights of the Telephone Company. That was one of the reasons he objected to the proposed licence of the County Council. Such a licence was quite unnecessary. This Company were using one of the County Council's subways between the City and Westminster. In his opinion the question of the removal of the wires into subways should be postponed until the subways had been constructed, or, at least, until the County Council had the power to construct them.

Colonel R. JACKSON, Vice-President of the National Telephone Company, stated that he knew the telephone system in London which was carried on under a licence granted by the Postmaster-General. At present they paid the Postmaster-General £37,240 a-year, which represented 10 per cent. of the net receipts.

You therefore pay for this licence a very heavy tax, which of course will increase as your business increases ?—Yes.

* A summary of this Bill appeared in our issue of January 30th, p. 392.

Digitized by Google

The entire system in London is conducted by overhead wires ?—Yes.

Has there been a single fatal accident caused by the Company's wires in the Metropolis ?—Not one.

Would the removal of the overhead wires into subways be expensive ?—You cannot remove our wires into subways, but you can take down the present overhead wires and substitute new wires for them. To do that would cost hundreds of thousands of pounds. Our present system is carried on with a single wire, and, therefore, if we are ordered to put our wires underground we shall have to alter our whole system and double our wires. If we were to put a single wire into a subway with an electric light wire our system would be stopped. In fact, if we are ordered to put our wires into subways, it will cause a revolution in our system, and entail a great expense. As the County Council have not the necessary subways, we must even now go on placing our wires overhead, and we might have to do so for years to come. It would be very hard if, after this great expense, we were called upon to go to the additional expense of placing our lines into subways.

Mr. POPE said under the Bill it would be for the arbitrator to decide whether the wires could be conveniently placed into subways. If the Bill was not clear on that point the County Council would be glad to insert words to remedy the defects.

Mr. PEMBER hoped his learned friend would go further and say that the arbitrator should also decide the question as to whether the Telephone Company or the County Council should bear the expense of removing the wires. The learned counsel then proceeded to sum up the case for the National Telephone Company.

Mr. LITTLER having addressed the Committee on behalf of the Inns of Court,

Mr. POPE summed up the case for the promoters. He argued that the provisions of the Bill were very reasonable, and that none of the contentions which had been urged against them afforded any justification for the Committee altering the measure.

The room was then cleared, and on the public being re-admitted the Chairman said the Committee would postpone their decision till the following day.

WEDNESDAY, MARCH 18TH.

The Committee having deliberated for over an hour and a-half, the public were re-admitted, and

The CHAIRMAN said: The Committee have come to the conclusion that the preamble of the Bill is proved. They are also of opinion that the marginal distance of 50ft. shall stand, that the Inns of Court shall have no exemption under the Bill, that all reference to subways shall be struck out of the Bill; that Clause 8, relating to charges for supervision of wires, shall be omitted, and that sub-section 2 of Clause 13, with regard to compulsory powers of entry by inspectors, shall be omitted.

The Committee then went through the clauses, and struck out those involved in their decision.

## AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *March* 6, 1891.

**Physiological Effects of Alternating Currents.**—Some very interesting experiments have recently been tried on the physiological effects of alternating currents of very high frequency. They were performed in the laboratory of Dr. Edward Tatum, whose contributions to this department of knowledge I have noticed more than once. Prof. Elihu Thomson placed at his disposal one of the most remarkable alternators that has been recently built. The machine had 100 armature coils, and gave a little over 8,000 alternations per second. Dr. Tatum's experiments were performed on dogs, as in his previous work, and the results were very remarkable. It was found that with a frequency of 4,500 per second the animals were more tolerant of current than at lower frequencies. For fatal results a current ten to twelve times greater was required with the high frequencies mentioned than was necessary with 120 alternations, about the usual rate in this country. Even at 300 alternations per second the amount of current required to kill was largely in excess of that at 120. In fact, Dr. Tatum's results indicated that the fatality is somewhere nearly inversely proportional to the frequency. Some experiments were made with a view of determining whether the current distribution with the high frequencies was different from that ordinarily found, but the results were negative. All this goes to show that raising the frequency in alternating systems might have a tendency to render them decidedly more safe than at present, a fact that *a priori* would be decidedly surprising.

**Electrical Development in the United States.**—Recent figures give the total number of electric light central stations in the United States as 1,718, a number considerably in excess of former estimates, and also noticeably greater than the number of public gasworks. The growth, especially through the West, in the past year has been something astonishing, and has taken place very largely in the smaller towns. The number of electric railways is, if possible, more difficult to estimate than the number of lighting centres; probably at present it is not far from 275, and rapidly on the increase. Speaking of electric railroads, it is very noticeable that the Broadway and Third Avenue-street Railway Companies in this city do not seem to be in a hurry about putting in the cable system, although the privilege of so doing was obtained some time since. It is understood that on investigation the cost of moving the complicated substructure of pipes that underlies Broadway was found to be so enormous that the stockholders revolted. Laid, as they are, without any reference to the possibility of rapid transit at any future time, the double cable conduits that would be required would necessitate a complete remodelling of the entire water, gas, steam, sewer and electric service. There would be an admirable chance for electricity on these surface lines were it not for the vicious opposition to overhead wires that has made itself felt so strongly. Mayor Grant has, however, apparently undergone a change of heart since he investigated the trolley system in Boston. It is already proposed to use the overhead system in the so-called annexed district on the upper part of Manhattan Island, and, indeed, the permits for the work have been granted. It would not be very surprising if efforts should be made to have this privilege extended. Street railway men do not seem to have much faith in the storage battery, nor in any of the electric conduit systems, and they are determined to have something better than horses.

## CORRESPONDENCE.

### THE BARKING-ROAD CARS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your last issue, Mr. King takes exception to the figures in my letter relating to the life of E.P.S. secondary batteries on tramcars, published in your number of the 6th inst. He says that the life of the positive plates is about 400 discharges more or less, according to the degree of care in handling, giving at the same time the life of the negative plates as about 750 discharges.

Well, let us see how these imaginary life figures compare with the actual results obtained up to the present time with the service of cars on the Barking-road—that is, how they compare with the real life figures to which he takes exception. The service of electric tramcars commenced (under Board of Trade rules and police regulations) on June 14, 1889, the first complete renewals were ordered of the Electric Construction Corporation, by letter from the writer, dated January 16, 1890, and delivery of same was completed at Barking-road on March 14th following. They were at once put into service in lieu of the original batteries now worn out by 10 months' work. These second batteries continued in use until December last, they, in their turn, then being worn out with 10 month's work. This time, instead of putting in complete renewals, an effort was made to economise by replacing the positive plates only; perhaps, at the suggestion of the authority, who on inspection had found that the first batch of discarded negative plates would certainly have run for another year. The result of these partial renewals has been that last month the negatives which it was attempted to retain have had to be thrown out, and new plates put in; these third batteries are now in use. Moreover, in order to keep the cars on the road during the time the old negatives were retained, a supplementary charge every afternoon from the dynamo was necessary, which meant extra fuel burnt, overtime made, &c., and three battery charges used in lieu of two per car and per day. The life of the batteries is, then, as shown in my letter (see *Electrician*, 6th inst.) ten months, or 300 discharges, as well for the negatives as the positives, and this with good fair handling. With the actual handling and working of accumu-

Digitized by Google

lators, the writer has perhaps had more experience than your correspondent, and has been engaged on accumulator work in Paris before their introduction into England.

No experiments, crucial or otherwise, have been made with the K type plates on accumulator cars in service.

The maintenance of traction batteries up to date is, then, 2¾d. per car mile; the one penny, like the two-thirds of a penny, being purely imaginary and prospective.—Yours, &c.,

T. Frazer.

114, Broadway, Plaistow, E., March 18, 1891.

## TRADE NOTES AND NOTICES.

"THE ELECTRICIAN"

**ELECTRICAL TRADES' DIRECTORY & HANDBOOK for 1891**

The new edition of our well-known Directory and Handbook is now ready, price 5s., postage extra. The book consists of over 900 pages, and has entailed this year a heavy amount of work. The Handbook Division contains a mass of most useful information. The Directory Division consists of 430 pages, and contains a very carefully compiled Alphabetical and Classified List of Firms and Persons engaged in the Electrical and Allied Trades in all parts of the world. This Division has been corrected up to date, and the book is thoroughly reliable, the very numerous changes which take place at the beginning of the year being incorporated. By the aid of this Directory, makers of Electrical Machinery, Apparatus, Instruments, Fittings, Sundries, Novelties, and other goods, may safely communicate direct with probable customers without the annoyance and great expense consequent upon using books which are mere lists of Members of Scientific Societies repeated again and again. A large number of copies have been already subscribed for from the Colonies, the Continent, the United States, and other Foreign Countries, whilst at Home orders have been received from Local Authorities, Railway, Tramway, Mining, and other large Industrial Corporations, as well as from those for whom the Directory and Handbook is primarily compiled. The Colonial and Foreign Division will be found extensive and reliable. *Orders should be forwarded at once.*

Tenders Wanted.—Tenders are wanted for putting up and maintaining the electric light installation at Falcon Cliff, Douglas, Isle of Man, from May to September, 1891. Particulars may be obtained of Mr. F. Rowe, Secretary, Falcon Cliff Company, Villiers-chambers, Douglas.

Mr. Napier Prentice.—We are informed by Mr. Napier Prentice that he has amalgamated his business with that of the well-known firm of Easton and Anderson (Limited), of Erith and London, and that his factory and staff have been removed to the firm's works at Erith, where, in future, the manufacture of his dynamos, &c., will be carried on under his supervision. It is intended to keep a large stock of standard machines in hand for prompt delivery.

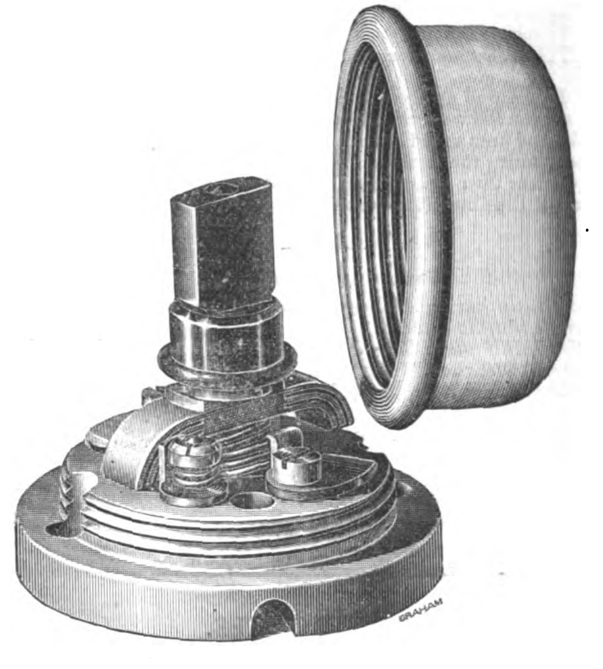
Dissolution of Partnership.—The partnership between Messrs. Fiford and Collier, trading as electricians at Bournemouth and Southampton, has been dissolved.

Messrs. McGaw and Co.—We are in receipt of an elaborately-illustrated price list of Messrs. McGaw's well-known specimens of electric light casings, mouldings, &c. The list includes mouldings, casings, pillars, and all kinds of similar accessories, and the method of printing adopted is very effective.

Messrs. F. and C. Osler.—The makers of metal and glass ware who have been tempted to turn their attention to electric light fittings, have in several cases produced more artistic work than those whose speciality lay in gas fittings, and who were quickly forced to take up electric work. The old-established firm of F. and C. Osler, who have long held a leading position as makers of cut glass, have some very artistic work at their show rooms at 100, Oxford-street. Their glass is almost exclusively brilliant cut flint, and for hall lanterns some very large pieces are employed, hanging below the ornamental metal work and not enclosed by it. The metal work of some table fittings in the French antique style is noteworthy for its excellent finish and design. For electrolier work fine brass chains are used with very graceful effect. Messrs. Osler provide a darkened room specially arranged for showing their fittings with the lamps burning.

Yacht Lighting.—The electric lighting of H.S.H. the Prince of Monaco's yacht, "Princess Alice," has been placed in the hands of Woodhouse and Rawson, United. The engine is of the single cylinder vertical type, running at from 200 to 250 revolutions per minute with a steam pressure of 150 lbs. The dynamo is coupled direct to the engine, and gives, when running at 250 revolutions per minute, current for 100 16 candle-power lamps at 135 volts, this particular E.M.F. being provided to allow of charging the accumulators. There will probably be a set of accumulators, a projector, and a submarine arc lamp for carrying on scientific observations at night.

The New Diamond Switch.—An improved switch known as the "New Diamond," has recently been introduced by Messrs. Poole and White, of 58-9, Bread-street, E.C. Although this new switch is made under the patents granted to Messrs. Poole and White for the well-known "Diamond," it is also the subject of further patents for improvements taken out by this firm. The illustration shows the switch as it is at present made in its circular form. It is made in three sizes for currents up to three, seven, and fifteen amperes respectively. The base is of porcelain, and is fitted with a screwed cover of the same material. The contact bridge has brass separating pieces between the contact pieces, thus giving greater freedom of motion to each individual spring. Instantaneous break action is assured by stout steel wire springs. The suddenness of the break is independent of the motion of the hand. These switches are constructed in a rectangular form to carry currents of from fifteen amperes to 1,000 or more if necessary.



In the larger sizes the bases are of enamelled slate and the thumb taps are replaced by lever handles. The porcelain bases and covers of the circular forms are made either in plain black or white, or decorated in design suitable for any style of mural decoration.

The Demon Water Motor.—This motor appears to be of the well-known Thirlmere type. It is made by Mr. P. Pitman, of Aubrey-road, Whittington, Manchester, in four sizes, from "a quarter man," at 1,800 revolutions per minute, to "two man" at 800 revolutions. The maker supplies castings and forgings for those who desire to make them up.

## PATENT RECORD.

### APPLICATIONS FOR PATENTS.

February 27, 1891.

3,609. E. Hartmann and W. Braun. London. Improvements in electricity meters.

February 28, 1891.

3,628. G. R. Postlethwaite. Aston. Improvements in dynamometers or force measurers.

3,629. C. D. Barker. London. Improvement of insulators.

3,643. F. J. Rowan and W. McWhirter. Glasgow. Improvements in means for holding portable electric lamps.

3,650. L. Pope. London. Improvements in electric clocks.

3,644. G. Binswanger. London. Improvements in electrical switches.

3,673. A. C. Seibold. London. Improvements in electric arc lamps.

3,675. E. Edwards. London. Improvements in apparatus for the transmission of telegraphic messages by means of direct or alternate electrical currents.

3,680. H. H. Lake. London. Improvements in electric lighting apparatus for gas burners (The Aktiebolaget Göranssons Mekaniska Verkstad Company (Limited), Sweden).

Digitized by Google

## SPECIFICATIONS PUBLISHED.

1890.

475. SACK and ZIESEL. Telegraphic, &c., communication. (Price 8d.)
2,108. WHITMORE and AKESTER. Switches for electromotors. (Price 8d.)
2,504. WYNNE. Propelling vehicles by electricity, &c. (Price 8d.)
3,276. WHALLEY. Telephonic apparatus. (Price 8d.)
4,004. BARNETT. Electric discharge paths. (Price 4d.)
4,992. GAY and HAMMOND. Recording electric measurements. (Price 11d.)
5,836. RADCLIFFE. Dynamo-electric machines, &c. (Price 8d.)
13,044. BARDONNAUT and JUPPONT. Electric lighting. (Price 11d.)
18,589. WADDELL. Electric railway signals. (Price 8d.)

1891.

83. THOMPSON (Striemer). Electric guest calls. (Price 8d.)
616. ALLISON (Ward). Carbon stick for arc lights. (Price 6d.)
624. AMERICAN ELEVATOR COMPANY (Otis Bros. and Co.) Electrical elevator apparatus. (Price 8d.)
647. LAKE (Weston). Electric measuring instruments. (Price 8d.)
649. LAKE (Eickemeyer). Electric elevators. (Price 11d.)

# COMPANIES' MEETINGS & REPORTS.

## The London Electric Supply Corporation.

The fourth ordinary general meeting of the shareholders was held on the 13th of March, at the City Terminus Hotel, Cannon-street, under the presidency of James Staats Forbes, Esq.

The MANAGER and SECRETARY (Mr. Charles B. Waller) having read the advertisement convening the meeting, the report of the Directors was taken as read.

The CHAIRMAN then said: I should like you, if you please, to follow me through the accounts, in order that the figures may reveal themselves up to date. These accounts, as you know, are rendered in accordance with the form prescribed by the Board of Trade. They are very full and comprehensive, and they do, as they are intended to do, carry forward from year to year the state of the capital and the expenditure under a great many sub-divisions. I had occasion at the last meeting (I daresay much that I said on that occasion is forgotten) to dwell at some length on the position of the Company at that moment; and I suppose that the proprietors have had sufficient interest in the business to have read what took place on that occasion. What I have to say to-day is rather in continuation of that text. Now, with reference to the accounts, No. 1 statement shows the capital, and there you see that the whole of the ordinary share capital that has been issued has been paid up —£555,000. The preference capital last year stood at £100,000, and during the year a further portion of it has been paid up. You may remember that we were in some difficulty as to how to deal with the preference shares, because, under the arrangement of the prospectus, the calls were to be made by a particular time. I explained at the meeting, a year ago, that we were not in pressing need of money, and that we thought that the circumstances of the time were such as not to make it very desirable to call up people's money when interest was at a very high rate. They themselves would be the losers of the difference between what we paid and the interest they could get on deposit for their money; but in order that there might be no ground of complaint we offered the preference shareholders the option of paying in advance, and that option has been exercised to the extent of £53,043. We have therefore now £153,043 of preference share capital paid up, and £96,957 of this capital remains to be paid up and will meet obligations incurred, or that may come on in the future. That is the end of our available assets at the present moment. Of course if that fund be exhausted you have 89,000 unissued ordinary shares to fall back on. No. 2 account does not require any observation, because we have not raised any money on loan. We are all shareholders. In the next account you come to the expenditure, and this account is pretty clear as to what has become of the money. At the end of the first column you find that at the close of 1889 we had expended £504,954, and you will see by running down the column, by analysing it, how that money went. You will see that there are 14 different items on which that amount was expended, and during the past year you will see that that outlay has been very largely increased—by no less than £143,501. If you cast your eye on the column showing the total expenditure, you will see that we had a balance to the credit of the capital account at the end of last year of £59,566. We are therefore getting extremely near the end of our tether as regards capital powers. Of course you want to know what this money has been spent upon, but you can find that out by looking at the different headings—buildings, freehold land, general construction at Deptford; plant and machinery; mains; and the purchase of the business. That, of course, is the foundation price, so to speak, of the undertaking, and this item—including the small payment shown during the past year on account of some old legal expenses—stands at £250,397. Then beyond the items I have mentioned you will notice that there are several others—transformers, meters, electrical instruments, &c. This indicates, of course, that during last year there must have been a very considerable advance in the provision of the machinery for lighting, and that is the case, as I shall be able to show you presently. We have spent, in fact, in preparation—in the progress, I hope, towards the completion of what may be called the first stage of our existence—£143,501 during the past year. The revenue account is also very explicit; and on the one side you have the costs, on the other the proceeds. I am sorry to say that the proceeds just about balance the costs. On the first blush of it, that does not appear a very satisfactory state of things. The Board, however, had prevision enough last year, when we met, to point out that we must consider ourselves by no means "out of the wood." We had, for good or evil, launched ourselves on a new path; we had no beaten way to follow. Mr. Ferranti's system, as everyone knows, is different to the accepted system under which some other companies—most other companies—are at present working, and therefore it was in the nature of an experiment—a very costly experiment, if it should fail, a very lucrative one, probably, if it should succeed. This time last year, though we were lighting up, we were not lighting up with our permanent system, but, with temporary machinery, a system which had been originated and had grown from small beginnings at the Grosvenor; and we had before us the necessity of turning out of the Grosvenor during the year, and transferring the whole of our business, at the same time that we were going on constructing. I need hardly say that that is a very difficult thing to do. That turned out to be, perhaps, somewhat in the nature of a curse, because it was owing to that state of things that the fire occurred at the Grosvenor which put a sudden stop to our business. I said "a curse," but, like a good many of these things, it will probably turn out to be a blessing, because though we have lost a good many customers, and though, no doubt, during the time of that *interregnum* we shall have lost a great deal of money in the nature of revenue, it enabled us, by the total cessation of business for a considerable time, to complete the thing much more rapidly than we could have done had the business been running. You see what these expenditures are. It is a dangerous thing to prophesy, because, if it happens to turn out well, then it is well, as a matter of course; but if it should turn out not to be well, then blame is lavished pretty freely. Therefore "old birds" like myself are very cautious what we prophesy. At the same time you ought to know that we consider the costs represented by this account not to be at all normal in their character; and we have not had, up to this time, the advantages which we anticipate—which we are pretty positive we shall have—when the permanent thing goes by itself—that is to say, Deptford. During the greater part of the time we had the Grosvenor Station we had to keep up a large expenditure at Deptford, because this complicated and novel machine had to be learnt—in fact, all this business had to be learnt. We have had to find out as we have gone along, and our misfortunes have resulted from the very natural reason that you cannot find out everything at once. Still, we have found out one or two things. The main object of these particular observations which I am now making is to impress upon you that this large expenditure, which is about equal to the revenue, is not normal expenditure, but is quite abnormal. During a portion of the year we transmitted part of the supply from Deptford to the Grosvenor Station. The Grosvenor supplied a portion of the current, and Deptford the other. That was in order to test the possibility of doing what a good many people thought could not be done—that is to say, that this idea of transmitting electricity from so great a distance must fail; but it has not failed. We had to make a beginning, and we did so; and we found that the anticipations of Mr. Ferranti were entirely confirmed by the result. Then we have had a great number of mains laid on Mr. Ferranti's principle—concentric mains, the great trunk conduits which run from Deptford to London—to be distributed through the minor conduits, or smaller mains, to the consumers. They had to be tested, and testing them is an expensive business. Then, again, we had to clear out of the Grosvenor Station—to take out the engines, dynamos, the whole of the machinery, and to remove a great deal of it to Deptford. All that caused continual expense and continual interruptions to the business; and, in fact, I for one am surprised that the accounts have come out as well as they have, because, in addition to the difficulties and large expenditure incurred in working under the conditions of the moment, came the fire, when everything went out. The converters were all destroyed, and without the converters we cannot light. Well, we took advantage of the opportunity. We were a little staggered for the moment by the fire, but we made up our minds that that was the time to postpone for a sufficient length of time any attempt to light, trusting to the forbearance of our customers and their sympathy; and I must say, in passing, that we have received it without stint. We have now lighted up again. Lighting up, though, on the present modest scale has tested one or two important things. Our district of London, for the last two or three weeks, had been lighted from Deptford exclusively, because there are now no means of producing the light at the Grosvenor, and the mains have acted; and I am given to understand that recently, at all events, there have been no complaints about the light. For a day or two, when we first started, there were, of course, occasional hitches, but latterly it has been going without complaint. When the fire broke out we were lighting, probably, 36,000 lights—something like that—and now we have got back to 10,000; and we shall not be wanting in customers as our capacity to increase the supply grows from week to week and day to day. In the face of these difficulties you see what we took. We managed to get by the sale of the current per meter £16,283, and by the sale of current under contracts £9,701. If you have the accounts before you of last year you will see that they are very nearly identical in the totals, but quite different in division. Last year the great bulk of the lighting was done by contract, and very little of it by meter, and now much the largest part is done by meter and much the less by contract. That means that in the interval we have also found a reliable meter, and we, at all events—and I suppose most of our customers—prefer the supply to be paid for upon a reliable standard than upon the uncertain footing of contracts. I have no doubt that the contracts, particularly those of preceding years, were very bad for us. There was no experience in this business upon which to found lighting by contract. Rental, sales and repairs of apparatus, and transfer fees are the items which

Digitized by Google

follow; and the result of all that is that the income has just about covered the expenditure, and I confess that I am very much surprised that it was so, under all the circumstances. The fire occurred on November 15th, and from that date to the end of December we had no customers—no income and large expenditure. I hope that that explanation, and perhaps some further remarks which I may have to make when I get to Mr. Ferranti's report, will induce you to consider that, after all, the report is not so bad as it might have been—like so many other things in this world. The time is approaching when the capital part of the business is reaching completion. You cannot initiate a business of this kind and enter upon a large building operation like that at Deptford, putting thousands of pounds in lots of machinery, without an enormous amount of difficulty and trouble, and while that class of work is in progress it is both usual and reasonable that the bulk of the charges should fall upon the construction. The moment construction is finished, however, you are upon the footing of an ordinary commercial undertaking. The expenditure must then come upon the revenue, and what we have done this year, seeing that we were approaching so nearly the completion of the first stage in our business (the construction) is this—we have increased considerably the appropriation of revenue to the general charges. That item itself should account for about £1,500 – that is, the increased amount that we have charged revenue with as compared with the previous year. The amount carried to the management expenses in the preceding year was £2,500, while this year the amount, in round figures, is £3,900. I suppose when the thing runs purely and entirely as a going concern that the whole of these charges will come against revenue. We have made rather a larger reserve for bad and doubtful debts and other items. We had a good many accounts outstanding when the fire occurred, and people were very sore about it, but by explanation and persuasion and a little pleading they took a very reasonable view, and it is very gratifying to know that the great bulk of our accounts have been paid up in full. There were cases where we found it expedient to make some slight concessions, cases of peculiar hardship, and we thought it better, as all these points were not settled, to reserve more than in the previous year. Then we thought that as the fire was a calamity, we had better get rid of it by putting it against revenue. The mere loss by the fire was small—£1,183. The real loss we sustained was by the loss of our business; but that, we believe, we shall pick up by the opportunity which the fire gave us to proceed with our business more efficiently than we could have done if we had had to light and to construct at the same moment. The whole thing is in a nutshell when you come to the next account, where you see we carry forward a balance of £813, against last year £920. That is the result of all the patience, the responsibility, the blame, &c., of the past year. If it were at all a state of things which one had to accept as being the state of things under which one would have to live, it would be sufficiently discouraging, but I do not think it is. I think that there is every indication that during the present year things will assume a totally different aspect. The reserve fund account is a mere formal account. Then we come to the balance-sheet. I do not propose to go further into these accounts, except in the nature of answers to questions. I observe that there are some critics present, and I may be asked some questions, and to the best of my ability I will answer them. I am now going to reverse the order of things. Generally, we begin with the Directors' report, but the fact is that the Directors in this concern play a comparatively secondary *rôle*. At the present moment the important factor is the engineer, and we had to bring him to earth last year. We made him report last year to the shareholders. We adopted his report, of course, because we were satisfied as to its general accuracy. We thought this year that he had better report again, and we in the same way adopted his report again, believing in its general accuracy. I dare say every proprietor has taken the trouble to read Mr. Ferranti's report, and it is the whole story. I could tell it to you again in different words, but there it is; and, epitomising it, it comes to this—that during the past year the large expenditure which has been incurred seems to have been justified by the result. These concentric mains, which were an idea a year ago, are now a fact. A good many clever people thought they would not work, but they do work. A good many clever people thought they could not possibly work without great detriment to the Postmaster-General and the Telephone Company; but they do work without detriment to either. This system will be not only the most economic system when it is in full operation, but beyond question the safest system; and here I must say a word or two about the Board of Trade. They have already consented, as far as we are concerned, to suspend one of the stringent conditions of the original Order under which the different electric lighting companies were created. These companies were, under no circumstances whatever, to earth the current. The theory was that if we earthed the current the Postmaster-General, the Telephone Company, and the railway companies could not carry on their business; and there did appear, for a time, to be some fear that was so. However, the moment these concentric mains under the earth were made the channel of conveying the current, that difficulty vanished. Then we thought earthing can be done, and if earthing can be done it will make this the safest system; and after a great deal of difficulty, and only by bringing in the aid of some of the greatest scientific authorities—Mr. Ferranti, Sir William Thomson, and Dr. Fleming—we at length persuaded the Board of Trade to grant us this immense concession. We satisfied ourselves that earthing would not interfere with the Postmaster-General, and, with the entire concurrence of the Post-Office, that authority has been given, and we are now at earth. Being allowed to earth, all danger of fire is absolutely averted. I say "absolutely," but of course all things are relative. Still, those dangers which the timid apprehended have been enormously modified, at all events, if one may not say absolutely averted. I suppose under this system the electric lighting of houses will be infinitely safer than lighting by gas, and vastly safer than by either oil or candles. There is another remarkable thing which has to be mentioned. This 10,000 volts, which is to be the normal pressure of our work, was thought to be one of the impossibilities. There were two opinions about it. Some people thought it would not do at all, and others thought it could only be done at such enormous waste in transmission as to nullify altogether the economy in production. We have tested this, and that prognostication has been contradicted. The loss of current from the dynamo into the transformer at the transforming station is practically *nil*. Between the transformer, in our case, as in the case of all the other companies, there is an essential quantity of current wasted in getting into the houses of the customers; but as between Deptford and the transformer, which in our case answers to the dynamo of the low-tension people, there is no loss. It is at any rate quite insignificant. The idea of 10,000 volts made people's hair stand on end. Mr. Edison's hair stood on end when I told him about it, and he is not a man who is very lightly to be alarmed. He expressed some doubt first as to whether it could be done, and secondly, whether, if it were done, the waste would not be very great. Well, we have taught Mr. Edison that, anyhow. He has taught us a great deal, and it is a satisfaction to be able to help him. Now he will be able to turn Niagara to account, for if they are going to do that, they must have high tension. Low tension cannot do that business. In order to give you some idea of the capacity and the efficiency of these mains I may mention that they have really been tested up to 17,000 volts. I have now exhausted pretty nearly the first paragraph in Mr. Ferranti's report, which says, in other language, what I have just been telling you. There is, however, one little point in this paragraph which is pregnant with meaning, and which we all ought to study when, in the momentary annoyance caused by the light going out, we proceed to ejaculate about the evil deeds of the Company. Mr. Ferranti says: "The work of laying was of necessity performed by unskilled labourers, who had neither experience nor training in such work." Well, that is the whole story. It is not only the labourers who are unskilled in this matter; we are all unskilled. The skill has to be created, and people who take the trouble to consider this for a moment may find some sympathy in their minds or in their hearts for those who have to make everything, as we have to do, and find out things by stages. Paragraph 2 speaks of the Board of Trade allowing the earthing arrangement, which I have explained. In the next paragraph you are told that during the past year the whole of the machinery from the Grosvenor station has been removed to Deptford; and at the present moment it is the means by which we are lighting up. We have got a pair of dynamos working away up to a capacity of 30,000 lights. The dynamos of greater capacity are being finished. They are being readjusted, and when they are ready they will send up current to the extent of 60,000 volts. We have now before us, nearly completed, and paid for, a capacity of 90,000 lights. We should not think of using the full capacity, however, and, in fact, if the Board of Trade had not made any regulations on this subject we should have made them for ourselves. We should never work up to the full capacity, but should always have a reasonable reserve. No railway company I ever knew of ever turns out all its locomotives, and we shall not turn out all ours. All that is explained in the third paragraph of Mr. Ferranti's report. This brings me to the little bit of information interlined between the 3rd and 5th paragraphs: "With these two large machines supplying your circuits, the first important stage of your undertaking will be completed." That is to say, that up to 90,000 lights we have practically done all the work. There are some details yet to be completed, and Mr. Ferranti is always finding out something. He has found out that he can produce electricity on a great scale at Deptford with perfect ease and safety, and that he can transmit it to the transforming station in London with perfect ease and great economy, but I do not think he has found out quite enough about the little bit that is between the transforming station and the customer's house. I am quite sure that the mind, and the genius, I would almost say, which has overcome the difficulties which he has surmounted in the last two years can overcome the lesser difficulties in that matter. They are not very great. It is a question of adaptation of the transformer. There have been one or two fires in London, not exclusively connected with the lighting up of this Company, but we are all critics in a new business, and the experience of one new company is very much the experience of the others, and this experience has been used in reference to the installations, &c., of the consumers. It may as well go out from me to the world that the consumers themselves will be chiefly to blame if fire forms an element of serious consideration in electric lighting, because, with an installation conducted with care, and in accordance with plans which are now thoroughly well understood, and adopted by the insurance companies, fire is next to an impossibility; but of course, if the work is done in a scampy, slovenly, un-scientific manner, there will be fires. One hears of gas pipes being put in in a manner not altogether workmanlike. Then the gas escapes, and there is a blow up. One also knows that plumbers are not always trustworthy, and then something goes wrong with the water pipes. Every installer should take care that the work is put into proper hands, and properly supervised. However, that is the affair of the installer and not of the company. Now we come to the second stage. You see that our money is running out, and it is with companies just as it is with men. If you start young with a full purse you are never easy until you get to the bottom of it. You only begin to be prudent when the last gold pieces come out. That is our condition. We are now going to be mighty prudent, that is to say, before entering on the next stage of our operations, the stage which will complete and develop 200,000 more lights, we shall want some more money. I do not think we shall get it myself, or I do not think I shall have any hand in trying to get it, until we have established the first stage as a profitable commercial undertaking; because if you were to attempt to raise more money until that is tested, you could only raise it on disastrous terms. I think that when we have well secured 60,000 lights, which means something more, perhaps, than £60,000, we shall have no difficulty in going into the more heroic thing, and I hope that it will not be long before that experience is attained. I am much too old to be caught prophesying, but there are others who are

Digitized by Google

willing to do so. There is our secretary—he is very sanguine—he would say that he has no doubt we shall have 60,000 lights by next year. Well, if so, I think we may induct from what we know that our credit and our position will be so much improved that we shall have no difficulty in getting the money for our further progress. I want the shareholders to take what I am now about to say on the strength of Mr. Ferranti. I do not know any man who, during the last year, has had a more terrible responsibility upon his back than Mr. Ferranti. He pledged his reputation, his fortune, his labour —day and night—to achieve the result he promised to the Directors. He has achieved it greatly, and has done so much in redeeming what a year ago seemed a most difficult position and a most uncertain one, that he is justified in his present opinion, which is expressed in this paragraph :—" I desire to call attention to the fact that from the commencement of your operations to the present time, no engineering or electrical difficulties whatever have arisen which I have not been able to overcome, and at the present moment I know of no weak point in your system, and consider success to be now assured." Well, that is his frank opinion. He is a man with convictions of his own, and he has a very strong will, but he would not have said this if he were not absolutely convinced of its truth, nor should we have allowed it to appear in his report unless we had felt that we could believe it ourselves. In his next paragraph Mr. Ferranti deals with the fire, and states that that enabled us to do what I have already described to you. You know the bogey of fear about overhead wires, and, by the way, a Parliamentary Committee is sitting on that matter at the present moment. There is nothing in it, but everything is going to be closed by overhead wires. Therefore, when the companies in London got their constitutions, or Orders, they were put under the obligation to remove the wires within two years. Our time is up in August. The whole of our electricity was conducted, until very recently, from the Grosvenor Station over those wires. This fire that we had cut off all connection between those wires and the Grosvenor Station ; and as we had to get out by August, we have availed ourselves of the interregnum to put down our mains as rapidly as possible to supply the customers, and that process is going on from day to day. It is a long process, but we shall get it all done before August. The difficulty in connection with the switching has been greatly modified, and Mr. Ferranti has in that matter as in others made great improvements. We have secured sites for three additional distributing stations. I daresay anyone who lives in the neighbourhood of a steam engine will know the difference between a distributing station and a generating station. I am told that the latter are absolutely silent. Well, I am rather a night bird. Having a good deal of work to do in the day, I occasionally take a walk at night, and in the course of my perambulations I have found myself in the neighbourhood of some generating stations which have certainly not been altogether silent. In fact, if you take a walk up by that fine building known as Whitehall Court, where there is one of these stations, you will find considerable vibration; and I think anyone who lives in those chambers must have found that out. There are other evils attending these stations, and the speculative lawyer makes use of them. I was connected with a company before you were in existence, and we have now descended into the modest business of lamp making ; but we were an electric light company—the Edison and Swan—and we had several installations about London. We got out of them, however, as rapidly as possible, but with great loss, because the speculative lawyer got up damages for vibration, and so on, and we had to compound them. I hope that our rivals—no, I will not say our rivals, there is so much of this business that there is no room for rivalry—I hope that those who are working these stations will not find that they have to suffer from these disadvantages. We found them at the Grosvenor Station. Someone's shirt-fronts got dusty, and so did Savory and Moore's medicines, and we were required to make compensation. However, nothing of that kind can take place at a transforming station. The movement there is very silent. The electricity has to move in at one wire and get into another. That is done silently, and no one knows anything about it. We have got three of those stations, and some of them will be in operation almost immediately. One of them is called the Trafalgar, from its neighbourhood to the great monument, or, rather, the monument of the great hero, for I cannot think the monument itself great. There will be two separate sources of supply then. The current sent from Deptford to the Grosvenor, and sent at the same time from Deptford to the Trafalgar Station, will be at the service of both areas. If anything goes wrong at one, the other will have an ample source of supply. I think I have now said very nearly all that I need say, but I should like to finish up by this quotation from Mr. Ferranti. It is the last paragraph in his report, and he says :—" The great advantage of the high-pressure system is apparent in that the loss involved in transmission of current from Deptford to the distributing stations is inappreciable, while the facilities for procuring coal and water there, sufficiency of room for machinery and appliances, and freedom from the legal and financial consequences attending the erection of generating stations in crowded neighbourhoods, cannot fail to tell their own tale in the working expenses of the current year." That just shows what a young man he must be. He has said there something very encouraging to you ; but he has put himself at the same time under a serious obligation, which is to get down the expenses in current year. I should not have done that in my report, but I am glad he has done it, because he is now bound. I hope you have read Mr. Ferranti's report carefully. It deserves to be thoroughly read and studied. I have nothing further to say, because the peculiarity of our two last reports is that they have been mere echoes of Mr. Ferranti's. Having had him, as it were, to speak at first hand, you would probably not care to have it diluted by anything we could say. It really means all that I have told you. I think we have, well, " weathered the storm " is the familiar expression—that we have overcome great difficulties and see daylight. That is the opinion of all my colleagues, and certainly all the engineers. We have not only Mr. Ferranti, in whom we have deservedly great confidence, but we have also Dr. Fleming, an electrician of the greatest eminence. He has watched this thing very narrowly, and we believe now that we have really entered on the stage which will lead to prosperity. At all events we hope so. As to our customers, I will take this opportunity of expressing to them the deep thanks of the Board for the enormous amount of forbearance and consideration which they have shown us under circumstances which, of course, entailed upon them considerable annoyance and, probably, loss; but, on approaching and explaining the reasons, they have almost uniformly and unanimously met us by the greatest forbearance and consideration, and have paid their bills. With regard to the Board of Trade I must also say a few words. There seems now to be a desire to put us under a system—a grandmotherly system—which did not make England the place it is, and which has emasculated a great many places. We are going to be nursed by the State. There is a great disposition for the State to do everything, but how they are going to do it I don't know. With reference to the Board of Trade, a more efficient, honourable, disinterested, and courteous body does not exist in any country ; and if my experience had not satisfied me as to the abomination of State interference in commercial matters—of which I have seen a great deal abroad—I should be a little shaken by the manner in which we have been met by the Board of Trade ; because, so far from showing the least disposition to exact the letter of the law about the regulations, or to exercise any arbitrary authority, or to act like those busy-bodies who, " in another place," make themselves so cheaply popular in the interests of the working man or of someone else, they have always shown the greatest consideration and forbearance to us, and have assisted us in every possible way to overcome our difficulties. They are advised by an electrician—Major Cardew—to whom, I feel sure, the Board feel greatly indebted for the almost brotherly interest which he has taken in Mr. Ferranti. So far from there being any narrowness, or smallness, or desire to shirk responsibility, I am bound to say that the Board of Trade, from the highest official to the lowest, have done everything they could to afford the Company a chance of establishing its principle of electricity. I am sure that the shareholders will feel with us that the Board of Trade on that account deserve our best thanks. I feel that I should not have done my duty had I not said this. I now propose :

" *That the report and accounts be adopted.*"

LORD WANTAGE : I beg to second that.

Mr. ADAMS said that the Chairman had stated that 60,000 lights meant £60,000. He had himself endeavoured to find out from the Metropolitan Company what 60,000 lights meant, and the answer was nearly £30,000.

The CHAIRMAN : Our contracts were at £1 a light, and we thought it bad business. The difficulty in regard to this point, however, is that none of us have a common factor. We reduce ours to a common denominator of an eight candle-power lamp, whereas a great many of the lamps are of 16 candle-power. The experience in our own case is that £1 per light is not only not excessive, but is not enough. If we had 60,000 lights we should consider that £60,000 was the minimum amount that we ought to receive. We would not take a contract at £1 per light—that is, per annum.

The resolution was then carried unanimously.

On the motion of the CHAIRMAN, seconded by Lord WANTAGE, the retiring Directors—Mr. Francis Ince, Mr. Joseph Pyke, and Mr. Arthur F. Wade—were severally re-elected ; and Messrs. Kemp, Ford, and Co., the retiring auditors, were also re elected.

Mr. CROUCH then proposed a vote of thanks to the Chairman and Directors, and referred to the trying times through which they had passed last year.

Mr. ADAMS seconded the motion, which was carried unanimously.

The CHAIRMAN : I am sure, on behalf of myself and colleagues, that I thank you heartily for this vote expressing your confidence in us. The directors of a company in the position of this Company fulfil a duty which only strong convictions and strong personal interest and reputation make tolerable. I am not going to enlarge upon our anxieties during the last two years. They have been very great, but they have been cheerfully borne, because we felt, in the first place, that we had the confidence of the shareholders ; and, secondly, because if we had not had their confidence we should have felt it our duty to persevere to realise the principle on which this Company was started, and doing what we could in our small way to ensure its success. It is encouraging, particularly at moments which are not in themselves cheerful ones, to find the proprietors believing in those in whom they have been good enough to leave their interests.

Replying to an observation from a shareholder, the CHAIRMAN added : Mr. Edison, who has a face which immediately reveals what his tongue would say, told me himself that he had never seen anything like our Deptford Station, either in boldness of design or beauty of work. But then he was born in Canada, not America. If he had been born in America I am sure that he would not have said that (laughter).

The proceedings then terminated.

## The Direct Spanish Telegraph Company (Limited).

The thirty-fifth ordinary general meeting of this Company was held at Winchester House, Old Broad-street, on the 17th inst., under the presidency of Sir James Anderson.

The Manager (Mr. C. Gerhardi) having read the notice convening the meeting,

The CHAIRMAN said : Gentlemen, before moving the adoption of the report, I shall as usual make a few remarks upon such points as may interest you. You will see from the report that we have earned £1,612 more money in the half-year, and to do this we have carried 138,000 more words, at an increase of working expense of £221. You will be pleased to learn that the average length of our telegrams remains steadily at $10\frac{1}{4}$ to $10\frac{3}{4}$ words, and has so continued for two years. I hope this is evidence that the science of coding which has long baffled us has reached a point below which they

Digitized by Google

cannot usefully go, at least for some years to come. We have established the duplex upon our London-Bilbao circuit, and the average time occupied in transmission of telegrams to Bilbao is only three minutes, and to Madrid 30 minutes. Upon this we have been congratulated by the Director-General of Telegraphs in Madrid, and I venture to think it leaves little more to be desired, at least for the present. I will ask the Manager to read the letter we have received.

The MANAGER accordingly read the following translation of the letter, which was dated Madrid, March 5, 1891, and addressed by the Director-General of the Post Office and Telegraph Department of Spain to the Company's representative at Madrid, Senor Don Jose Aparicio :—"Dear Sir, I have with the greatest satisfaction taken good note of all you communicate to me in your official letter, No. 19, of the 14th February, concerning the duplex communication established since 15th January last between Bilbao and London, with automatic translation at Falmouth. I have much pleasure in addressing, through your intermedium, to the Direct Spanish Telegraph Company my hearty and warm congratulations for the solicitude shown by the Company, and the sacrifices they make in trying to render the line from Bilbao to London for rapidity and correct transmission equal to the best international communications of Europe. On my side, in communicating this improvement to the Inspector-General of the service, and to the Director-Chief of the Central Office of Madrid, I have again recommended strongly that the direct communication of Madrid with the station of the Direct Spanish Company at Bilbao shall be constantly kept up at any risk, and that for that purpose all efforts be made to maintain in good condition the wire by which this communication is effected. I reiterate my compliments to your Company and to yourself, with the assurance of my high consideration."

The CHAIRMAN, continuing, said that this was very satisfactory. I think that to be able to telegraph to Madrid in half an hour, and to Bilbao in three minutes, is about as much as we can expect to do at present. One does not know what the next generation will do, but we are going as fast ahead in regard to speed as modern science has taught. The report shows that our reserve fund now amounts to £23,051, nearly the whole of which is invested and bearing interest, which also goes to increase that reserve. Then we have expended upon duplexing our London-Bilbao circuit £886, and we have wiped off £431, the balance of the cost of fitting up our new London station in Gracechurch-street, and £43 for the removal of our Bilbao station, viz., £1,300, all out of revenue, and we carry to the contingencies account £566, after paying upon the ordinary shares 7 per cent. I confess this is a better result than I anticipated when I last addressed you, but we have yet to see the result of the half-penny per word reduction in our tariff, which commences upon the 1st July, and we shall have to count upon some decrease of traffic since the end of December, 1890, owing to the effect of frost upon the crops in Spain, the effect of strikes in our own country affecting the shipments of iron ore at Bilbao, and the recent unprecedented snow storms, interrupting all traffic beyond Exeter practically for a whole week. We are much indebted to the Post Office staff for their exertions to remove these serious obstructions. They did all they could to assist us and to put us through, but the storm was so blinding that it was a very arduous task, and we must be very thankful to them. I have been reading a letter this morning from the Eastern Telegraph Company's station at Lands End describing the storm, and the endeavours of the staff to get the traffic through from Porthcornow to Penzance, a distance of only seven miles. Two of the Eastern Company's men were nearly lost, but there were more volunteers immediately, and, in fact, everyone volunteered. I see that the superintendent fell off a hedge (I do not suppose that he knew that it was a hedge), and it was with difficulty that he was extricated from the snow. Altogether they have had a terrible time there, such as has never been experienced before, that I am aware of, in the South of England. Our people, as well as those of the Eastern Company, have zealously done their duty, and personally I feel indebted to them, for I am anxious that we should keep our traffic up. We went so far during that storm as to engage a tug boat at Plymouth to take the messages on to Falmouth, where our cables start from. That cost us only £20, and it enabled us to keep up so much traffic. In telegraphing we had to get round to the Land's End by New York and by Marseilles, Gibraltar, and Lisbon. We have managed to keep up the traffic all this time, losing very little indeed. Now that we have restored communications again, I doubt not that we shall get back all our traffic. At the same time I wish it to be known how much we endeavoured to do in order to keep up the communication. Happily, also, telegraphy is getting to be so arranged that there are many ways of reaching a given point, and it is almost impossible really to cut off communications from any place nowadays. There are so many lines to the continent, America, round by Marseilles, Trieste, and by India, that we can always get communication by a little trouble. I do not take any pessimistic view of our future revenue. We may not always be able to give you 7 per cent. We have therefore called 1 per cent. a bonus, which means that we do not yet consider this 1 per cent. part of an assured dividend which we can properly divide and promise to divide continually. We shall all hope, however, that it may really be continued. Then I express the hope that even if the traffic increases we shall not divide any more of our revenue than is represented by a dividend of seven per cent. I am extremely anxious that we should lay by every shilling we can after giving you this seven per cent. We have a large mortgage debt bearing six per cent., and we are only a single cable Company. It is true that we have a joint purse with the Eastern Telegraph Company, and that arrangement goes a long way to save us, but I do not consider any telegraph company a success until their system is duplicated. I hold that any enterprise of this kind—whether a telegraph or a railway—to be successful, should have a large margin of carrying capacity, and a large margin of security. Without that margin of security I do not think you can properly say that you are in a good position, and I look forward to the time when the increase of traffic and the increase of our revenue will justify us in duplicating our whole system. For that reason I should like to accumulate all the money we can. I think a dividend of seven per cent. is enough to pay until you have your property secured in the manner I have described. We look forward at this Board to be able to renew half our debentures in 1894 at four per cent. Now, gentlemen, I have heard from some friendly critics that the preference shareholders are feeling sore when they see the ordinary shareholders getting seven per cent. I propose to do what I can to explain what would have been the position of the proprietors had we not reduced our capital when this Board was reconstituted. You were not receiving any dividend, and it became evident that your principal cable was derelict, and beyond repair. The dividends upon the preference shares were three years in arrear, these shares were hardly saleable at £7. We had totally lost our main cable, and we had raised £62,000 in debentures to keep our Company's concession and property from being utterly lost. We had to go to court to get the question decided whether we could reduce our preference capital as well as our ordinary capital. I may remind you that we had our own doubts about this, and we had a desire to give the preference shareholders a larger proportion of shares than they have obtained, but the Court on appeal said decidedly no. But supposing we had not reduced our capital, we could not by law have paid any dividend whatever until our lost assets were restored. Even had our revenue shown the elasticity which it has recently done we could not have paid upon the preference shares any dividend for about 10 years. By the reduction of capital we were in a position to pay upon the preference shares the whole of the three years arrears at once, and a continuous dividend of 10 per cent. upon the reduced capital ever since. The shares are now at £10 in the market, before we reduced the capital they were hardly saleable at £7. I do think we acted altogether in your interest when we decided to know the worst, examine our cable, and decide upon facing the position. All your revenue would not have maintained the original cable. Now we have a reserve of £23,000 and a contingency fund of £3,000. We have a growing revenue and are justified in looking forward to the reduction of our debenture debt at a comparatively early period, and at a price which our improved credit will entitle us to ask either in the open market or from our shareholders. I do not think we can very well, looking back upon the whole thing, have possibly done anything better in any way. We have saved the concern from bankruptcy, and we have got a growing revenue, and a very fair result. I think that by calling up the £1 of the uncalled capital in 1894, and in one way and another we shall manage to get our debenture debt paid off, or such part of it as not to leave us in any position of anxiety. By-and-by, if the traffic grows, we may look forward to duplicating the cables. However, "sufficient for the day is the evil thereof." I have told you enough now in regard to our present position, and to me, at all events, it is satisfactory. If you have any questions to ask I shall do the best I can to answer them. Meantime, I will move—

*"That the report and accounts now presented be, and are hereby received and adopted."*

Mr. EDMUND ETLINGER: I beg to second the motion.

Mr. JACKSON said that the Chairman had dwelt upon the necessity of increasing the reserve fund, which was a matter of the greatest importance, especially in the case of a company having single cables; but no idea had been given to the shareholders of the amount which might be thought necessary. Of course it would affect the interests of the shareholders very largely while the fund was being accumulated, and he would like to know something as to the amount which would be regarded as sufficient to satisfy the Board.

The CHAIRMAN: I think you have got to consider, in regard to this question, that our tariffs are coming down on every occasion whenever any of these telegraph conventions are held, and I am very anxious in all the companies to which I belong to see our capital kept down and our carrying capacity increased, and I should like to have a large reserve so that we might be in a position to extend our carrying capacity to the best advantage, and to be able to go into the market and buy the cable for cash. I should be very sorry indeed to fix even in my own mind what reserve might be enough. I am not at all satisfied that we have got sufficient yet, or anything like sufficient. I think if you get 7 per cent. for your money you will not do badly.

A SHAREHOLDER inquired what the cost of a single cable would be.

The CHAIRMAN: I do not think you could buy that cable under £180 a knot. It would take about £100,000 to lay a cable to Bilbao, and about half as much from Marseilles to Barcelona. There is no doubt about this—that if your reserve is in 1894 as large as I hope it will be, you will get your Debenture in very easily at 4 per cent., for our credit will then be good. I think as long as we pay 7 per cent. we had better pause and realise our glory.

Mr. COCHRAN said he had not been aware that there were any critics of the Board now as regarded the policy which had been followed in reducing the preference capital at the time of the reconstruction of the Company. He had fought that matter with all his might, but the day had gone by now for questioning it, and he did not see any use in referring to it. He had, however, intended to speak about the very rapid increase of the reserve fund. He remembered that when the reconstruction scheme was proposed, and the attendant reduction of the capital, the Chairman said that he would not be connected with the Company unless the Board were permitted to put by £5,000 a year to reserve fund; but in the last eighteen months they had been putting by money at the rate of £7,000 a year. He was always in favour of a strong financial position for any company with which he was connected, and he was quite in favour of putting by £5,000 a year, but he did not know that his interest in posterity was so very strong that he must go on perpetually making sacrifices. He considered that if the Company went on constantly putting by £5,000 a year, it was not making a bad provision for the con-

Digitized by Google

tingencies that might overtake it. In their old and somewhat unsatisfactory position they were able to get the cable constructed on Debenture issue, although, no doubt, at an extravagant interest, and therefore he could not see any difficulty in providing for that eventuality, especially as they were building up a reserve fund, and that they would be able to deal with the Debentures when they fell in in 1894.

The CHAIRMAN: Half of them.

Mr. COCHRAN, continuing, repeated that he saw no reason why, in their present position, they should be making such a large sacrifice. He could not forget that on the faith that he was really getting a preferential security, he bought his preference shares, that half of that capital had been wiped off, and that he had thus only been receiving on half his capital the full dividend which had been promised him. Still, he thought that if the Chairman would give some indication of the amount of the reserve fund, with which the Board would be satisfied, the shareholders would probably be inclined to wait patiently for the development of the Directors' policy. It was to be remembered that, besides carrying forward £566, about £1,300 had been charged to revenue in the past half-year on account of exceptional expenditure; and, therefore, he did not think they ought to encourage the Board to consider that 7 per cent. even on the ordinary shares was the ultimate distribution which the holders of those shares should receive. He thought that if an available margin remained the Directors should give the shareholders a shade more.

The CHAIRMAN: As to this "shade more" (laughter) you know when we gave you 6 per cent. that was a shade more, and now we pay 7 per cent. I do not say that Mr. Cochran is wrong. It is the expression of a natural wish that you should get more, but I fall back upon this: It is not posterity that I am thinking about, but of making this a first-class property, and one that will make dividends, even if the tariff does go down, and it will go down. I want the margin of carrying capacity and that security for carrying capacity, which only money can give. I do beg the shareholders to be satisfied with it. You know when we went to the Court about this we showed only 2 per cent. on our ordinary shares. Now the traffic has improved, and the progress that has occurred since, has strengthened and improved our property. It is of no importance to me personally, but you will get along much more smoothly if you will agree to what is suggested. No company or telegraph company is in a right position unless it can have a large margin of carrying capacity and a large margin of security, and for that purpose you must have money. I do not think that at the price at which our ordinary shares are held anyone is to be pitied at getting 7 per cent.

The resolution was then put to the meeting and carried unanimously.

The CHAIRMAN then proposed,—

*"That the dividend at the rate of 10 per cent. per annum (less income-tax) on the preference shares, and a dividend at the rate of 6 per cent. per annum, together with a bonus of 1 per cent. (both free of income-tax) on the ordinary shares, all for the half-year ended December 31, 1890, be, and are hereby, declared."*

Mr. ETLINGER seconded the resolution, which was carried unanimously.

On the motion of Mr. ETLINGER, seconded by Mr. JOHN DENISON PENDER, Sir James Anderson was re-elected to his seat; as was also Mr. Etlinger, on the motion of the CHAIRMAN, seconded by Mr. PENDER.

Mr. COCHRAN then proposed and Mr. KENNETH ANDERSON seconded, the re-election of Mr. Herbert R. Duke as auditor, and the motion was agreed to.

Mr. COCHRAN next proposed a vote of thanks to the Chairman and Directors. They did not always see things in the same light, but the shareholders had no hesitation in believing that the intention of the Board was for the general good of the Company.

Mr. JACKSON seconded the motion, which was carried unanimously.

The CHAIRMAN: We are very much obliged to you. We can only have one object, of course, which is to make this property valuable. I like all the companies I am in to be very strong and firm, and to possess a good large reserve.

The meeting then separated.

## The South of England Telephone Company (Limited).

An extraordinary general meeting of the South of England Telephone Company (Limited) was held at Winchester House, Old Broad-street, London, on the 16th inst., under the presidency of Mr. D. Owen Bateson.

The SECRETARY (Mr. Fred. L. Robinson) having read the notice calling the meeting,

The CHAIRMAN said: Gentlemen, as Chairman of the South of England Telephone Company, it is my duty to preside on this very important occasion. You have all been informed by circular that the Board propose to sell the Company and all its assets to the National Telephone Company, and the terms of such sale. Personally, however, I have had little to do in this matter. When the National Company approached the South of England Company with reference to this business, it was decided to appoint a sub-committee, in whose hands the negotiations were placed, and after numerous conferences they resolved to recommend to the shareholders the acceptance of the terms embodied in the circular. I dare say you will wish to hear from the negotiators why you are asked to consent to this sale and upon these terms. I therefore now call upon Mr. Billett, my co-Director, who will doubtless satisfy you, as he has satisfied himself, that the proposal is a fair one and ought to be accepted by the shareholders. Mr. Billett, will you kindly explain the reasons for this sale?

Mr. BILLETT: Mr. Chairman and Gentlemen, I do not think, as we have stated in the circular which we have issued, that there could be much surprise, at any rate in the minds of most of the shareholders, that this matter has been entered upon. Amalgamation has been spoken of at most of our meetings, and it has been generally received, I think, among the shareholders as a thing that was very desirable indeed both on the part of this Company and the National. When the matter was brought more prominently before our Board, as our Chairman has just stated, two of the Directors were appointed to meet two from the National Company, and we formed a committee, and had the subject under our consideration; but previously we had consulted with several of the largest shareholders whether they considered that amalgamation was desirable or not. In every case we found that the opinion was that amalgamation was desirable, and we therefore entered upon the negotiations which have resulted in the terms now put before you. Of course our own idea of the terms was very different from what has been finally settled upon. We had to propose our terms, which were not received favourably by the National Company, and the National Company proposed terms to us which were equally not received by us, and which we did not feel justified in putting before the shareholders. We then had to discuss some modified proposal, which is now before you. There are several reasons why we have placed this proposal and these terms before you. We are perfectly well aware that there is no ground for exceeding enthusiasm about the terms, but we think, on the other hand, that the terms offered do represent an advantage to the shareholders of this Company. In the first place, with respect to the preference shareholders, I know there is a strong feeling that they are making a tremendous dip from 6 per cent. to 4½ per cent.; but they must take into consideration the very much better security which they will have in consequence of accepting 4½ per cent. In the first instance, you have got shares which, for some time past, with £3. 10s. paid upon them, have been bought in the market at £2. 10s. to £3 per share; and even after this amalgamation had been talked of and some of the terms had been known, we have passed transfers at the Board at from £3 to £3. 10s. for these shares. When you consider that the Four and a-Half per Cent. Debenture Stock now issued by the National Company is quoted at from 2 to 3 premium, or thereabouts, I think you will see, at any rate, that you secure a stock by means of which you are able at once, if you please, to get your money back again. You may say. "We do not want our money back again, we want our 6 per cent." It is true that if you can get 6 per cent. with the same security that you had with 4½ per cent. it would be so much more advantage to retain the higher interest; but if you are to accept better security you must face the fact that you must put up with a less dividend. There is no doubt about it that in the position of a company like this, with a comparatively small margin behind the dividend of 6 per cent., the connection with a company which is earning a 9 per cent. dividend behind its debenture stock affords a security which is certainly very much greater than you can possibly have in the South of England Company. You get your capital immediately back therefore, and we consider that this was certainly a favourable arrangement for the preference shareholders. There are some who want to get back their capital. They are placed in this extremely awkward position under the present circumstances, that they must go into the market and put up with a very large sacrifice, whereas now, if they want to secure their capital, they can secure it, and not only that, but with a small premium. Then, with respect to the ordinary shareholders, our own hope and thought was that we should have got one National Company share for 20 of our own, but the National Company, considering the dividend and the revenue which we show, and all the possibilities and risks that there are, and they are many, could not agree to this. You may say that there are risks in all companies, but there may be exceptional risks in our case which perhaps some of the shareholders do not see or know of. In the first place, we have got very near to the end of our capital. We may, however, borrow more, but then comes this fact—that when we borrow money and our revenues do not increase correspondingly, your shares must suffer. Then, again, there is one thing which ought to be done, and which must be done, if this Company goes on—that is, we must have a large reserve, or else a considerable amount of that which is paid away in dividends or that which is put to capital must come out of the revenue, and so decrease the dividend on the ordinary shares. In a telephone company there is a great deal of expended capital which cannot be recovered, and therefore a large reserve must be provided to make up for that capital which cannot be recovered. You run your lines especially in a district which is widespread, and with no large centres, and the cost of these lines ought somehow to be reserved. Then, again, the capital expenditure in a telephone company can never cease. You can never say there is so much capital, and now you must stop. If a telephone company is to go on you must go on and increase your capital, unless you have a reserve so large that you can draw upon it. We have comparatively a small concern, and we have got a district which, at any rate in our negotiations with the National Company, it has been said cannot be improved—that they do not see where they are to get any improvement. They said to us: "You have done the work so cheaply and so well that there is nothing for us by which we can get any improvement." However, notwithstanding that we have got a comparatively poor district, it has so far yielded us a fair revenue, but we cannot expect, without a large expenditure of capital, the dividends to go on increasing. Last year we were able to pay a dividend of ½ per cent., and the year before we paid 1 per cent. It is possible that we may pay a dividend of 1 per cent. again; but if we are to make the large reserve which we ought to make, it is a great question whether we can increase beyond that 1 per cent. Instead of continuing in this position, you get by this proposed arrangement with the National Company one share in that Company for 25 of your ordinary shares. You will say—it has been said—that the National Company's shares are at a discount Well, they earned 9 per cent. last year, and there is every prospect of their earning 9 per cent. this year. Although the terms were not so good as we had anticipated and hoped to get, at the same time they are terms which put us into a company much stronger, which gives us a marketable share, and which also affords the prospect of

Digitized by Google

a largely increased dividend. The National shares have already received a dividend of 6 per cent., and I believe that though they paid only a 5 per cent. interim dividend, there is no doubt that the dividend will be made up to 6 per cent. for the year. You would, therefore, get 6s. per share, whereas, supposing we could pay 1 per cent., you would receive only 5s. We also get the benefit of the very large reserve fund which they have in hand, and which will be increased continually. Then we get the prospect presently of a larger dividend. All these things have weighed with us before we put the matter before you, and before we submitted these terms to you; and we thought that, although we should have liked to get more, the terms offered to us were sufficiently favourable to justify us in putting them before you. We have therefore done so, and have submitted them to your approval, and in doing so I myself feel that we are doing right by you; and although the action of Directors in a peculiar case like this is always open to question, at the same time we think we have done our best, and that, taken altogether, they are favourable terms for the shareholders in the South of England Company. I am quite sure that the National Company will lose nothing, but the point is, do we lose anything? and I think we do not by exchanging our shares, either preference or ordinary, into shares and debenture stock of the National Company. I have therefore much pleasure in proposing this resolution:—

"*That the agreement submitted to this meeting, and expressed to be made between this Company and the National Telephone Company (Limited) for the amalgamation of the two Companies, by a transfer of the business and property of this Company (with certain exceptions) to the National Telephone Company (Limited) be, and the same is hereby, approved.*"

Mr. MacGREGOR: I rise to second the resolution proposed by Mr. Billett. He has so very clearly and ably pointed out to you the advantages of amalgamation and the difficulties and dangers which lie before us as an isolated company that I have very little to say. I thoroughly agree with and confirm all that he has said. The dangers ahead of us are very real, though, perhaps, not immediately apparent. Throughout these negotiations we have had but one object in view, namely, the interests of our shareholders, and of our shareholders only. We have endeavoured to make the best bargain we could, and I think that we have made a very fair one. I am myself the largest individual holder of the ordinary shares of the Company, I also hold a large number of preference shares, and I feel that I can confidently recommend this resolution for your adoption. I now therefore beg to second the resolution.

Mr. PAWLE moved the rejection of the proposal. They were, he said, asked to take 1s. 9d. each for their ordinary shares. At former meetings nothing had been said about the necessity of a reserve fund. Only ½ per cent. was paid last time, but they were led to believe that this was owing to snowstorms, &c., and that they would get better dividends in the future. They were asked to accept a price for their shares which had never existed, and which even in the worst times of the Company would not have been justified, and they were asked, moreover, to take shares in a company which were at a discount. One gentleman had said that they might pay 1 per cent. next time, and that would make the shares worth a great deal more than 2s. 6d., and yet they were asked to take 1s. 9d. each for them.

Mr. BILLETT: You are wrong in your figures. The price is 3s. 9d. anyhow. Get your figures right, and then let us have your particulars, and we may base some argument on it. What you are asked to take, even supposing you take the lowest figure quoted for the National Company's shares—which are now 4½ to 4¾—is 3s. 9d., not 1s. 9d.

Mr. H. H. THOMPSON seconded the amendment. It seemed to him that to sell their shares to the National Company at 3s. 9d. or 4s. was great folly, just when the Company was beginning to turn the corner, with the business beginning to increase, and with a good reasonable prospect of its steadily increasing. It seemed to him that the National Company were getting altogether the best of the bargain.

Mr. BREACH supported the amendment. He came from Brighton, and he knew that the Company was extending its business and growing in popular favour in the district.

Mr. FITZGERALD: I should like to say a few words upon this subject, because I think that among the body of shareholders there is a great deal of misapprehension. I am supposed to know a little about the telephone, and I think that one danger which the shareholders have overlooked is that of competition. Are the shareholders aware that there is such a thing as competition threatening them? Now, competition in the telephone business is a rather disastrous thing. I have had one or two telephone fights, and I know what it is to have your rates knocked down, and all your profits taken away. A small company like this Company, with its capital account running rather short, appears to me to be in rather a dangerous position. A few gentlemen could combine together, knowing very little about the business, and compete with us. (A Voice: "Are you a shareholder?") I have nearly £5,000 in preference shares and nearly 2,000 ordinary shares. I am not talking against my own interests. A few men, I say, could go into this business and compete with you and knock down your rates, and where would the South of England Company be then, with its capital nearly gone? Now, you are asked to join a big body, who have asked their shareholders for £300,000 and were offered £900,000. Is not that an argument for you to come into the big ship instead of remaining in the little one? Some one spoke about the price of the shares. But you cannot go into the market and sell 1,000 shares at 3s. 6d., whereas you are offered 3s. 9d. Again, some of the shareholders ignore the fact that they are to receive double the dividend which they received last year. I am very much pleased with the proposal. It is true I have to make a sacrifice as regards the amount of my preference dividend, but look at the security I get. The security of the debentures in the National Company is backed up by their large capital, on which they are earning, as Mr. Billett has said, 9 per cent. It is perfectly true it is not paid, but the fact makes that security an absolutely marketable security of very good value, and you are quite certain that you will receive your dividend. This sort of argument weighs with me a great deal more than the idea that because some one has paid too much for his shares in this Company, this is a bad bargain. If I give 7s. 6d. for a share for which I can only get back 3s. 6d., that is no reason why I should say that some one ought to give me 8s. for it. However, there is the big company offering to buy us up. You have to fix in your mind that you may have competition, thus reducing your subscriptions, and consequently your running the risk of earning no profit at all. Therefore, I for one say, and I think most of my clients too (and I have a very large number of them), that I shall support this resolution for the sale of the business. I should like to hear some of the gentlemen produce more argument against the resolution than simply the price of the shares. Personally, I think if the shareholders do not pass this resolution they will probably find themselves in a very bad way in about a year. That is my own private opinion. I may be wrong, but I think so.

Mr. TANNER: As a holder of 500 shares I beg to say that I shall support the sale.

Mr. SPICER said that there could be no two opinions that the amalgamation of this comparatively small Company with the National Company would be a very good thing for the South of England Company. It seemed to him that it was essential that the amalgamation should take place, but not necessarily on the basis proposed. That was the only matter for consideration. He was disappointed at the price that had been offered; but the meeting had heard what the seconder of the resolution and Mr. Fitzgerald had said in favour of the proposal. The remarks of these gentlemen should tend to convince them that the best bargain was being made; but at the same time he would like to be a little more certain on the point. If the National Company could not get into London without making an

PATENT

SILICIUM BRONZE AND SILICIUM COPPER WIRE.

The best for overhead Telephone and Telegraph Lines,

AND ALL ELECTRICAL PURPOSES.

Hard Drawn High Conductivity Copper Wire.

ROLLED AND DRAWN PHOSPHOR BRONZE.

PHOSPHOR BRONZE — VULCAN — PHOSPHOR — DURO METAL

PHOSPHOR BRONZE BEARINGS, BUSHES, AND OTHER PARTS OF ELECTRICAL MACHINERY

*SOLE PROPRIETORS of the British, Indian and Colonial Patents,*

THE PHOSPHOR BRONZE COMPANY (Limited),

*87, Sumner Street, Southwark, London, S.E.*

WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

Digitized by Google

arrangement with the South of England Company he thought they might stand out for better terms. Were they to receive an equal amount of the National Company's debenture stock for their preference shares?

The CHAIRMAN replied in the affirmative.

Mr. KAIN said that their Company were alone able to own or carry out any telephone matter in their own district, and therefore he would most strenuously stay any transfer to the National Company.

The CHAIRMAN: We are subject to competition. Anyone may run a telephone in our district.

Mr. TAYLOR thought that an amalgamation would be advantageous to both Companies. He, however, regretted that the National Company were not able to offer them 3,000 more shares.

The CHAIRMAN: I think a great many of us are of the same way of thinking as yourself. I will now put the amendment.

Mr. CRISP: There is no amendment; it is a rejection. You cannot put that.

The CHAIRMAN: Then I will put the resolution (read resolution again). Those in favour of that will kindly hold up their hands. On the contrary. There are 25 in favour of the motion and 14 against it, and, therefore, it is carried.

A SHAREHOLDER: May I ask what are the "certain exceptions" mentioned in the resolution?

Mr. CRISP: The principal exception is that we cannot sell the licence which we have from the Postmaster-General. The licence would be forfeited if we sold it.

Mr. BILLETT: I have now to move the second resolution:—

*"That with the view of giving effect to the above-mentioned agreement and in order to enable the Debenture stock and shares to be allotted thereunder, as part of the purchase consideration to be distributed among the members of this Company, this Company be wound up voluntarily under the Companies Act, and that Mr. Thomas Abercrombie Welton be, and is hereby, appointed liquidator for the purpose of winding up its affairs and distributing its property."*

Mr. MACGREGOR seconded the resolution, which was adopted.

On the motion of Mr. BILLETT, seconded by Mr. MACGREGOR, the following resolution was also passed:—

*"That pursuant to the 161st section of the Companies Act, 1862, the liquidator be, and is hereby, authorised to carry the said agreement into effect, and to receive the Debenture stock and shares agreed to be allotted, and the cash payable thereunder, and to distribute the same among the members of this Company."*

A SHAREHOLDER inquired what was intended to be done as regarded those who held shares which were not multiples of 25?

Mr. WELTON replied that he would probably issue fractional certificates, which could be combined together so as to command a whole share, which could be disposed of in the market. Those not brought in by a certain date would be represented by shares in his hands, the proceeds of which he would have to hand over to the holders of the fractional certificates.

A vote of thanks to the Chairman closed the proceedings.

## The Telephone Company of Egypt (Limited).

The following is the report of the Directors for the year ended December 31, 1890, to be presented at the eighth ordinary general meeting of the Company, to be held at the offices of the Company, 14, Austin Friars, E.C., on Tuesday, the 24th inst., at 1 p.m.

The revenue account, after providing £345 for interest on Debentures, shows an amount to credit of £3,670. 10s. 1d., adding to this the sum of £1,459. 1s. 4d. brought forward from December 31, 1889, there remains a balance for disposal of £5,129. 11s. 5d., out of which the Directors recommend the payment of a dividend of 6 per cent. on the preferred shares, free of income-tax, carrying forward £1,508. 5s. 5d.

Considerable expense has been incurred during the past year in the renewal of lines and instruments, all charges in connection therewith having been provided for out of revenue. The Directors have also deemed it advisable to eliminate from the accounts certain subscriptions, the collection of which appear doubtful.

A further issue of £1,500 Six per Cent. Debentures was made during the year in order to replace a portion of the revenue that has been expended on capital account.

The business at Alexandria and Cairo shows a less favourable tendency, due to local circumstances. The growth of the exchange at Port Said, on the other hand, has more than fulfilled the expectations of the Directors, and this exchange will in time add to the income of the Company. A small exchange was opened during the year at Assiout, and negotiations are now in progress for the establishment of an exchange at Suez, with a branch at Port Tewfick.

The gross revenue of the Company at December 31, 1890, was £10,852. 8s. 2d., and the total number of subscribers in Egypt, 994.

Under the Articles of Association Mr. Henry Grëwing retires from the Direction, but being eligible offers himself for re-election. Messrs. Price, Waterhouse, and Co., the Auditors of the Company, also retire, and offer themselves for re-election.

## NEW COMPANIES REGISTERED.

**JOHN PRIEST AND SON (LIMITED.)**—Registered with a capital of £30,000, in £10 shares. Object: To carry on generally the business of iron and steel founders, engineers, &c.

**THE LIVERPOOL AND DISTRICT PULSION TELEPHONE COMPANY (LIMITED).**—Registered by Thomas T. Hull, 22, Chancery-lane, with a capital of £5,100 in £1 shares. Object, to adopt an agreement made February 20th between the Primary Syndicate (Limited), of the one part, and Alfred Howard Cowie of the other part, and to carry on generally the business of a telephone, telegraph, and electric light, &c., company.

## CITY NOTES, &c.

**BRAZILIAN SUBMARINE TELEGRAPH COMPANY.**—The receipts of this Company for the week ended March 13th amounted to £5,066.

**BRIGHTON AND HOVE ELECTRIC LIGHT COMPANY (LIMITED).**—The fifth annual report, to be presented at the meeting next week, recommends a dividend of 5 per cent., with £220 forward.

**CITY AND SOUTH LONDON RAILWAY COMPANY.**—The receipts of this Company for the week ended March 14th amounted to £749.

**TAUNTON ELECTRIC LIGHTING COMPANY (LIMITED).**—The whole of the debentures in this Company have been taken up, and Colonel Milman has joined the directory.

**UNITED ASBESTOS COMPANY (LIMITED).**—At the annual meeting of the shareholders of this Company, held yesterday, a dividend of 10 per cent. was declared and paid upon the preference shares, and the balance of profit for the year, equal to a little over 5 per cent. on the ordinary shares, was carried forward.

**WEST COAST OF AMERICA TELEGRAPH COMPANY.**—The traffic receipts of this Company for the month ending February 28, 1891, amounted to £4,600.

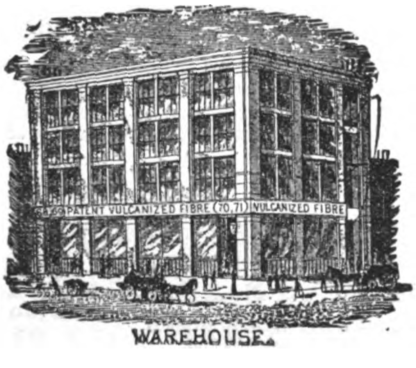
**WESTERN AND BRAZILIAN TELEGRAPH COMPANY.**—The traffic receipts of this Company for the week ending March 13, 1891, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £4,063.

**WEST INDIA AND PANAMA TELEGRAPH COMPANY.**—The receipts of this Company for the half-month ended March 15th, show a decrease of £368 as compared with the corresponding period.

**WHITE'S ASBESTOS COMPANY (LIMITED) v. HOARE.**—An appeal by the Company against a decision of Mr. Justice Day (*The Electrician*, December 26, 1890, page 249) came before the Appeal Court on Tuesday, when it was stated that the parties had arranged that an order should be taken by consent, dismissing the appeal, with costs.

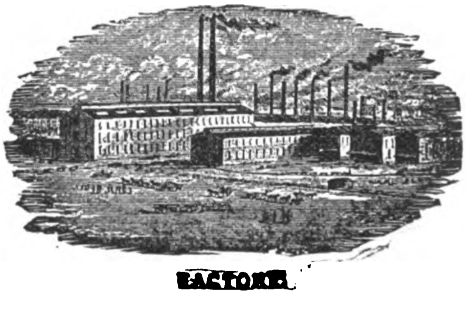
THE NON-CONDUCTOR OF ELECTRICITY.

VULCANISED FIBRE,
PATENTED.



WAREHOUSE.

This new material is supplied in two qualities, Flexible and Hard.
The FLEXIBLE is a substitute for Leather, Rubber, Gutta Percha, &c., and is extensively used by Brass Founders, Axle Makers, Hydraulic, Sanitary, and other Engineers, Pump Makers, Carriage Builders, &c.
It makes the best Hot and Cold Water Packings, and for Axle Washers of all kinds it is unequalled.
The HARD is a substitute for Metals, Hard Wood, Ivory, Vulcanite, Ebonite, &c., and is a good Insulator.
Sold in sheets, 5ft. 6in. by 3ft. 6in., varying in thickness from 1-50in. to 1in.


FACTORY.

FLEXIBLE, 2/- per lb.; HARD, 2/3 per lb.

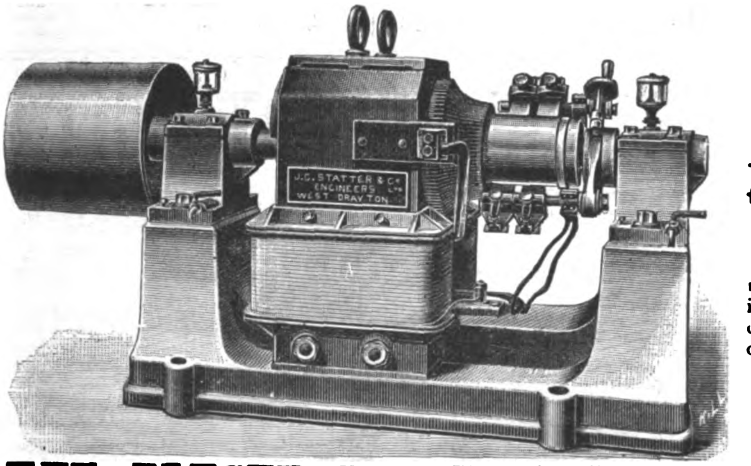
MOSSES & MITCHELL, 70, Chiswell-st., London, E.C.

Digitized by Google

# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name. | Previous Week's Price, March 11. | | Price Wednesday, March 18. | | Rate per Cent. Yielded. | Dividend Due. | Business Done During Week Ending Mar. 18. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | £ s. d. | | Highest. | Lowest. |
| | | | **TELEGRAPHS.** | | | | | | | | |
| £1,381,380 | Stock | 15/0 | Anglo-American | 47½ | 48½ | 47½ | 48½ | 5 18 7 | Jan., Apr., July, Oct. | 48⅜ | 48¼ |
| £2,809,310 | Stock | 30/0 | Do. Preferred | 84½ | 85½ | 84½ | 85½ | 6 14 6 | ,, ,, | 85⅝ | 85 |
| £2,809,310 | Stock | .. | Do. Deferred | 11¼ | 11¾ | 11 | 11½ | .. | .. | 11⅝ | .. |
| £250,000 | 100 | 4% | African Direct, Telegraph 4% Debentures | 99 | 102 | 99 | 102 | 3 18 5 | January and July .. | .. | .. |
| 130,000 | £10 | 3/0 | Brazilian Submarine | 11¾ | 12¼ | 11¾ | 12¼ | 6 2 5 | Mar., June, Oct., Dec. | 11 11/16 | .. |
| £84,500 | £100 | 5% | Do. 5 per Cent. Bonds | 100 | 103 | 100 | 103 | 4 17 1 | January and July .. | .. | .. |
| £75,000 | £100 | 5% | Do. 5 per Cent. Bonds (2nd Series, 1906) | 103 | 107 | 103 | 107 | 4 13 6 | June and December | .. | .. |
| $7,216,000 | $100 | 7% | Commercial Cable Capital Stock | 108 | 110 | 108 | 110 | 5 18 2 | April and October .. | 109¾ | 109¼ |
| 16,000 | 10 | 8/0 | Cuba Submarine | 10½ | 11½ | 10½ | 11½ | 6 19 2 | February and August | 11 3/16 | 11 |
| 6,000 | 10 | 10% | Do. Preference 10% | 16½ | 17½ | 16½ | 17½ | 5 14 3 | ,, ,, | .. | .. |
| 12,931 | 5 | 7% for '90 | Direct Spanish (£4 paid) | 3¾ | 4¼ | 3¾ | 4¼ | 6 11 9 | April and October.. | 4 1/16 | .. |
| 6,000 | 5 | 10% | Do. Preference 10% | 9½ | 10½ | 9½ | 10½ | 4 15 3 | ,, ,, | .. | .. |
| 60,710 | 20 | 3/6 | Direct United States | 10⅛ | 10⅝ | 10¼ | 10½ | 6 13 4 | Jan., Apr., July, Oct. | 10¾ | 10½ |
| 400,000 | 10 | 2/6 | Eastern | 14 | 14½ | 14¼ | 14¾ | 4 10 5 | ,, ,, | 14½ | 14 |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference | 15¼ | 15¾ | 15¼ | 15¾ | 3 16 2 | ,, ,, | 15⅝ | .. |
| £1,200,000 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock | 107 | 110 | 107 | 110 | 3 12 9 | May and November | 109 | 107¾ |
| £200,000 | 100 | 5% | Do. 5 per Cent Debentures, 1899 | 107 | 110 | 107 | 110 | 4 10 11 | February & August | .. | .. |
| 250,000 | 10 | 2/6 | Eastern Extension | 14¾ | 15¼ | 14¾ | 15¼ | 4 11 10 | Jan., Apr., July, Oct. | 15 | 14⅞ |
| £320,000 | £100 | 4% | Do. 4 per Cent. Debentures Stock | 105 | 108 | 105 | 108 | 3 14 1 | .. | .. | .. |
| £91,800 | 100 | 5% | Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900 | 103 | 106 | 103 | 106 | 4 14 4 | January and July .. | .. | .. |
| £145,300 | 100 | 5% | Eastern & S. African 5 per Cent. Mor. Deb., 1900 | 103 | 106 | 103 | 106 | 4 14 4 | ,, ,, | .. | .. |
| 180,227 | 10 | 1/9 | Globe Telegraph and Trust | 9⅛ | 9⅜ | 9¼ | 9½ | 5 2 7 | Jan., Apr., July, Oct. | 9⅜ | 9 |
| 180,042 | 10 | 6% | Do. 6 per Cent. Preference | 15 | 15¼ | 15 | 15¼ | 3 18 8 | ,, ,, | 15¼ | 15 |
| 150,000 | 10 | 5/0 | Great Northern | 16¾ | 17¼ | 17 | 17½ | 3 8 7 | Jan., April, and July | 17⅜ | 17⅛ |
| £230,000 | 100 | 5% | Do. 5 per Cent. Debentures, 1883 | 103 | 106 | 103 | 106 | 5 13 2 | March & September | .. | .. |
| 17,000 | 25 | 12/6 | Indo-European | 37 | 39 | 38 | 40 | 6 5 0 | May and November | 39 | .. |
| 38,348 | 10 | 4/0 | London Platino-Brazilian | 6½ | 7½ | 6½ | 7½ | 5 14 4 | ,, ,, | .. | .. |
| £100,000 | 100 | 6% | Do. 6 per Cent. Debentures | 105 | 108 | 105 | 108 | 5 11 1 | March & September | .. | .. |
| 9,000 | 8 | 4/0 | Reuter's | 8½ | 9 | 8½ | 9 | 5 11 1 | April and October.. | 8 13/16 | 8 11/16 |
| 3,381 | £100 Cert. | 6% | Submarine Cables Trust 6% | 115 | 120 | 115 | 120 | 5 0 0 | ,, ,, | .. | .. |
| 15,609 | 10 | 4/0 | West African Telegraph | 8 | 9 | 8 | 9 | 5 11 1 | January and July .. | .. | .. |
| £290,900 | 100 | 5% | Do. 5 per Cent. Debentures | 97 | 100 | 97 | 100 | 5 0 0 | March & September | .. | .. |
| 30,000 | 10 | 3/0 | West Coast of America | 2 | 4 | 2 | 3 | .. | January and July .. | .. | .. |
| £150,000 | 100 | 8% | Do. Debentures 8% 1902 | 94 | 99 | 92 | 97 | .. | June and December | .. | .. |
| 88,321 | 10 | .. | West India and Panama | 2¼ | 3 | 2¼ | 3 | .. | .. | .. | .. |
| 34,563 | 10 | 6/0 | Do. 1st Preference 6% | 11½ | 12 | 11½ | 12 | 5 0 0 | May and November | 11⅞ | 11 13/16 |
| 4,669 | 10 | £3 | Do. 6 p. c. 2nd Pref. | 11 | 12 | 11½ | 12½ | 4 16 0 | ,, ,, | .. | .. |
| 64,174 | 15 | 6/0 | Western and Brazilian | 12 | 12½ | 12 | 12½ | 4 16 1 | ,, ,, | 12 7/16 | 12¼ |
| 27,873 | 7½ | 6/0 | Do. 5 per Cent. Cumulative Preferred | 6¾ | 7¼ | 6¾ | 7¼ | .. | — | 6¾ | 6¼ |
| 27,873 | 7½ | 4/6 | Do. 5 per Cent. Deferred | 5¼ | 5¾ | 5¼ | 5¾ | .. | .. | 5⅝ | 5½ |
| £200,000 | 100 | 6% | Do. 6 per Cent. Debs., Series "A" 1910 | 103 | 106 | 103 | 106 | 5 13 2 | February & August | .. | .. |
| £250,000 | 100 | 6% | Do. 6 per Cent. Mort. Debs., Series "B" 1910 | 103 | 106 | 103 | 106 | 5 13 2 | ,, ,, | .. | .. |
| $1,336,000 | $1,000 | 7% | Western Union 7 per Cent. 1st Mortgage | 120 | 125 | 120 | 125 | 5 12 0 | May and November | .. | .. |
| £175,100 | £100 | 6% | Do, 6 per Cent. Sterling Bonds | 100 | 104 | 100 | 104 | 5 15 5 | March & September | .. | .. |
| | | | **TELEPHONES.** | | | | | | | | |
| 224,850 | 14/0 | 0/4½ | Consolidated Telephone Const. & Maintenance. | 7/16 | 9/16 | 7/16 | 9/16 | .. | May and November | .. | .. |
| 220,000 | £1 | 3½% | Oriental (11s. paid) | ¼ | ⅜ | 5/16 | 7/16 | 4 8 7 | Yearly | .. | .. |
| .. | .. | .. | Mutual Telephone Co. | .. | | .. | | .. | .. | .. | .. |
| 438,984 | 5 | 2/6 | National | 4⅝ | 4⅞ | 4½ | 4½ | 6 2 3 | June and December | 4⅞ | 4 13/16 |
| 15,000 | 10 | 6/0 | Do. 6 per Cent. Cumulative 1st Pref. | 12¾ | 13¼ | 12¾ | 13¼ | 4 10 7 | ,, ,, | .. | .. |
| 15,000 | 10 | 4/9⅜ | Do. 6 per Cent. Cumulative 2nd Pref. (£8 pd) | 10¼ | 10¾ | 10 | 10½ | .. | ,, ,, | 10 | .. |
| 209,750 | 1 | ½% | South of England, Ordinary | ⅛ | ¼ | ⅛ | ¼ | .. | — | .. | .. |
| 20,000 | 5 | 2/1 | Do. 6 per Cent. Cumulative Pf. (£3 10s. pd) | 2¾ | 3¼ | 2¾ | 3¼ | 6 9 0 | .. | .. | .. |
| 58,000 | 5 | 1/0 | United River Plate | 3 | 4 | 3 | 4 | .. | January and July .. | .. | .. |
| £146,128 | Stock | 5% | Do. 5 per Cent. Debenture Stock | 85 | 95 | 85 | 95 | 5 5 3 | .. | .. | .. |
| £3,200 | 100 | 7% | Do. 7 per Cent. Debentures | .. | | .. | | .. | — | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | | | |
| 19,900 | £5 | .. | Electricity Supply Co. of Spain | .. | | 4½ | 5 | .. | .. | .. | .. |
| 111,000 | 5 | .. | London Electric Supply | 1⅞ | 2⅜ | 2 | 2¼ | .. | .. | .. | .. |
| 43,900 | 10 | .. | Metropolitan Electric Supply (£9 paid) | 8¾ | 9¼ | 8¾ | 9¼ | .. | — | 9 1/16 | 9 |
| .. | £5 | .. | St. James' and Pall Mall | .. | | 6½ | 6¾ | .. | — | .. | .. |
| 42,853 | 5 | .. | Westminster Electric Supply (£4 paid) | 3¾ | 4 | 3¾ | 4 | .. | — | 4 | .. |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | | | |
| 63,416 | 3 | .. | Brush Electrical Engineering | 1⅞ | 2⅜ | 2¼ | 2½ | .. | .. | 2 7/16 | 2⅜ |
| 63,416 | 2 | 1/1 | Do. 6 per Cent. Preference | 1½ | 2 | 1½ | 2 | 6 0 0 | June and December | 1¾ | .. |
| 20,000 | 5 | 3/6 | Crompton and Co., 7 per Cent. Pref. Shares | 5 | 5½ | 5 | 5½ | 6 7 3 | January and July .. | .. | .. |
| 17,139 | 5 | .. | Edison and Swan United | .. | | .. | | .. | .. | .. | .. |
| 45,000 | 10 | 6% | Electric Construction | 5 | 6 | 5 | 6 | .. | .. | .. | .. |
| 70,000 | 2 | 10/0 | Elmore's Patent Copper Depositing | 2¾ | 3¼ | 3 | 3½ | .. | .. | 3¼ | 2 15/16 |
| 20,000 | 5 | .. | Fowler-Waring Cables (£4 paid) | 2½ | 3½ | 2½ | 3½ | .. | .. | .. | .. |
| 41,600 | 10 | 10/0 | India Rubber, Gutta Percha & Telegraph Works | 18½ | 19½ | 19 | 20 | 5 0 0 | February & August | 19½ | 18¾ |
| £200,000 | 100 | 4½% | Do. 4½ per Cent. Debentures, 1896 | 104 | 106 | 104 | 106 | 4 4 11 | March & September | .. | .. |
| 11,334 | £10 | 6/1 | International Okonite Limited Ordinary | 8½ | 9 | 7 | 8 | .. | .. | .. | .. |
| 11,334 | £10 | 5/0 | Do. Preference | 9¼ | 9¾ | 9¼ | 9¾ | 8 4 1 | .. | .. | .. |
| 78,949 | 5 | 4/10½ | Swan United (£3. 10s. paid) | 4½ | 5 | 4½ | 5 | 6 19 10 | May and November | 4¾ | 4 9/16 |
| 37,350 | 12 | 12/0 | Telegraph Construction and Maintenance | 46 | 48 | 45 | 47 | 5 0 0 | March and July..... | 46½ | 44½ |
| £150,000 | 100 | 5% | Do. 5 per Cent. Bonds, red. 1894 | 102 | 105 | 102 | 105 | 4 15 3 | January and July .. | .. | .. |
| | | | **RAILWAYS.** | | | | | | | | |
| 50,000 | £10 | .. | City and South London Railway | 5½ | 6½ | 5½ | 6½ | .. | .. | 5 | .. |


# IMPROVEMENTS IN DYNAMOS




## STATTER-BRUNTON DYNAMO.

**The latest design in the market, made with all the advantages of the latest scientific knowledge and the highest mechanical skill.**

The woodcut represents our B TYPE DYNAMO. A most efficient machine, working noiselessly, and without sparking or overheating; is highly finished and well proportioned. The output is so rated in our Catalogue that the machines may be worked very much in excess of their stated full output for short periods.

**STOCK SIZES UP TO 77 KILOWATTS.**
**MACHINES BUILT TO 500 KILOWATTS.**

**THE ELECTRICAL ENGINEERING CORPORATION. LIMITED,**
STATTER'S] [UNITED

68, Victoria Street, London, S.W.

WORKS:—ALLIANCE ENGINEERING WORKS, WEST DRAYTON, NEAR LONDON.


Digitized by Google

THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 671.—Vol. XXVI. FRIDAY, MARCH 27, 1891. Price Fourpence.

# NOTES.

It has been suggested by an ingenious evening contemporary that the Postmaster-General's course of action in regard to the Boy Messenger Company, is dictated solely by the desire to afford an "object lesson" writ very large, of the disadvantages of State interference. The Board of Trade is apparently doing likewise. The complicated tangle which that department has managed to make of such a simple matter as a clause for the protection of telephones, is a powerful argument against Governmental meddling in concerns which do not necessarily affect the public weal. The whole history of this unfortunate muddle is concisely set forth in the admirable report of the Sub-Committee of the Electrical Trades' Section, which will be found in another column. As a question of principle the Chamber of Commerce would do well to take the matter up.

The latest dispute which has arisen between the Municipal Council and the Paris electric lighting companies shows the danger of fixing charges on too scientific a basis. it has been asserted that the ideal method of charging for current supplied is by the light it produces. Now the Paris authorities, in fixing the price of the electric light, took the price of gas as the basis of their calculations. They assumed that a light of one carcel was produced for a consumption of some three cubic feet of gas per hour, and worked out the cost of the carcel hour at about 3d. Then they said to the electric light companies, you shall be allowed to charge some 50 per cent. more than this, namely, ·432d. per carcel hour. French lamp makers were equal to the occasion, and a lamp having a three-watt efficiency was soon on the market, at least so we must conclude, since the charge per 1,000 watt-hours was worked by the companies at 14·4d., which a little calculation will show can only be justified on that assumption. Taking the more ordinary efficiency of 4 watts per candle, the price per B.T. unit comes out at 10·8d.

In order that those of our readers who are interested in such matters may have an opportunity of comparing English with German practice, we publish in another column the full text of an Electric Lighting Bill at present before the German Parliament. The scope of the Bill is much wider than that of our own Act of 1882 (which relates solely to electric supply), including, as it does, private installations and electrical factories. For the cumbersome and costly procedure, which in this country is a necessary antecedent to the obtaining of electrical lighting powers, is substituted a month's notice to the Postal Telegraph Department, the Local Authority, and persons likely to be interfered with. If there is no opposition the Local Authority may give assent to the scheme subject to such conditions as it may think fit to impose. In case of refusal to grant permission an appeal within two weeks to the Central Land Court is open to the promoter. As an offset to this straighforward method there is frequent mention of special police regulations, so that it is possible that the evil day of petty harassing is in Germany only postponed until the electric light scheme is in operation, while with us Provisional Orders once obtained, comparative peace and quiet is assured.

The misrepresentation of the remarks of Mr. Newman Lawrence and Dr. Harries by our correspondent, last week, does not appear to us so serious as their letter in the present issue suggests; indeed, some of the qualifications which he omitted, accentuate rather than modify some of the views expressed. On the interesting subject of cataphoric medication, our correspondent gave several criticisms which we omitted. He complained that no counter-experiment was adduced, and that, in the absence of this, not even a qualitative experiment is of much value. The authors compare the effect of a drug applied by a pad under a metal electrode, a compress, in fact, with the mere painting of the solution on the skin. They have on former occasions brought forward interesting information on this subject, and we hope soon to hear more actual facts about it. Meanwhile, these gentlemen should remember that useful as their work is, they have hitherto met with but little criticism; less, probably, than they care for.

In the January number of the *Journal de Physique* will be found an account of some remarkable experimental work, by Mr. Otto Weiner, made with the object of determining the direction of the vibrations in a beam of polarised light. Hertz succeeded in getting stationary electro-magnetic waves by reflection at a metallic surface, and, as light waves only differ from these in mere magnitude, it occurred to Mr. Weiner to apply the method to a beam of polarised light reflected from the surface of a plane mirror. The method of test employed was very interesting, on account of its delicacy. If the light is reflected normally by the mirror the nodes and internodes occur in planes parallel with the reflecting surface, but by inclining a thin photographic film at a very small angle with the mirror, it was found possible, in spite of the minuteness of the wave length, to sufficiently separate the parts of the film where interference took place to obtain

Digitized by Google

photographic bands corresponding with them. The study of these bands, obtained under different circumstances, confirms FRESNEL'S theory in several ways. It is shown that in the act of reflection a reversal of phase occurs, and also that the chemically active vibrations are always perpendicular to the plane of polarisation. The latter point is important, and was established by studying the effect of reflecting polarised light at an angle of about 45deg. with the mirror. When the plane of polarisation coincided with the plane of incidence well defined bands were obtained, but when the planes were perpendicular to each other, none could be detected. The experiments form an interesting instance of the reaction, on optical theory, of recent researches on electrical oscillations; and, when taken in conjunction with the work of HERTZ and TROUTON, they prove for the first time that there is a distinct optical difference between the two kinds of vibration which occur in an electromagnetic wave. The magnetic vibrations have no influence on a photographic film, while the electric vibrations are chemically active.

THE conclusion that the electrical vibrations are those associated with chemical effect seems only natural when it is considered what close relations chemical and electrical phenomena exhibit. The electromotive force of a voltaic cell can be calculated from the chemical affinity of its different constituents, and the quantity of an electrolyte decomposed by the passage of a current is strictly proportional to the quantity of electricity which causes the decomposition. Many chemists have endeavoured to explain chemical action by supposing the atoms to be electrically charged, and it is possible that all known cases of electrification are to be accounted for by the presence of free atoms on the charged surfaces. Prof. J. J. THOMSON has very successfully applied the theory of atomic charges to explain the passage of electricity through gases; while in the current number of the *Philosophical Magazine* he endeavours to show that, even in the case of conductors, we may reasonably suppose that the passage of electricity through a body is essentially accompanied by chemical changes, and that, in fact, ordinary conduction is ultimately a form of electrolysis. That moceular actions take place is shown by the heating which occurs, and the change of structure ultimately caused by the passage of the current. On the other hand, very few instances are known in which magnetic phenomena exert any direct or indirect influence over chemical actions, so that it is not surprising to find that the magnetic vibrations in an electro-magnetic wave exert no chemical effect. To which set of vibrations is due the sensation of light experienced by the eye, Mr. WIENER'S experiments do not determine; and thus partisans of FRESNEL'S theory cannot claim that its truth is established by this research until they can show that the stimulation of the optic nerve is of the nature of a chemical action, and not of a magnetic one. It appears that the idea of determining the direction of the vibrations in a beam of polarised light by analysing the interference of two rays crossing at right angles is not new, having been suggested by Mr. ZENKER, of Berlin, in 1867. Mr. WIENER, however, was able to devise an indicator of sufficient delicacy to test the phenomena experimentally.

THE movement which has recently been made by Dr. FOERSTER, at the congress of makers of surveying instruments, at Bremen, in favour of the centesimal method of measuring angles elicited the fact that this system is gaining favour in Germany, and that its unpopularity is chiefly due to the unsatisfactory arrangement of the trigonometrical tables which have hitherto been published on the centesimal method. The circle, according to the German system, is divided into 400 degrees, instead of 360. The new graduation has been extensively employed at Baden, and since 1820 it has been used on the Government surveys. This change is, we think, rather too sweeping, abolishing, as it does, our convenient and well-known angles of 30°, 45°, and 60°; but we would gladly welcome a decimal subdivision of the degrees, retaining 90° to a quadrant.

THE transition from degrees to minutes always strikes us as barbarous. We arrive at a sine or tangent by simple decimal arithmetic, and turn to the tables to find the angle, for the purpose perhaps of finding its cosine or some other trigonometrical function. We find the nearest degree at once, and then we are forced into figures of another notation, interrupting the train of thought, and necessitating the careful use of proper signs to distinguish them from decimals, while confusing them with feet and inches. Where it is not necessary to use trigonometrical tables, we naturally fall into decimals, and at a recent meeting of the Physical Society, angles expressed in decimals of a degree, and in minutes, were given on the blackboard simultaneously. The complete change will no doubt come in the course of the next century, but it will probably follow the extension of the decimal system in other and more popular directions. The complete change after all only gives us 50° for 45°; and the well-known figures 33·33° instead of 30°. Meanwhile, the abolition of minutes and seconds would be a most useful preparation.

SURVEYORS, sailors, and astronomers are perhaps more concerned with angles than anyone else. The profession of the first is, or should be, a branch of engineering, and it is among engineers and scientific men that the decimal system has made its way. The second are rapidly becoming engineers, and, indeed, should be scientific engineers if they are to understand the modern warship and her intricate details. And lastly, astronomers are nothing if not scientific. No obstacle should be raised by them. Perhaps the most serious difficulty would be felt in connection with the Nautical Almanac. But electrical engineers have little to do with that important publication, and the decimal subdivision of angles would be peculiarly useful to them because minutes and seconds are the more troublesome since they have so rarely to use trigonometrical tables.

**St. Pancras Electrical Exhibition.**—It has been decided to keep this Exhibition open until April 1st.

**Personal.**—Mr. H. D. Wilkinson has been appointed electrical engineer to the Executive of the Royal Naval Exhibition.

**Telephone Extensions in Bavaria and Wurtemberg.**—The towns of Stuttgart and Ulm will shortly be placed in telephonic communication with Neu Ulm, Augsburg, and Münich.

Digitized by Google

**Hanover.**—The public supply of current was commenced on the 4th inst., and will be continued during the present month without any charge being made.

**Potsdam.**—The town of Potsdam is to be lighted by electricity. The central station is to be built by the German Continental Gas Company of Dessau.

**Telephonic Communication with Heligoland.**—A telephone now connects Heligoland with the bathing island of Sandy, and another connects it with Cuxhaven.

**Proposed Electrical Exhibition at the Crystal Palace.**—It has been decided by the Directors of the Crystal Palace to hold an Electrical Exhibition there in the autumn.

**Institution of Civil Engineers.**—On Friday, April 3rd, the students of this Institution will visit the mechanical laboratory of the Central Institution, Exhibition-road.

**"Cost of the Generation and Distribution of Electrical Energy."**—A Paper on this subject will be read by Mr. R. E. Crompton before the Institution of Civil Engineers on Tuesday, April 7.

**New Westinghouse Traction Motor.**—Following the example of the Thomson-Houston Company the Westinghouse Company have brought out a "single reduction gear" motor for tramway purposes.

**Indian Telegraphs.**—Something like 1,800 miles of wire were added to the Indian telegraphic network last year, and the profit on the operations of the year amounted to about 21 lakhs of rupees.

**Electric Lighting of the Hamburg Municipal Theatre.**—At a recent meeting of the Town Council of Hamburg, it was decided to vote the sum of £15,000 to the electric lighting of the Municipal Theatre.

**City and South London Railway.**—The Directors of the City and South London Railway Company are introducing on their trains a system of tablets which indicate to passengers the name of the next station.

**Telephonic Communication between London and Brussels.**—According to the Brussels correspondent of the *Times* the question of establishing telephonic communication between Brussels and London is under consideration.

**Technical Instruction Bill.**—This Bill having been read a third time in the House of Lords on Friday evening, was passed after amendment. The Lords' amendments to the Bill were considered and agreed to by the Commons the same evening.

**Electric Traction at Marseilles.**—The Compagnie Française des Tramways has adopted the overhead trolley system of electric traction for its new line at Marseilles. The work has been entrusted to MM. Sautter Harlé et Cie., and to the Oerlikon Works.

**Proposed Berlin-Vienna Telephone Trunk Wire.**—It is intended to lay a telephone line between Zittau and Reichenberg. This will establish connection between Berlin and Vienna, as lines already exist between Berlin and Zittau, and between Vienna and Reichenberg, through Pesth.

**Coast Telegraphic Communication.**—Telegraphic communication between the coastguard station at Ilfracombe and Morthoe, will, it is stated, shortly be established. The necessity of this has been long felt in the locality, and repeated efforts have been made to induce the authorities to carry out the proposal.

**Telegrams for Jelebu.**—Telegraphic communication has now been extended to Jelebu, in the Malay Peninsula, and telegraph offices have been opened in the towns of Jelebu and Kwala Kwalang. The rates are as follows for each word:—Eastern Company, 6s. 7d.; Indo-European Company, 6s. 7d.; *viâ* Turkey, 6s. 5d.

**Bristol.**—The Electric Light Committee of the Town Council have authorised Mr. Preece to proceed at once with the necessary steps for the initial electric light installation. The Temple Backs site will be at once cleared for building purposes. It has also been decided to appoint an engineer at a commencing salary of £300.

**Appointment Vacant.**—The Corporation of Bristol being about to establish an electric light installation, requires the services of a mechanical and electrical engineer, who has been trained in first-class workshops, and is thoroughly familiar with the theory and skilled in the practice of steam and of electrical science, machinery and appliances, and able to superintend and take charge of the same. Particulars will be found in our advertisement columns.

**Proposed Underground Electric Railway in Berlin.**—The Thomson-Houston International Electric Company have sent in a petition to the chief magistrate of Berlin, asking for permission to construct and work an underground electric railway in Berlin. The proposed railway to be built in iron tunnels similar to the City and South London Railway.

**The Albert Medal.**—The Council of the Society of Arts will consider early in May next the award of the Albert Medal, and invite members of the Society to forward to the secretary, on or before April 18th, the names of such men of high distinction as they may think worthy of the honour. The medal was struck to reward "distinguished merit for promoting arts, manufactures, or commerce."

**Postal Telegraph Appointments and Promotions.**—We notice that Mr. J. Little, formerly of West Strand Telegraph Office, has been promoted from the Postmastership of Staines to that of Chichester. Mr. G. F. Herring, telegraphist at Southport, has been appointed Postmaster of Beverley; and Mr. C. S. Covington, telegraphist at the Central Telegraph Office, Postmaster of Goole.

**The Italian Telegraph Service.**—The growth of the telegraphs in Italy is shown by a recent report of Mr. Dering, the Secretary of the British Embassy at Rome. It appears that at the end of 1861 there were 355 telegraph stations, exclusive of Venice and Rome, of which 40 were railway offices. At the close of 1871 the total amounted to 1,351, while in 1889 the number had risen to a total of 4,283, composed of 2,477 Government and 1,806 railway offices.

**Glasgow.**—Only four tenders for the lighting of the "compulsory area" scheduled by the Glasgow Electric Lighting Provisional Order have been received. The following firms tendered:—Messrs. Mavor and Coulson, R. E. Crompton and Co., the House-to-House Company, and the Thomson-Houston Company, of America. The Special Committee on Electric Lighting have seen the tenders, but have not done anything in regard to them. They have resolved to pay a visit to Bradford and Leeds to learn if they can collect any information.

**Electric Traction in Guernsey.**—In our issue of February 6th the Guernsey Railway Company invited tenders for the working of their line $2\frac{3}{4}$ miles long by some overhead system of electric traction. Tenders were received from Messrs. Siemens Bros. and Co., the Westinghouse Electric Company, the Brush Electrical Engineering Company, the Electrical Engineering Corporation, the Electrical Construction Corporation, Messrs. Crompton and Co., and the Thomson-Houston International Electric Company. The tender of Messrs. Siemens Bros. and Co. has been accepted.

**The Electric Light in the Suez Canal.**—Last year of a total of 3,389 vessels as many as 2,836 are reported to have employed the electric light. The following table shows the progress that has been made in diminishing the average time of transit:—

| —— | 1887. | | 1888. | | 1889. | | 1890. | |
|---|---|---|---|---|---|---|---|---|
| | h. | m. | h. | m. | h. | m. | h. | m. |
| Average time of transit ........... | 33 | 58 | 31 | 15 | 25 | 50 | 24 | 06 |
| " with electric light... | ... | | 21 | 26 | 22 | 30 | 22 | 09 |
| Shortest time........................ | 14 | 65 | 14 | 55 | 14 | 45 | 14 | 15 |

**The Telegraph Line between Calcutta and Bombay.**—It was a great event in the annals of Indian telegraphy, says the *Indian Engineer*, when one day last week the new copper wire just completed between Calcutta and Bombay, along the line of the Bengal-Nagpore Railway, was worked direct for the first time. Messages at once poured in as fast as the operators could receive and signal them, showing how the line is likely to be appreciated by the public. The total length of the circuit is nearly 1,300 miles, and the Indian Department can now boast that it works the longest aerial circuit in the world.

Digitized by Google

**Aberdeen.**—Some time ago the Gas Committee of the Town Council issued circulars to gas consumers whose annual bills amount to £5 and upwards, within the area scheduled by the Board of Trade, asking whether they would be likely to adopt the electric light. It was carefully explained in the circular that the quantity of electricity sufficient to give the same amount of light compared with gas was estimated to cost about four times the price of gas. It is not surprising, therefore, that the replies show that gas consumers whose accounts represent annually a total in all of £4000, do not wish the light; consumers representing £900 have not made up their minds, and consumers representing £100 are favourable. The Corporation now propose to allow a Company to come in.

**Gas and Electric Light Mains in Paris.**—At a recent meeting of the Paris Municipal Council the Director of Works reporting on an accident in connection with the Popp Company's mains which has lately taken place in the Rue Royale, stated that, in his opinion, gas and electric light mains should be kept as widely apart as possible, and he proposed to submit sundry regulations on this point to the Council at an early date. The Council, after the reading of this report, passed a resolution calling for a complete list of the accidents attributable either to gas or electricity, to be submitted to the Council, together with the new regulations, at the earliest possible date. The Council at the same meeting voted £240 for the expense of analysing the smoke emitted by municipal works.

**The Lighting of the City.**—"The Commissioners of Sewers," says the *Journal of Gas-Lighting,* "ever since the days of Jablochkoff, have neglected the possibility of improvement in gas lighting, presumably in view of the prospect of the City streets being delivered over, some time or another, to the electricians. Then, at the last, they take a plunge from old-fashioned gloom into meretricious glitter; paying for superfluous brilliancy far more than either it is worth or than they ought to afford for such a purpose." On the other hand, in the *Saturday Globe* of New York, we read that "London has for many centuries bent the knee and veiled the eyes before the presence of her November fogs; now, however, the grim visitor must yield before the radiant usurper of her wintery throne."

**The Accident at the Walbrook Installation.**—The accounts of the accident at this installation which have appeared in the daily papers were much exaggerated. One of the injured men was back at his work within an hour, and the other the next day (Friday). Mr. Williams is also getting along very well. What took place was somewhat as follows:—Fluctuations having been noticed in the light, Mr. Williams went down to the engine-room and found the two men in charge on the floor insensible. Mr. Williams, in trying to restore them, was himself overcome, and, shortly afterwards, Mr. Frank King found all three on the ground, and became himself in turn affected. An alarm was given, however, and all the sufferers were removed. The mishap was due to the inhalation of coal gas escaping from the engines into the heated atmosphere.

**Science at South Kensington.**—In the House of Commons on Thursday evening last week, Sir H. Roscoe asked the Chancellor of the Exchequer whether an unknown donor had offered £80,000 to build an art gallery on a site at South Kensington, the erection of which would interfere with the purposes for which land was recently bought by Government for housing the science collections, and for the necessary erection of suitable chemical and physical laboratories in connection with the Royal School of Science. In reply, the Chancellor of the Exchequer stated that it was true that a public-spirited gentleman had offered £80,000 to build an art gallery on a site at South Kensington; but the offer only affected about one-tenth of the land recently bought by Government, and the remainder would still be left available, if required, for science collections. The interests of the Royal School of Science, and of the science collections, were being carefully kept in view.

**The Overhead Wire Question in New York.**—In December, 1889, it will be remembered that the New York municipal authorities made a sudden raid upon the overhead electric light circuits, and poles were chopped down in all directions. One result of these energetic measures was an action for damages by the Brush Electric Illuminating Company and the United States Electric Illuminating Company against the city authorities. The first-named Company places its damages at $525,000, while the latter presents a claim for $550,000, making a total of $1,075,000, or £215,000, which the city of New York are called upon to pay. The claims include the temporary loss of business caused by the destruction of the poles and wires. The defence is that the city has the right to regulate structures in the public thoroughfares which affect the life and health of the public, and that the plaintiffs had wrongfully neglected and refused to remove the poles.

**The London-Paris Telephone Line.**—The capacity per mile of the land line in this country is slightly higher than in France, since the Post Office earths each pole. The 83 miles to Dover have a capacity of ·015 microfarad per mile, the 204 miles in France have ·012 microfarad per mile. The cable, which is 24 miles long, has a capacity of ·23 microfarads per mile. The whole line is perfectly balanced, and the introduction of $\frac{1}{10}$ microfarad into either wire is enough to seriously interrupt communication. The four wires are maintained apart at the uniform distance of 14in. The line was recently put through to the Treasury, and it was found that speaking was quite impossible until the magnet of an indicator was cut out, when communication was found to be excellent. Those who consider that self-induction assists telephony should see to this. The call is made by twelve 6-block agglomerate Leclanché cells. Only two of these are used for speaking.

**Cambridge.**—An inquiry on behalf of the Local Government Board was recently held at Cambridge respecting the application made by the Corporation for authority to borrow £35,000 for the carrying out of the electric lighting scheme. The Town Clerk stated that tenders involving an expenditure amounting to £25,000 had been received, and there was an estimate for a further outlay of £10,000. It was further stated that the authorities of Trinity College alone had intimated that they would require 2,000 lights installed, 1,500 of them to be in simultaneous use. If all the colleges had a similar supply, the first scheme would be quite inadequate. The Inspector then remarked that it was very possible the Local Government Board would say that £35,000 was a very large sum of money to spend on electric lighting when the town was still undrained. Dr. J. A. Fleming then gave evidence in favour of the scheme, and Alderman Balls, Chairman of the Gas Company, argued that the Gas Company had done their duty alike to the town and to the shareholders, and he protested against the Corporation fighting a battle with the money of the ratepayers. The inquiry then closed.

**The Edison Telephone Patents in France.**—In the letter which appeared on p. 586 of our issue of the 13th March, our Paris correspondent referred to a decision which had been recently given in favour of the Edison telephone patents. These patents are owned by the Société Génerale des Téléphones and have between eighteen months and two years to run, being dated December 19, 1877 (English patent No. 2909, 1877), and January 15, 1878. The following is a *précis* of the judgment delivered in the French Court of Appeal. ——The combination of an induction coil and a telephone is novel application of known parts giving a commercial result. The experts' report makes it clear that the advantages of this combination are considerable, and that it is indispensable in the transmission of articulate speech to a distance. If Elisha Gray and Graham Bell employed this combination before Edison, they only did so in connection with the transmission of musical sounds. The conclusion must, therefore, be, that Edison or his assigns have an exclusive property in the combination of the induction coil and a speaking telephone. The instruments seized are, therefore, infringements, and may be confiscated, and it is necessary to grant damages to the Telephone Company; but the Court cannot, owing to absence of precise information, at present, fix the amount. The demand for further reports and experiments is rejected. The Berliner patent only takes date from January 15, 1878, and not from October 16, 1887.

Digitized by Google

## ELECTROMAGNETIC THEORY.—VII.

BY OLIVER HEAVISIDE.

*(Continued from page 567.)*

§ 39. The vectors representing impressed electric and magnetic force demand consideration as to the different forms they may assume. Their line-integrals are impressed voltage and gaussage. Their activities or powers are **eJ** and **hG** respectively per unit volume, and in this statement we have a sort of definition of what is to be understood by impressed force. For, **J** being the electric current anywhere, if there be an impressed force **e** acting, the amount **eJ** of energy per unit volume is communicated to, or taken in by, the electromagnetic system per second; and this should be understood to take place at the spot in question. It must then be either stored on the spot, or wasted on the spot, or be somehow transmitted away to other places, to be there stored or wasted, according to a law which will appear later on. Similarly as regards **h** and **G**.

But this concerns only the reckoning of impressed force, and is independent of its physical origin, which may be of several kinds. Thus under **e** we include,—

(1.) Voltaic force.
(2.) Thermo-electric force.
(3.) The force of intrinsic electrisation.
(4.) Motional electric force.
(5.) Perhaps due to various secondary causes, especially in connection with strains.

And under **h** we include :—

(1.) The force of intrinsic magnetisation.
(2.) Motional magnetic force.
(3.) Perhaps due to secondary causes.

§ 40. Voltaic force has its origin in chemical affinity. This is still a very obscure matter. For a rational theory of Chemistry, one of the oldest of the sciences, we may have to wait long, in spite of the activity of chemical research and of the development of the suggestive periodic law. Yet Chemistry and Electricity are so intimately connected that we cannot understand either without some explanation of the other. Electricity is, in its essentials, a far simpler matter than Chemistry, and it is possible that great light may be cast upon chemical problems (and molecular physics generally) by previous discoveries and speculations in Electricity. The very abstract nature of Electricity is, in some respects, in its favour. For there is considerable truth in the remark (which, if it has not been made before, is now originated) that the more abstract a theory is, the more likely it is to be true. For example, it may be that Maxwell's theory of displacement and induction in the ether is far more than a working theory, and is something very near the truth, though we know not what displacement and induction are. But if we try to materialise the theory by inventing a special mechanism we are almost certain to go wrong, however useful the materialisation may be for certain purposes. No one knows what matter is, any more than ether. But we do know that the properties of matter are remarkably complex. It is, therefore, a real advantage to get away from matter when possible, and think of something far more simple and uniform in its properties. We should rather explain matter in terms of ether, than go the other way to work.

However this be, we have the fact that definite chemical changes involve definite voltages, and herein lies one of the most important sources of electric current. Furthermore, there is the remarkable connection between the quantity of matter and the time-integral of the current (or quantity of electricity) produced, involved in the law of electro-chemical equivalents, which is one of the most suggestive facts in physics, and must be a necessary part of the theory of the atom which is to come. That the energy of chemical affinity may itself be partly electromagnetic is likely enough. That even conduction may be an electrolytic process is possible, in spite of the sweet simplicity of Ohm's law and that of Joule. For these laws are most probably merely laws of averages. The well-known failure of Ohm's law (apparent at any rate) when the periodicity of electromagnetic waves in a conductor amounts to billions per second may perhaps arise from the period being too short to allow of the averages concerned in Ohm's law to be established. If so, this may give a clue to the required modification.

§ 41. Thermo-electric force has its origin in the heat of bodies, manifesting itself at the contact of different substances or between parts of the same substance differing in temperature. Now heat is generally supposed to consist in the energy of agitation of the molecules of bodies, and this is constantly being transferred to the ether in the form of radiant energy, *i.e.*, electromagnetic vibrations of very great frequency, but in a thoroughly irregular manner. It is this irregularity that is a general characteristic of radiation. Now the result of subjecting conductors to electric force is to dissipate energy and to heat them. This is, however, an irreversible process. But when contiguous parts of a body are at different temperatures, a differential action on the ether results, whereby a continued effect of a regular type is produced, reversible with the current, and therefore formularisable as due to an intrinsic electric force, the thermo-electric force. At the junction of different materials at the same temperature it is still the heat that is the source of energy.

The theory of thermo-electric force due to Sir W. Thomson, based upon the application of the Second Law of Thermodynamics (the First is a matter of course) to the reversible heat effects has been verified for conductive metallic circuits by the experiments of its author, and those of Prof. Tait and others. With some success the same principle has also been applied by von Helmholtz to voltaic cells, which are thermo-electric as well as voltaic cells. There are wheels within wheels, and Ohm's law is merely the crust of the pie.

§ 42. Intrinsic electrisation is a phenomenon shown by most solid dielectrics under the continued action of electric force. It is the manifestation of a departure from perfect electric elasticity, and is probably due to a molecular rearrangement, resulting in a partial fixation of the electric displacement, whereby it is rendered independent of the "external" electrising force. Thus the displacement initially produced by a given voltage slowly increases, and upon the removal of the impressed voltage only the initial displacement will subside, if permitted, immediately. The remainder has become intrinsic, for the time, and may be considered due to an intrinsic electric force **e**. If $\mathbf{I}_1$ be the intensity of intrinsic electrisation, and $c$ the permittivity, then

$$\mathbf{I}_1 = c\mathbf{e} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

$\mathbf{I}_1$ is the full displacement the force **e** can produce elastically, all external reaction being removed by short circuiting. It is not necessarily the actual displacement. The phenomenon of "residual charge," "soakage," &c., are accounted for by this **e** and its slow variations.

Maxwell attempted to give a physical explanation of this phenomenon by supposing the dielectric to be heterogeneously conductive. This is perhaps not the most lucidly successful of Maxwell's speculations. How far electrolysis is concerned in the matter is not thoroughly clear.

§ 43. Intrinsic magnetisation is, in some respects, a similar phenomenon, due to a passage from the elastic to the intrinsic form of induction externally induced in solid materials. Calling the intensity of intrinsic magnetisation $\mathbf{I}_2$, we have

$$\mathbf{I}_2 = \mu\mathbf{h}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where **h** is the equivalent intrinsic magnetic force, and $\mu$ the inductivity (elastically reckoned).

In one important respect intrinsic induction is a less general phenomenon than intrinsic displacement. There is no magnetic conductivity to produce similar results as regards the magnetic current as there is electric conductivity as regards the electric current. But if there were, then we could have a magnetic "condenser," with a magnetically conductive external circuit, and get our residual results to show themselves in it, quite similarly in kind to, though varying in magnitude and permanence from, what we find with an electric condenser.

Digitized by Google

The analogue of Maxwell's explanation of "absorption" would be heterogeneous magnetic conductivity. This is infinitely more speculative than the other, which is sufficiently doubtful.

Ewing's recent improvement of Weber's theory of magnetism seems important. But as in static explanations of dynamical phenomena the very vigorous molecular agitations are ignored, it is clear that we have not got to the root of the matter. We want another Newton, the Newton of molecular physics. Facts there are in plenty to work upon, and perhaps another heaven born genius may come to make their meaning plain. Properties of matter are all very well, but what is matter, and why these properties? This is not a metaphysical inquiry, but concerns the construction of a physical theory.

§ **44.** The motional electric and magnetic forces are the forces induced by the motion of the medium supporting the fluxes. To express them symbolically, it will save much and repeated circumlocution if we first define the vector-product of a pair of vectors.

Let **a** and **b** be any vectors, and **c** their vector-product. This is denoted by

$$\mathbf{c} = \mathrm{V}\mathbf{ab}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

the prefix V meaning "vector," or, more particularly here, "vector-product." The vector **c** is perpendicular to the plane of the vectors **a** and **b**, and its tensor (or magnitude) equals the product of the tensor of **a** into the tensor of **b** into the sine of the angle between **a** and **b**. Thus

$$c = ab \sin \theta, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

if the italic letters denote the tensors, and $\theta$ be the included angle of the vectors. As regards the positive sense of the vector **c**, this is reckoned in the same way as before explained with regard to circuitation. Thus, when the tensor $c$ is positive, a positive rotation about **c** in the plane of **a** and **b** will carry **a** to **b**. If the time by a watch is three o'clock, and the big hand be **a** and the little hand **b**, then the vector **c** is directed through the watch from its face to its back. These vector-products are of such frequent occurrence, and their Cartesian representation is so complex, that the above concise way of representing them should be clearly understood.

On this understanding then, we can conveniently say that the motional electric force is the vector-product of the velocity and the induction, and that the motional magnetic force is the vector-product of the displacement and the velocity. Or, in symbols, according to (3),

$$\mathbf{e} = \mathrm{V}\mathbf{qB}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

$$\mathbf{h} = \mathrm{V}\mathbf{Dq}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

where **q** is the vector velocity.

§ **45.** It should be remembered that we regard the displacement and the induction as actual states of the medium, and therefore if the medium be moving, it carries its states with it. Besides this, it usually happens that these states are themselves being transferred through the medium (independently of its translational motion), so that the resultant effect on propagation, considered with respect to fixed space, is a combination of the natural propagation through a medium at rest, and what we may call the convective propagation. Of course we could not expect the two laws of circuitation for a medium at rest to remain true when there is convective propagation.

The matter is placed in a very clear light by considering the very simple case of an infinite plane lamina of **E** and **H** travelling at the speed of light $v$ perpendicularly to itself through a homogeneous dielectric. This is possible, as will appear later, when **E** and **H** are perpendicular, and their tensors are thus related:—

$$\mathrm{E} = \mu v \mathrm{H} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

Or, vectorising $v$ to **v**,

$$\mathbf{E} = \mu \mathrm{V}\mathbf{Hv} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

according to the definition of a vector-product, gives the directional relations as well as the numerical.

Now, suppose we set the whole medium moving the other way at the speed of light. The travelling plane electromagnetic sheet will be brought to rest *in space*, whilst the medium pours past it. Being at rest and steady, the electric displacement and magnetic induction can only be kept up by coincident *impressed* forces, viz. :—

$$\mathbf{e} = \mathbf{E} \qquad \mathbf{h} = \mathbf{H}.$$

Now compare (8) with (5) and (6); consider the directions carefully, and remember that the velocity **q** is the negative of the velocity **v**, and we shall obtain the formulæ (5), (6), which are thus proved for the case of plane wave motion, by starting with a simple solution belonging to a medium at rest.

The method is, however, principally useful in showing the necessity of, and the inner meaning of the motional electric and magnetic forces. To show the general application of (5) and (6) requires a more general consideration of the motional question, to which we now proceed.

*(To be continued.)*

## THE MAGNETIC CIRCUIT OF TRANSFORMERS: CLOSED VERSUS OPEN.

BY S. EVERSHED.

*(Continued from page 599.)*

§ **43.** Suppose No. 2 closed transformer is run by an alternator giving a zig-zag E.M.F. wave (Fig. 11). Of course no such alternator exists, every practicable machine having the angles of the zig-zags rounded off to some extent, but the plain zig-zag can be looked on as a limiting curve more or less closely approached by some actual generators. In dealing with zig-zag functions, such old friends as

$$\text{effective E} = \frac{\text{maximum E}}{\sqrt{2}}$$

and mean power $= \dfrac{\text{max. E} \times \text{max. C}}{2} \cos$ (angle of lag) must be abandoned. If A′ is the maximum value of a zig-zag function, and T the period, the equation to the "curve" from

$$t = 0 \text{ to } t = \frac{1}{4}\,\mathrm{T}$$

is

$$y = \frac{4\,\mathrm{A}'}{\mathrm{T}}\,t$$

and the mean square of $y$ is

$$y^2_m = \frac{4}{\mathrm{T}} \int_0^{\frac{\mathrm{T}}{4}} \frac{16\,\mathrm{A}^2}{\mathrm{T}^2}\,t^2\,dt = \frac{\mathrm{A}'^2}{3}$$

so that the *effective* value of $y$ is $\dfrac{\mathrm{A}'}{\sqrt{3}}$

The *mean* value of $y$ is, of course, $\dfrac{\mathrm{A}'}{2}$, so that mean value = effective value $\times \dfrac{\sqrt{3}}{2} = \cdot 87 \times$ effective value. To find the expression for the mean power in a circuit in which a zig-zag current differs in phase from a zig-zag electromotive force, involves a somewhat tedious integration of several terms, for discontinous functions are here being dealt with, and those of us who are not Oliver Heavisides find it requires very wary walking to avoid a fatal slip into infinity. As the expression when found is of no practical importance, the working out will not be given, but the result may be set down as a curiosity.

Mean power for zig-zag E and C having a time lag $= \theta$

$$\mathrm{W} = \frac{\mathrm{E}'\,\mathrm{C}'}{6}\left(2 - 48\frac{\theta^2}{\mathrm{T}^2} + 64\frac{\theta^3}{\mathrm{T}^3}\right)$$

E′ and C′ are the maxima of E and C; T is the periodic time and $\theta$ is the lag in *time* of C behind E. Note that when $\theta = 0$, $\mathrm{W} = \dfrac{\mathrm{E}'\,\mathrm{C}'}{3}$, as it ought to be; when $\theta = \dfrac{1}{4}\,\mathrm{T}$, the factor in

Digitized by Google

brackets vanishes, and $W = 0$; and, lastly, when $\theta = \frac{1}{2}$ T, and the current therefore cophasal with E, but of opposite sign, the bracketed expression becomes $-2$, and $W = -\frac{E'C'}{3}$, that is to say, the part of the circuit considered is the seat of the electromotive force. With these rough and ready tools we proceed to discuss the working of transformers by a zig-zag E.M.F. wave.

§ 44. The value of a zig-zag E., reckoning time from the epoch when E has its maximum value E′, is

$$E_t = E' - at \qquad = 0 \text{ when } t = \frac{E'}{a},$$

but $E = 0$ when $t = \frac{T}{4}$, so that $a = \frac{4\,E'}{T}$; now since E is the counter E.M.F. in the primary coil, it is due to $\frac{d\,B}{d\,t}$, and is equal to $N\,A\frac{d\,B}{d\,t}$, (A being the area of the core), and we have

$$E_t = N\,A\frac{d\,B}{d\,t} = E'\left(1 - \frac{4}{T}t\right)$$

and therefore $B_t = \frac{E'}{N\,A}\int\left(1 - \frac{4}{T}t\right)dt = \frac{E'}{N\,A}\left(t - \frac{2\,t^2}{T}\right)$ the equation for $\frac{d\,B}{d\,t}$ shows us that B is a maximum when $t = \frac{T}{4}$ as we should expect, and this value being inserted in the equation for $B_t$ we have for the maximum value of B

$$B' = \frac{E'\,T}{8\,N\,A} = \frac{\sqrt{3}E\,T}{8\,N\,A}.$$

Recalling the corresponding expression in the case of a sine function, namely :—

$$B' = \frac{9}{10}\frac{E\,T}{4\,N\,A} = \frac{3\sqrt{3}}{5}\cdot\frac{\sqrt{3}E\,T}{8\,N\,A},$$

we notice that if E is to be 2,000 volts, we must put $E_z = E_s$, or B′ N A F (for zig-zag) $= \frac{5}{3\sqrt{3}}$ B′ N A F (for sine), so that one of the four factors, B′ N A F, must be reduced in the ratio $\frac{5}{3\sqrt{3}}$, or by about 4 per cent., in order that the values of E for the sine function and zig-zag may be equal. The simplest change to make to keep the effective E.M.F. right is to reduce the frequency so that the transformer will require no alteration of windings or core, and the induction cycle will be the same as before, namely 5,000 gausses, so that the the B H curve given in Fig. 9 can be used in drawing the new diagram. The frequency then will be reduced from 70 to 66·4 periods per second, and a slight diminution in the hysteresis loss follows as a necessary consequence. The time scale should remain as before, but quarter periods corresponding to the lower frequency (*greater* periodic time) must be marked before the E.M.F. zig-zag is drawn. E′ is evidently $2{,}000 \times \sqrt{3} = 3{,}470$ volts, and this value is plotted alternately positive and negative at intervals equal to $\frac{T}{2}$, and these points when connected by a zig-zag series of lines, complete the E wave.

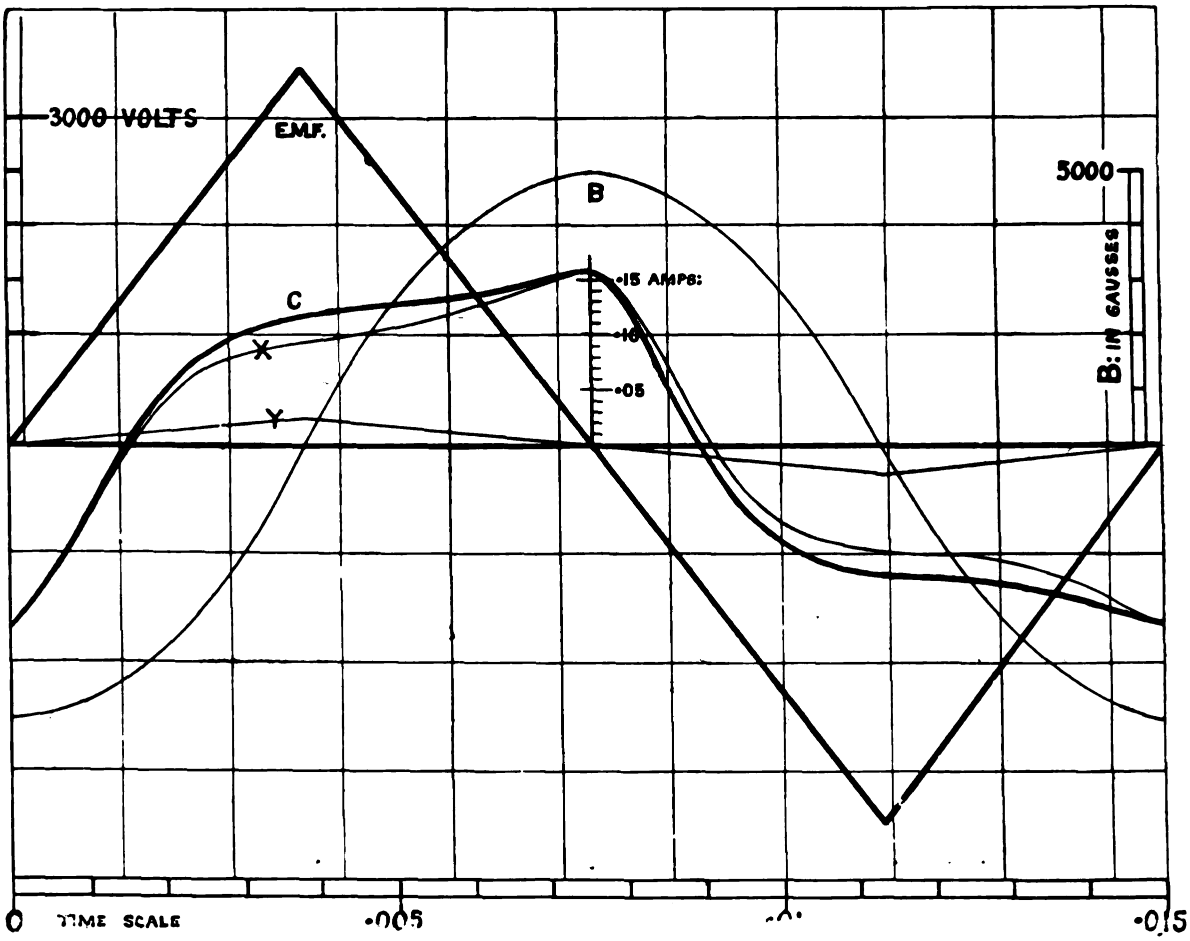



Fig. 11.—No. 2 Closed Transformer excited by zig-zag E.M.F. Output = 0.

§ 45. The induction curve is easily plotted from the equation

$$B_t = \frac{E'}{N\,A}\left(t - \frac{2\,t^2}{T}\right),$$

remembering that T is now $\frac{1}{66\cdot3} = \cdot0151$ second. It is perhaps simpler to eliminate $\frac{E'}{N\,A}$ by inserting the value found for the maximum induction, viz. :—

$$8\,B' = \frac{E'\,T}{N\,A},$$

so that $\qquad B_t = 8\,B'\,F\,t\,(T - 2\,t).$

The geometrical student will see a conic section in these equations for **B**; and in fact the positive and negative waves of induction are a series of parabolas having parallel axes normal to the time axis, spaced at intervals equal to $\frac{1}{2}$T. Where the induction changes sign one parabola ends and the next begins, at which point there is an abrupt change in the *direction* of curvature of the otherwise continuous line. In fact, the value of $\frac{d\mathbf{B}}{dt}$, while having the same numerical value for the curves on each side of zero, suddenly changes its sign; this is, of course, only a roundabout way of saying that E at this epoch suddenly changes the sign of its slope. It is interesting to note how very little the parabolic induction wave differs in form from the sine wave in Fig. 10, *Electrician*, March 20, p. 598; yet how great a change has been brought about in the counter E wave. Note also that the slightest departure from a true parabolic form when carrying the induction wave through zero (so as to make the two parabolas melt into each other with abrupt change) leads to a rounding of the angles in the E zig-zag resulting in a curve closely resembling those given by some actual alternators. No calculations are needed before drawing the X component of the exciting current, for a sufficient number of values of X have already been worked out from the **B H** curve when making Fig. 10. To draw the Y (eddy current) component of the exciting current we require its maximum value, and the investigation made in the case of the sine function diagram shows that this depends only on the maximum value attained by the **H** due to eddy currents, and this again on the maximum of $\frac{d\mathbf{B}}{dt}$ or $\dot{\mathbf{B}}$; now clearly

$$\frac{\dot{\mathbf{B}} \text{ for zig-zag}}{\dot{\mathbf{B}} \text{ for sine}} = \frac{E'_z}{E'_s} = \frac{3470}{2830}$$

so that the required maximum for Y is

$$Y' = \cdot0225 \times \frac{3470}{2830} = \cdot027 \text{ ampere.}$$

Y can now be plotted, being a zig-zag curve cophasal with E.

§ 46. The last diagram we shall draw for this transformer (No. 2 closed) is one in which E is assumed to alternate between − 2,000 and + 2,000 volts (Fig. 12), the change from + to − being instantaneous. The induction wave will now be a zig-zag, for $N A \frac{d\mathbf{B}}{dt} = E =$ constant. In the present case effective E = mean E = maximum E, and E = 4 **B**′ A N F. Now for a sine wave we had E = 4·4 **B**′ A N F, so that we must *increase* one of the factors **B**′ A N F, in order to make E = 2000 volts. As before we will alter the frequency, making it $F = \frac{4 \cdot 4}{4}$ (F for a sine) = 77·6 periods per second. It must be noticed here that if the frequency is worked out from the equation E = 4 **B**′ A N F, by inserting the known values of E **B**′, A and N, the result is F = 76·4 instead of 77·6. The discrepancy is due to our original sin in neglecting the fact pointed out in the first article, that **B**′ is only 4,900 gausses, and not 5,000 as assumed in the whole of the calculations. We must therefore take the value F = 76·4 if we make **B**′ = 5,000. After plotting E and **B**, X may be put in, and we note that it is now precisely the same shape as the **B H** curve from which it is obtained; in fact it is put on the diagram (Fig. 12) just as though the cyclic loop had been placed with its **B** axis along the time axis of the diagram, and the loop then cut at one of its turning points, and the negative portion folded forward along the time axis. Of course the values of **H** are replaced by the corresponding values of C before carrying out the operation. The Y component is of the same form as the E wave, and its value (which is constant) is found by precisely the same method as we have described in connection with Figs. 10 and 11.

$$C' = Y = \cdot0156 \text{ ampere.}$$

(*To be continued.*)

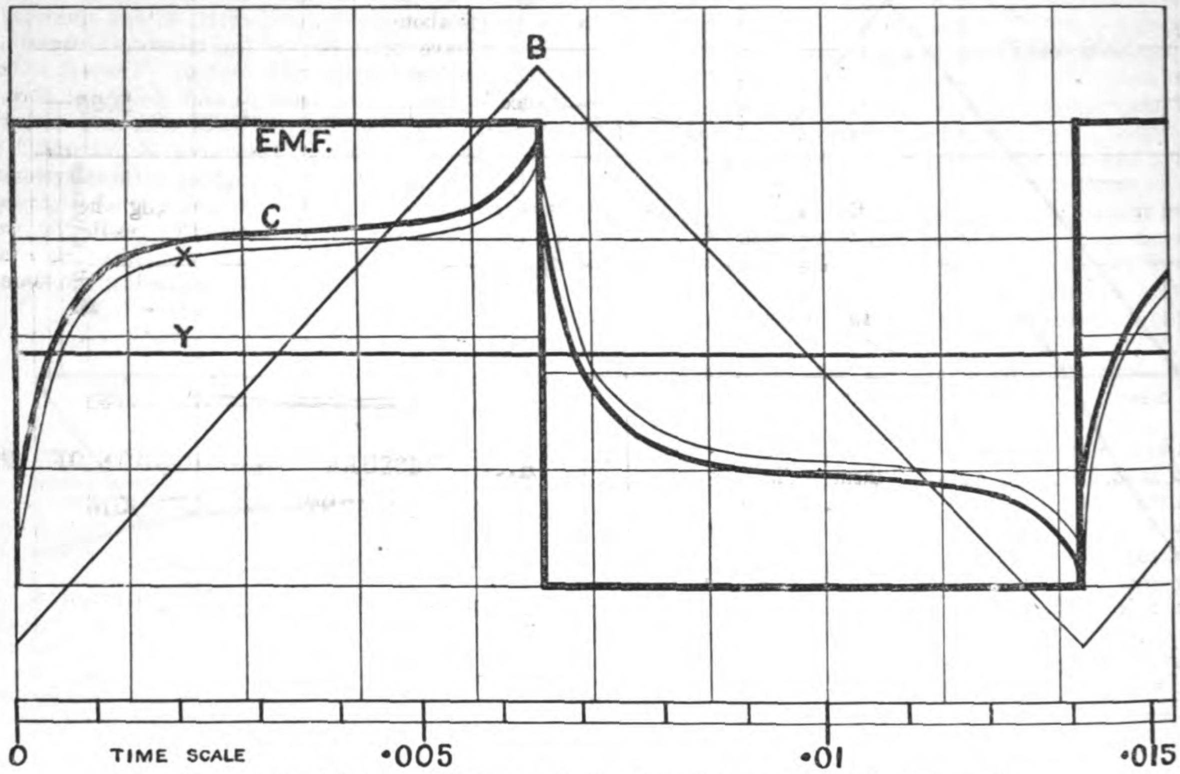


FIG. 12.—No. 2 Closed Transformer excited by alternating constant E.M.F. Output = 0

## ELECTROMOTIVE FORCE.

The side issues of discussions on electrolysis are of more general interest than the fundamental theories. Two papers on this subject were read at the Physical Society on Friday last, and in the latter of these, formulæ were introduced dealing with a number of different electromotive forces which may be assumed to be present in a cell. These, it was said, were "entirely a question of definition." The author suggested that perhaps there was, after all, no "seat of electromotive force" in a cell, in the same way that there is no difference of potential, according to the

Digitized by Google

ordinary use of the term, in a unipolar dynamo. Where is the seat of motive force" in a steam boiler?

If electro-chemists would only consent to drop electromotive forces and differences of potential, and try to account for the observed facts in the first place by simple current, resistance, and energy, there would be some chance that others might follow them, and that the teaching of elementary electricity might be modified. Let current be treated as the important thing, and resistance as that which impedes it. Then consider the volts as a loss or drop due to the resistanee; an effect, not a cause; a consequence, not a principle. Then you can call it "difference of potential," if you like such an academical expression, but "electromotive force" will have ceased to have any remnant of sense. The current and the resistance, according to all authorities, are *in* the conductor, so it is better to deal with them than with energy which (*pace* Mr. Sprague) is elsewhere.

Chemists do not hesitate to say that a chemical combination gives rise to heat, or generates or liberates heat. More broadly, it liberates energy. Why, then, should not a cell be said to liberate energy? Electrical energy is made up of two components, pressure and quantity. Or it may be said to generate power. Power is made up of pressure and current. Why take one of these only, and speak of setting up an electromotive force? It would be just as logical to say that a current is set up. To be exact, one must take both components into consideration, and speak of the energy. But it is difficult to deal with the energy of a circuit. Most students accept the conclusions of Prof. Poynting and the deductions of Dr. Oliver Lodge, while Mr. Sprague is quite justified in opposing them, because he cannot believe them, and he attempts to find another explanation. In the meantime, the student may leave open the difficult question of energy; and if he is to deal with one component, let current be that component. When a cell is on open circuit, it tries to generate a current and cannot. It only succeeds in giving an electrostatic charge to its terminals. Measure that electrostatically if you will, and estimate it in volts by all means. What do we want with electromotive force?

Again, you have a pair of terminals on an electric supply system. You have 100 volts between them. The current is ready to rush through the lamp when it is connected. Why need you say that, in the first place, there are 100 volts waiting for the lamp, and as soon as it is switched on these volts urge a current through the filament? Why not say that the magnetic field in which the armature of the dynamo rotates urges a current through the wire? You measure the amount of urging by noticing the relation between the current that will pass, with this urging, through a resistance. But if the current being constant, the resistance were reduced to a minimum, the urging would vanish also, but the current would still be there. Let the current, then, be the main thing, and of the first importance. Then consider the resistance, and leave the volts to take care of themselves. To teach electrical science thus, the text-books would have to be re-written. No matter, they need it.

Electro-dynamics would get on very well if current were put first and difference of potential followed as a result. Oersted's experiment of the deflection of a magnetic needle by a current can be clearly explained, and is generally taught without any allusion whatever to electromotive force. Such a needle was used by Wheatstone for driving clocks by suitably-timed impulses. A magnetic needle in a simple galvanometer coil may then be considered as the simplest form of electric motor. It is reversible; the motion of the needle in the coil will generate a current. But to account for the *reversed* action a totally different explanation is generally offered, and the cutting of lines of force by closed conductors is said to give rise to electromotive force, and, except under certain circumstances, to a difference of potential. Let it be granted that a dynamo and a motor are not designed on exactly the same lines, and that therefore a dynamo is not strictly reversible. But the want of complete reversibility is so slight that it has often been ignored; it consists of certain secondary effects. The general principle is reversible, why, then, should not the explanation be reversible? It is less difficult to imagine how magnetic induction sets up a current than to understand how "cutting" or "linking" lines of force can set up an "electromotive force." Every student is expected to accept this "explanation." The electro-chemists, too, stop the way with their "seat of electromotive force." Take the old paradox of a hundred cells, each giving one volt, and each of one ohm resistance; join them all in series in one "*couronne de tasses.*" One ampere will then flow through one hundred ohms. According to Ohm's law, there should be one hundred volts. Take a voltmeter, you who are so fond of electromotive force, and show us where and between which two points you will find these hundred volts. Take an electrometer, a proof plane, what you will; show us this difference of potential. If you take a proof plane and carry it round, you are cutting lines of force and are doing work. Carry it ten times round, and you will get a thousand volts. If you try and talk about cyclic potential you will drift into metaphysics.

This is not a question of what is the ultimate truth and the real accurate description, but one of ordinary every-day use of scientific terms, especially in relation to teaching. The idea of pressure or voltage must often present itself, but it is too often treated as the thing generated, and thus confusion arises, especially when it is necessary to locate it. It is easy to get into a tangle about cause and effect, we can generally observe effects and have to guess at the number of causes present. Let some teacher change this system. Current is there and resistance is there; work, energy, and power are there. It is no explanation to say that in some awkward cases there is electromotive force, but no difference of potential. Exactly the same thing happens when a magnet is thrust symmetrically through a ring. Dr. Oliver Lodge's cog-wheel analogy will readily give an idea how the magnetism pulls the current in the ring. You get the current and you have the resistance, but as the pressure is generated and used at the same place, you cannot point to the difference of potential. If electromotive force wants a seat, let it take a back seat.

## THE HIGH-PRESSURE TRANSMISSION OF POWER EXPERIMENTS AT OERLIKON.*

BY DR. OSCAR MAY.

As is already known, the Maschinenfabrik Oerlikon, in conjunction with the Allgemeine Elektricitäts Gesellschaft of Berlin, propose to transmit 300 horse-power derived from a waterfall at Lauffen, near Heilbronn on the Neckar, to Frankfort-on-Main, in connection with the Electrical Exhibition. This transmission is, of course, to be effected by electricity, and the power obtained is to be used both to run motors and lighting installations. The distance between the two places is not less than 112 miles, and the conductor will have to pass through portions of Württemberg, Bavaria, and Prussia. The allowable fall in potential being taken at 10 per cent., and the section of the copper at ·06 sq. in. (38 sq. mm.), we find that the current strength must be about eight amperes and the initial pressure about 27,600 volts. A pressure as high as this has not hitherto been applied for transmitting power. The nearest approach to it is the pressure of 10,000 volts in the Deptford mains, which, however, have not yet (February 5, 1891) started work permanently. It was consequently decided, having regard to the enormous length of conductor required and to the fact that pressures of 20,000 volts and upwards are no more dangerous than those of 1,000 volts (inasmuch as either may prove fatal if proper precautions are not taken), to carry on preliminary experiments to prove that currents at pressures hitherto unapproached may be made to satisfy all demands as to reliability in working, insulation and immunity from danger. The utilisation on the spot of natural sources of energy such as waterfalls and coal beds, and the construction of huge plants for the distribution of the power in a rational manner to various localities are advantages which must cause all objections to the high pressures to be overcome. The state of affairs is similar to that which obtained before the introduction of steam boilers, gas lighting, railways, &c., with this important difference that whereas these, in spite of rules and regulations, annually give rise to thousands of fatalities, the use of electricity of a "fatally high" pressure, although it has been employed for many years in several countries,

* From the *Elektrotechnischer Anzeiger.*

notably in Germany, has hitherto caused very few fatal accidents. The objection that the danger of a high pressure current increases with the length of the conductor is hardly likely to be brought forward now when conductors of such lengths as to prohibit their being continually watched throughout have frequently been erected without any dangerous results following. The installation carried out in 1882 by Marcel Deprez between Miesbach and the Münich Exhibition may be cited. In this case the Bavarian Government acted most liberally, as they erected the line under the direction of their telegraph engineer, Herr Behringer. Its length was 35½ miles, which was quite long enough to make it impossible to keep

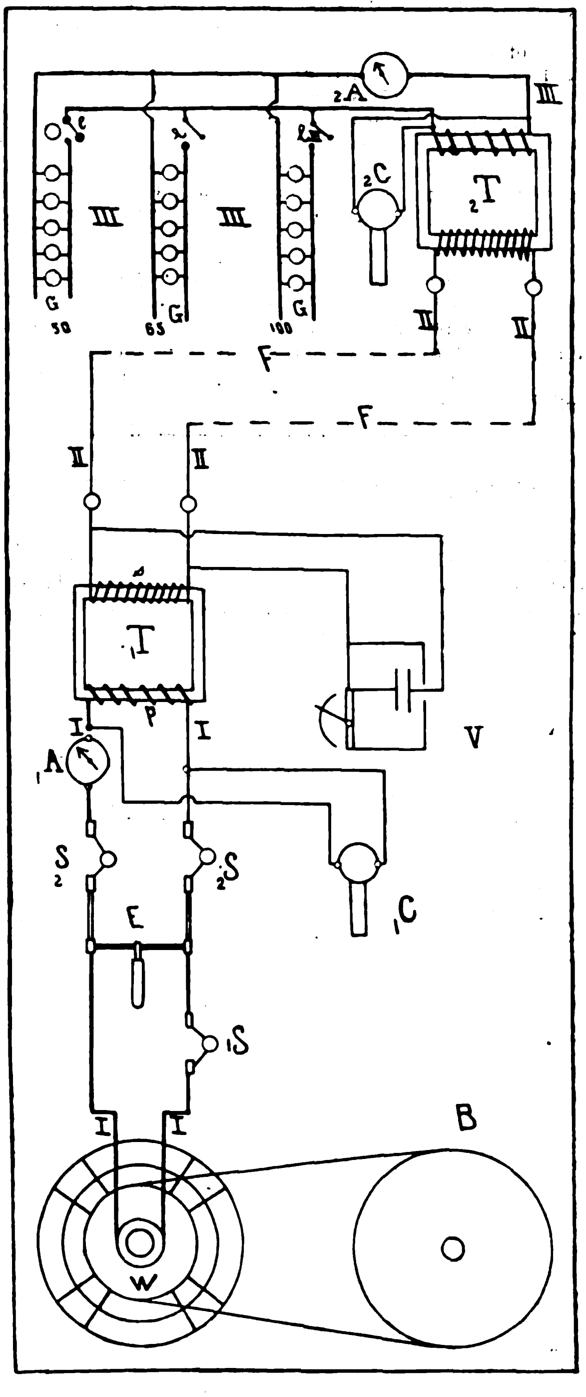



FIG. 1.—Diagram of the Oerlikon arrangements for Transmitting Power at High Pressure.

B source of power, W alternator, S safety fuse, $A_1$ and $A_2$ ampere meters, $T_1$ and $T_2$ transformers, $C_1$ and $C_2$ Cardew voltmeters, V Thomson electrostatic voltmeter, $G_{50}$, $G_{65}$, $G_{100}$ banks of glow lamps for 50, 65, and 100 volts respectively; F main conductor, I. primary, II. secondary, and III. tertiary, E and e switches

the whole of the line under constant supervision. It was worked at a pressure of from 1,000 to 1,300 volts, quite high enough to be considered "fatal," but no accidents happened.

For carrying out the Lauffen-Frankfort scheme, as in that between Miesbach and Münich, the consent and assistance of the local authorities, and in particular the postal and telegraph authorities was necessary. In order to obtain an impartial opinion on the practicability of the scheme, the committee of the Frankfort Exhibition invited these authorities to inspect the model plant erected by the Maschinenfabrik Oerlikon. This inspection took place on January 24th.

The arrangement of the test plant was as shown in the accompanying sketch (Fig. 1). The source of power was one of the electromotors in the factory, from which the pulley of the alternator was driven, the voltage given out by it being capable of regulation between 40 and 100 volts by altering the speed. In the Lauffen installation it is intended to use machines giving 4,000 amperes at 50 volts. In this respect the Oerlikon system differs from most of those employing alternators and transformers. This arrangement is regarded as decidedly cheaper, besides ensuring greater safety in working. From the alternator the low-tension current is led by the primary conductor to the tranformer $T_1$. The primary conductor is provided with a sensitive cut-out $S_1$, with a two-pole switch E and a two-pole Cockburn cut-out $S_2$. The working of these cut-outs was entirely satisfactory. The transformer $T_1$ was on Mr. C. E. L. Brown's system, and consisted of a core built up of sheet iron, on which are wound the primary and secondary windings in coils of circular section. The magnetic circuit is closed by two ⊔-shaped irons as shown in Fig. 2. Experiments have proved that for such high tensions vulcanite is an adequate insulator so long as it remains undamaged, but that as soon as a crack appears in it sparking takes place through the air which fills the crack. Some varieties of oils

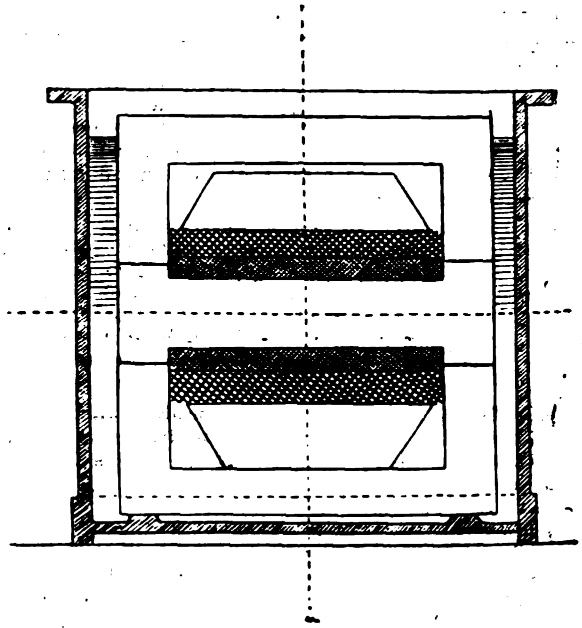


FIG. 2.—Section of the Oerlikon Oil Transformer.

have been proved to be as efficacious as vulcanite in the way of insulation; in order, therefore, to prevent a spark passing, the transformer as shown in the figure is enclosed in a chamber filled with oil, so that the oil fills the whole of the otherwise unoccupied space, and expels the air which might endanger the insulation. According to Mr. Brown, transformers constructed on this principle are perfectly safe up to pressures of 50,000 volts. The transformer multiplied the pressure 300 times. The currents supplied by the alternator in the present tests were at pressures of 40, 50, 65, 100, and 110 volts, so that in the secondary conductor pressures of 12,000, 15,000, 20,000, 30,000, and 33,000 volts were obtained. The conductor consisted of about ½ mile (1 km.) of bare copper wire of ·16in. (4mm.) in diameter, which was laid in four parallel lines on the same posts. The line was insulated from earth by Johnson and Phillips' oil insulators. The insulation was tested by allowing a hydrant to play upon the insulators. A 100-volt Cardew voltmeter was connected between the high-pressure secondary conductor and earth and showed no deflection. No leakage was observed during the recent snowstorms. In the experiments the number of insulators used was altogether 120. In the actual line, copper wire of ·16in. (4mm.) diameter will be used in spans of from 260 to 330ft., so that the test installation represented from 6¼ to 7½ miles of the actual line, so far as regards the insulation resistance of the insulators. The secondary conductor is led to a second transformer, $T_2$, which reduces the pressure 300 times, so that the current in the tertiary circuit is at the same pressure as that in the primary, which is fed direct by the alternator.

Digitized by Google

The tests of special interest were those relating to the action of the safety fuses, to the distance through which a discharge could take place through air, and to the working of a telephone circuit arranged parallel to the main wires on the same poles. In order to test the safety fuses, both a direct short circuit and the discharge current were employed. As may be seen from Fig. 1, the fuses were placed in the primary circuit. This was done, as it was impracticable to put them in the secondary, since the current strength in the latter is so small that it would have been necessary to use inconveniently thin wires. When the secondary conductor was short circuited by dropping across the two portions of it a short copper wire, the safety fuse was instantaneously melted. As is well known, the production of a momentary short circuit and the consequent melting of a fuse, both produce slight noises: in this case it was not possible for the ear to distinguish even the slightest difference in time between them. The extreme rapidity of the action is further shown by the fact that neither the secondary mains nor the short-circuiting wire showed signs of burning, although the arrangements adopted in the numerous tests made necessitated the contact being made at exactly the same spots both of the short-circuiting wire and the conductors. For producing an arc between the two conductors two wires were attached to them, so that their extremities were 22 mm. apart. When the pressure in the mains reached 18,000 volts. a momentary arc was started, which was immediately extinguished by the melting of the safety fuse.

To ascertain the influence of the secondary current on a telephone circuit, the latter was arranged on the same posts at equal distances from the two wires. It is to be noted that the secondary conductors were not arranged as shown in Fig. 1, but in four parallel lines, in order to get as great a length of wire as was possible in the limited space. The working of the telephone was quite satisfactory, although a slight noise, due to the proximity of the secondary conductors, could be clearly distinguished. The tests were only of a qualitative nature, but they clearly established that the working of the telephone between Heilbronn and Frankfort can be perfectly well carried on.

The action of the fuses proves that a short circuit such as may occur through the breaking of a pole or any other accident, will instantly cut off the current. The insulation under the most unfavourable circumstances that could be brought to bear (drenching insulators and posts with water) was practically perfect. It is impossible that any accident could happen through the breaking of a wire, and the installation can therefore be carried out with perfect security.

The experiments just described were made with an ordinary alternating current, but in the Lauffen installation it is intended to employ a totally new system depending upon what has been termed a "rotating" or "multiple phase," instead of an "alternating" current. This system is the invention of Herr von Dobrowolsky, head engineer of the Allgemeine Elektricitäts Gesellschaft. The current he uses is practically a combination of alternating currents, in which the phases are displaced with regard to each other; as a general rule three alternating currents are employed, though in special cases the number is increased. The currents are produced by a specially constructed alternator excited by a continuous current, the number of contact rings on the alternator corresponding to the number of currents used. When three currents are employed the angular displacement between each set of phases is 120°. The current impulses are made to follow one another in a fixed order, *e g.*, either 1, 2, 3; 1, 2, 3; 1, 2, 3, or 3, 2, 1; 3, 2, 1; 3, 2, 1, and they consequently produce a rotating magnetic field. A "rotating" current can therefore, unlike an "alternating" current be considered to possess a direction of flow. The difference between the three classes of current, "continuous," "alternating," and "rotating," can be clearly brought out by the action of a compass needle when surrounded by the conducting circuit. When the current is continuous, the needle takes up a position determined by the resultant of the earth's field, and that due to the circuit, and remains then at rest. If the current is alternating, the needle oscillates about the position it would take under the influence of the earth's field alone. When the current is rotating, the needle commences to rotate on its pivot. If the compass needle is replaced by an iron cylinder, a "rotating-current" motor is obtained, which has neither winding, collector, nor contact ring in its moving part, and the armature of which (if it may be so called) is not included in the circuit. Motors made on this principle, like continuous current motors, will start with a load, whereas alternating motors will only start from certain positions, even when without load. The "rotating-current" motors, moreover, are not larger than those for continuous currents for the same capacities, and they run perfectly quietly. In these respects they are distinctly superior to alternating current motors. They are extremely simple in construction, and work with perfect reliability; they are of course not synchronous, and can be regulated to run at very nearly constant speeds between light and full loads. As I am informed by Herr Dobrowolsky, the efficiency for a two-horse "rotating-current" motor was found to be 82 per cent. between outputs of $1\frac{1}{2}$ and $2\frac{1}{2}$ horse-power.

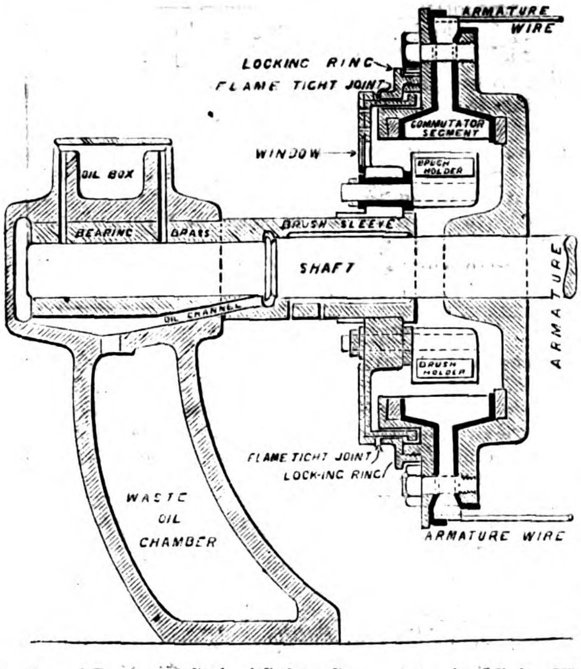
The "rotating current" transformer transforms all three currents together. It consists of three cores connected together at one end, the other extremity of each being attached to an iron ring. The apparatus, therefore, resembles an iron wheel with three spokes. On each core there is a primary and secondary coil. The whole arrangement is immersed in oil as above described. In driving motors each of the three conductors has to be connected to the coils of the motor fields. Arc lamps and incandescents are connected in equal numbers across each pair of the three conductors.

An installation on this system is in process of erection for transmitting water-power at Bülach to the Oerlikon factory. The available power is 400 to 500 horse-power, and drives four turbines, one of which serves as reserve. Each of these is coupled directly to a "rotating current" dynamo; the latter together supply 4,000 amperes at 50 volts. This current is transformed to one of 8 amperes at 25,000 volts, which is conveyed to Oerlikon, a distance of $13\frac{1}{2}$ miles (22 km.) by means of four conductors of bare copper ·16in. (4 mm.) in diameter, supported on Johnson and Phillips oil insulators. The loss in the wires is $1\frac{1}{4}$ per cent., one-eighth of that allowed for in the Lauffen-Frankfort installation. The Municipal Electric Works at Heilbronn, $12\frac{1}{2}$ miles from Lauffen, are also to be carried on on the same principle, and, in fact, the identical machines used in this case will be employed for the longer transmission to the Frankfort Exhibition.

From the above remarks, it will be seen that the employment of the means adopted will enable the project to be carried out with perfect security, and that its satisfactory working can be safely relied upon.

## DAVIS AND STOKES' SAFETY COMMUTATOR.

When motors are used in coal mines it is necessary, as a rule, to enclose the commutator in an air-tight casing. It is important from one point of view that the cubic contents of such a casing should be kept small, so that if an explosion takes place the surrounding metal will cool down the gases and thus prevent ignition of the surrounding gas. On the other hand, it must be remembered that a cubic inch of gas leaking into a closed chamber full of air will form an explosive mixture sooner if the contents of the chamber are small than if they are large.




Section of Davis and Stokes' Safety Commutator for Mining Work.

The accompanying illustration from the *Engineer* explains itself. A locking ring prevents the bolts which hold the commutator segments from turning, and the machine cannot be run until this is in place. If provision can be made for taking up the wear, for reducing the size of joint, and for preventing the accumulation of copper dust on the working surface of the commutator, this ought to prove a very useful arrangement.

Digitized by Google

# The Electrician.

**Published every Friday, Price Fourpence; Post Free, Fourpence Halfpenny**
**Editorial, Publishing, and Printing Offices:**
**SALISBURY COURT, FLEET ST., LONDON, E.C.**
*Telephone No.* 2714. *Telegrams:* "ELECTRICIAN NEWSPAPER, LONDON."

*All Letters relating to Subscriptions, Advertisements and other business matters should be addressed to the Publisher, "THE ELECTRICIAN," Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to "THE ELECTRICIAN" Printing and Publishing Company, Limited, and be crossed "Coutts and Co." All other letters to be addressed to the Editor.*

*All letters intended for insertion in "THE ELECTRICIAN," or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

*"THE ELECTRICIAN" is published every Friday morning, in time for the morning mails. Subscribers should receive their copies by the first post on Friday morning.*

*"THE ELECTRICIAN" is on sale at the railway bookstalls throughout the Kingdom on Friday morning, and can be obtained of all Booksellers and Newsvendors; or direct from the Publishing Offices as above.*

*New Volumes of "THE ELECTRICIAN" commence in May and November.*

## SUBSCRIPTION RATES.

The rates for Subscriptions to "THE ELECTRICIAN" are as follows:—

| | 3 months. s. d. | 6 months. s. d. | 12 months. s. d. |
|---|---|---|---|
| For the United Kingdom | 5 0 | 10 0 | 19 6 |
| For Foreign Parts and Colonies:— Within Postal Union | 6 6 | 12 6 | 24 0 |
| For Aden, Borneo, Ceylon, China, India, Japan, Java, Labuan, Mozambique, New Caledonia, Persia, Philippine Islands, Siam, Transvaal, and Zanzibar | 7 6 | 14 6 | 28 0 |



## TO ADVERTISERS.

*"THE ELECTRICIAN" offers exceptional advantages to Advertisers.* **It has by far the largest circulation of any English Electrical paper, and circulates all over the World.**

*Particulars relating to Advertisements will be promptly forwarded on application to the Offices as above.*

TRADE ADVERTISEMENTS *intended for the current issue must reach the Offices not later than First Post on Thursday morning. Renewals of expiring advertisement orders and alterations to standing advertisements should be in the Publisher's hands by Wednesday at latest. No alteration can be made in Wrapper advertisements after Wednesday evening.*

SMALL PREPAID ADVERTISEMENTS *(for Rates see page xvii.) are accepted up to 4 p.m. on Thursday.*

## TECHNICAL PRINTING.

"THE ELECTRICIAN" PRINTING AND PUBLISHING COMPANY (LIMITED) *inform Electricians, Electric Light Engineers, &c., that they make a specialty of Technical Printing, and have a large Staff thoroughly acquainted with Electro-Technology. They can, therefore, promise Accuracy and Despatch in the Printing of Electro-Technical Literature, &c.*

## "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. (Royal 8vo.)

*Early in each year is issued* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. *The* DIRECTORY *was established in 1883, and the 1891 Edition, published on the 23rd February, 1891, consists of 900 pages of printed matter. The names and addresses of all persons engaged in the Electrical Industries at home and abroad may be relied upon as accurate. Useful Tables and Electrical Formulæ, and information specially compiled for this work are given, together with popularly-written Biographical Notices of the leading Electricians, Electrical Engineers, &c., accompanied in many cases by Portraits.*

*The issue for 1891 is ready, and should be ordered at once. Price 5s., post free 5s. 9d. Abroad postage extra. Full particulars on application.*

## ELECTRICAL BOOKS AND PUBLICATIONS.

*All Books, Newspapers, and other publications, dealing with Electrical and kindred subjects, can be ordered direct of* "THE ELECTRICIAN" *Printing and Publishing Company, who are proprietors of the well-known* "ELECTRICIAN" *Series of Standard Electrical Works, and are agents for all the leading publishing houses at home and abroad.*


## CONTENTS OF THE CURRENT NUMBER.


NOTES ... 629
Electromagnetic Theory.—VII. By Oliver Heaviside. Con. 633
The Magnetic Circuit of Transformers: Closed versus Open. By S. Evershed. Continued. Illustrated ... 634
Electromotive Force ... 636
The High-Pressure Transmission of Power.—Experiments at Oerlikon. By Dr. Oscar May. Illustrated ... 637
Davis and Stokes' Safety Commutator. Illustrated ... 639
THE UNITED STATES AND THE TELEGRAPHS ... 640
Reviews ... 641
Transformer Distribution. By G. L. Addenbrooke. Concluded ... 642
Physiological Effects of Alternating Currents of High Frequency. By Elihu Thomson ... 644
The Frankfort International Electrical Exhibition. Illus. 644
Note on the Design of Dynamos. By Felix Melotte ... 646
An Experiment with the Electric Arc. By William Stanley, Jun. Illustrated ... 646
The Manufacture of Submarine Cables in France. By Max de Nansouty. Illustrated ... 648
Electric Lighting Legislation in Germany ... 649
Books Received ... 649
London Chamber of Commerce. —Meeting of the Electrical Trades Section Committee ... 650
American Notes ... 651
CORRESPONDENCE—
Electricity in Relation to the Human Body—H. Newman Lawrence ... 652
Capacity Measurements of Cables—Harold W. Ansell and Julian E. Young ... 652
Trade Notes and Notices ... 653
COMPANIES' MEETINGS, &c.—
The Brighton and Hove Electric Light Co. (Ltd.) ... 653
The Telephone Company of Egypt (Limited) ... 655
New Companies registered ... 655
City Notes, &c. ... 655



## STEEL-PLATE PORTRAITS

*Of W. H. Preece, F.R.S.; Michael Faraday; Sir John Pender, K.C.M.G.; Sir William Thomson, F.R.S. (Past-President of the Institution of Electrical Engineers); C. H. B. Patey, C.B. (Late Secretary of Telegraphs, G.P.O.); Dr. John Hopkinson, F.R.S. (Past-President of the Institution of Electrical Engineers); Dr. Oliver J. Lodge, F.R.S., and Prof. William Crookes, F.R.S. (President of the Institution of Electrical Engineers), have been issued as Supplements to* "THE ELECTRICIAN." *A few Copies of these admirably-executed Steel Engravings can be supplied, price 1s. each, post free on roller, 1s. 2d. Or framed in neat Black Pillar of Brown Ornamental Frames, price, post free, 4s. 6d.*


## THE UNITED STATES AND THE TELEGRAPHS.

The portly volume which represents the Annual Report of the United States POSTMASTER-GENERAL is this year of unusual dimensions, and, what is equally rare, contains much that will be interesting to English readers. Apart from the discussion of reduced rates to foreign countries, the vexed question of what constitutes a book packet, the abuses of the sample post, and so forth, the project of introducing a postal savings bank system is seriously entertained, on the lines followed by almost every civilised country outside the American States. The fact is instructive for those who labour under the impression that the United States is ahead of the world in everything that is popular and useful, and the further circumstance that a great part of the POSTMASTER-GENERAL'S Report is devoted to the still more instructive subject of postal telegraphy, which has not yet taken root in the States, affords another piece of evidence for the same class of people. Not only is the American Continent behind European countries in respect to the telegraph service, it seems to be powerless to raise itself to their level. Making every allowance for the exaggeration of partisanship—and there is a good deal of it in the pages now before us—it would seem to be the fact that the telegraphs in the States are not so cheap as they ought to be, and not as expeditous as in Europe. A scheme is now on foot, strongly backed by the post office authorities, for, at all events, cheapening the service; but so far from hastening it, the aim is confessedly to introduce what is neither more nor less than a "deferred service," to meet the real or supposed needs of the industrial classes. We may be sure

Digitized by Google

that such a limited reform as this would not satisfy the official mind, much less inspire it with enthusiasm, if anything more drastic or comprehensive were easily attainable. Indeed we are led to the conclusion that the telegraph companies are supposed to be in a position from which the United States Government has neither the courage nor the power to oust them, although supported by all the strength of the Knights of Labour, the Farmers' Alliance, Boards of Trade, Chambers of Commerce, and monster petitions signed by millions of enlightened citizens who, on paper, never want for anything long without getting it.

It is a curious and somewhat painful spectacle, rendered not less so by the lame, and, as we think, futile attempt at legislation to satisfy this great outcry. The authors of the "Bill to establish a limited post and telegraph service," describe it as a modest and harmless experiment, and we are not disposed to quarrel with it on that score. The remarkable thing about it is that so much fervid eloquence and acrimony have been brought to bear upon it. "To carry the postal system from pony-riders to stage-coach, and on to a railroad service, and to stop all further progress because 8,000 owners of telegraph stock oppose, is," we are told, "not in accord with the genius of our people or the spirit of the times." Again, it is grandiloquently asserted that "the measureless body of producers, in order not to be robbed by the speculators, need to be nearer the consumers; and the measureless body of consumers, in order not to be manipulated and robbed by the same speculators, need to be nearer the producers." This being granted, and we may readily grant it without endorsing the strong language, one naturally turns to the proposed remedy which is to do away with all this intermediate robbery by bringing the consumers and producers nearer together. Briefly stated, it amounts to this: Every post office where any telegraph business is likely to be done may be converted into a receiving-house for telegrams. If the telegraph companies extend their wires to these offices and pay the postal *employés* a commission for their services as telegraphists, then the telegrams handed in will go by wire; but if not they will be sent by post to the nearest telegraph office and thence to the telegraph office nearest to the place of destination, which, if it happens not to be a telegraph station, will again be served by post. For this service the State will charge two cents for postage, and a rate for the telegraph varying from 15 cents to 25 cents, according to distance—the present charges of the Western Union Telegraph Company averaging apparently 31 cents. The scheme, therefore, goes no further, at present, than to constitute the Post Office collectors for the telegraph companies, and to a certain extent their messengers. In return for this the Company will be required to take the post-office telegrams at lower rates.

We say that the project contemplates no more than this at present; but we can hardly suppose that its promoters intend to stop at that. Probably there is a covert intention of bringing down the rates of the Telegraph Company—for virtually there is only one—so that at length its acquisition by the State may be within measurable distance. Be this as it may, except for ulterior designs, the Company will probably not object to a multiplication of its agencies in the manner suggested, seeing that their establishment will dispense the Company from all further obligation to extend its wires to unremunerative districts, the criterion as to which will be accurately furnished by the number of telegrams collected at the postal receiving houses. It is just such a scheme as might have taken shape in this country twenty-one years ago, if Mr. Scudamore, instead of taking over the telegraph companies, had proposed to save them the trouble and risk of extending their wires, by opening in every rural district a post office for the receipt of *quasi* telegrams, to be despatched partly by post and partly by wire. That proposition, happily, was never before us; and we spent twelve or thirteen millions sterling in buying up the telegraph system bodily and doing what we liked with it instead. Had such a very "limited" extension of telegraphic facilities been offered us as is now being favoured by the American Postmaster-General, we might possibly have accepted it for lack of something better; but we should have found it hard to go into raptures over it as a heaven-inspired scheme for bringing the measureless body of producers nearer to the ditto of consumers, and robbing the plundering speculators of their prey.

We suspect that the real cause of all this vehement advocacy of a very tame proposal is, that it costs the State nothing but the trouble of proposing it, and the popularity which it may be capable of evoking in a country so sparingly provided with telegraphic facilities as are many parts of the United States. In this respect we can make no comparison with other countries that would not be perhaps unfair to the States. Its enormous area, the unequal distribution of its vast populations, and the varied character of their industrial pursuits, all combine to make it next to impossible for any private corporation to extend the advantages of telegraphy everywhere and to all alike. But all the greater reason for the State to step in, as it has done in Europe, and supply what is needed at the State's expense. That this is not an unprecedented proposition, even in America, is evidenced by the Postmaster-General's Report, on which we are commenting. In eloquent and convincing paragraphs, time after time, he dwells upon the social and economic advantages of having extended the beneficent arm of the Post Office to the remotest regions, and into every far off nook and corner, notwithstanding the fact that the service is conducted at a loss, and that the cost is defrayed by the more accessible, more populous, and wealthier areas. If it be true that the telegraph is of like importance to the welfare and well-being of the people—and the so-called Post Office Telegraph scheme is propounded on this assumption—surely it follows that the duty of providing it on the same terms is not less pressing and not less beneficial in its probable results. Whatever comes of the "modest" experiment now under discussion, a more ambitious and bolder one will have to be essayed by the United States Government sooner or later—and the sooner the better, we should imagine.

## REVIEWS.

**The Metal Workers' Handy Book of Receipts and Processes.** W. T. Brant. (London: Sampson, Low and Co.)

This book, published originally in America, appears at first sight to be an excellently arranged work upon a wide subject which has never been systemetically dealt with. It opens with chapters on the chemistry of metals, the properties of their more important compounds, and qualitative tests of alloys, &c. But, on reaching the fourth chapter, which describes numerous alloys and amalgams, the author begins to drift into discontinuous paragraphs, and the subsequent chapters on annealing and tempering, bronzing, casting, polishing, enamelling, plating, lacquering, soldering, &c., are merely collected from various sources and printed in the style of Spon's Workshop Receipts with even less attempt at classification than is to be found in those useful but unequal volumes.

Metal-working is an art which ramifies into numerous departments, and no one worker can ever have a thorough knowledge of them all. Where an art has not become a

science, there is nothing but skill and knowledge. The skill can only be acquired by practice; and the knowledge, until such books as this were compiled, was handed on traditionally from craftsman to apprentice. All that has been done has been to collect innumerable "receipts," to sort them out into a score of headings, and to make a book of so many chapters. Some systematic work has been done by Mr. Roberts-Austen, especially with reference to alloys, and the heavier subject of metallurgy has been raised to a science by Dr. Percy. Little is known about the changes which take place in tempering, and why soapy water is sometimes useful and sometimes disadvantageous; or if "blazing off" a spring depends on "letting down" by the heat of the flame, or on the chemical effect of the carbon in the mixture. Those who are practically engaged in working with metals rarely have time to inquire into reasons, and those who could usefully investigate the subject seldom have any workshop experience.

**Traite des Piles Electriques.** By DONATO TOMMASI. (Paris: Georges Carré.)

The literature of the primary cell must by this time have attained appalling dimensions, and a work giving within the compass of a single volume a reliable *résumé* of the history, theory and practice of the subject would be a welcome substitute for the numerous incomplete treatises which exist at present. Some such compilation could evidently have been brought out by M. Tommasi. He has, however, preferred to omit history and theory and devote himself mainly to a bald enumeration of the primary cells, single and double fluid, dry and wet, which have been devised by ingenious minds from the time of Sulzer to that of De Meritens. A mere enumeration, however, provided it be of manageable size, would have its uses, and the author, by the exercise of little more method and the excision of useless tables and extraneous matter, might have reduced the 600 pages of his book to half that number without in any way diminishing its value for reference purposes. To sanguine spirits, who fondly believe they have succeeded in inventing something new in primary cells, M. Tommasi's compilation may be safely recommended. If nothing similar is unearthed from among the three hundred and odd combinations mentioned by him, it may be reasonably concluded that the invention is novel.

**The Electroplater's Handbook.** By G. E. BONNEY. (London: Whittaker and Co., 1891).

This little book is one of the series which is headed by Sir David Salomons' well-known work. It is addressed to "amateurs and young workmen." The author is apparently unconscious of the fact that the ignorance among electroplaters, of dynamos, and indeed of electrical matters generally, is very remarkable. The machines which are made for the purpose, by manufacturers who turn out no other kind of dynamo, frequently show a complete want of knowledge of the principles of design, and they only find a market by the care which the salesman takes to find out what his customer wants; for the latter cannot, as a rule, make himself intelligible to the ordinary electrical engineer. About a dozen obsolete or unheard of dynamos are described, and two or three good ones. The prices of many of the tools and appliances are given. Only six pages are devoted to copper deposition, but the book contains a good deal of useful information and numerous receipes for plating solutions.

**Practical Inorganic Chemistry.** By EBENEZER J. COX, F.C.S. (London: Percival and Co.)

So long as our present examination system endures, books will be brought out which are "intended for the use of students preparing for the examinations." This little book dishes up in a palatable, *aide-memoire* style just those tests and analyses required to be assimilated for the time being by students preparing for the Science and Art Department examinations in elementary practical inorganic chemistry. The typography and general arrangement are excellent, and examinees desirous of passing by the path of least resistance will do well to study this manual.

## TRANSFORMER DISTRIBUTION.

BY G. L. ADDENBROOKE.

(*Concluded from page 601.*)

In the first portion of this article, which appeared last week, the great theoretical gain was pointed out which might be anticipated from the employment of transformers placed in sub-stations, a small transformer being used for supplying current to the system of secondary mains during the day and large ones being only switched on in the evening when the amount of current needed for lighting is largest.

There are, of course, a great many different ways varying in detail in which such a system can be carried out in practice, and the exact method which would be employed in any given case would largely depend on local conditions. Still, as all these variations would only be in points of detail, by taking one general case of an average character, as was done in the former portion of this article, and working that out carefully, we shall arrive at conclusions which, varied in a slight degree to meet particular cases, will be accurate within a small percentage of error, and quite sufficiently so for the purposes of the argument.

In the first place let us consider the transformer sub-stations themselves, and how they would be best situated. In this connection of course a good deal will depend on the distance apart at which it is decided that these transformer stations should be located, and also on the quantity of lighting which will have to be done in the area which they will supply. In any case they will not be very large.

I shall take it that such stations are designed for the supply of 100 kilowatts, as this is a convenient size, and if the transformer sub-station is constructed for this output, transformers could of course be placed in it for a smaller output if such alone is required. For such a station as this it would be necessary to keep always in circuit with the mains, after twelve o'clock at night, and during the day, a transformer of about 10 unit capacity, and a second transformer of the same capacity would need to be installed for use in case of an accident happening to the first. For the evening work an additional transformer capacity of 90 units would be necessary, and this might be conveniently arranged by having three transformers each of 30 units capacity. In addition to these it would also be advisable to install two further transformers of 30 units capacity each as a reserve.

The total transformer capacity therefore of such a substation would be two transformers each of 10 units, and five transformers each of 30 units.

Now a 10 unit transformer can easily be set in a space of eight cubic feet capacity, and a 30 unit transformer will not occupy more than about 15 cubic feet. The transformers in the sub-station, therefore, would altogether not occupy more than a space of 91 cubic feet, or, making some allowance for supports and intervals between them, say 100 cubic feet.

Now 100 cubic feet is contained in a space 5ft. long by 5ft. high by 4ft. deep. For the sake of accessibility it would be advisable to arrange the transformers partly on one side of the chamber and partly on the other, with a passage between; the switching and measuring instruments being situated on one end of the walls, say that opposite the entrance.

Now supposing that the transformers occupied a space of 2 feet deep at each side of the chamber, and that the passage down the centre was 3 feet broad, we should have a total cubical capacity necessary for the transformer sub-station of 175 cubic feet. But as a height of only 5 feet would be inconvenient, let us increase this height to 7 feet to allow proper head-room. Then the dimensions of the sub-station will be 7 feet broad by 7 feet high by 5 feet deep, and the total cubical capacity will be 245, or say, for convenience, 250 cubic feet, and as we have seen above, a sub-station of such a size would permit of the installation, with ample reserves, of transformers of sufficient capacity to supply current for 3,000 eight candle-power lamps burning at one time, each taking 33 watts.

Digitized by Google

This would permit of at least the equivalent of 6,000 such lamps being connected to the secondary circuits of the transformers.

Now in closely populated residential districts, such a substation would be about the size for the supply of all the houses situated within an area, measuring 300 yards each way. I shall therefore assume that the transformer sub-stations are situated about 300 yards apart in each direction, the secondary mains extending from them therefore will, on an average, of course, be considerably less than 300 yards in length, but in some cases may extend to as much as 400 or 450 yards where they have to be carried along one street and then down another at right angles to the first.

On this plan, supposing the transformer sub-stations were distributed evenly, we should get an average number of 35 such sub-stations to the square mile, and, according to the metropolitan returns, a square mile contains on an average a population of about 33,000 persons. The number of lights therefore provided in this scheme for each person is 3 eight candle-power lamps burning, or six installed, which would be a fair average for moderately wealthy residential districts, containing also a due proportion of shops and public buildings.

In poorer or in suburban districts, where the number of lights required from a given length of main would be less, the transformer sub-stations could, of course, be situated at greater distances apart, but as the secondary mains leading from them would be required to supply less current per unit length, they could be proportionately reduced in size, so that within moderate limits the arguments here used in dealing with more densely populated portions of ordinary towns will still apply with some slight modifications, or until, in fact, the houses were so far apart that it would be better to install a separate transformer in each. Of course, in practice, the two systems of placing transformers in houses and in sub-stations would be employed together, the transformers at first being situated in the houses until the number of houses lighted in any area became sufficiently numerous to warrant the adoption of the sub-transformer system.

In densely populated districts, however, such as the central portions of large towns, it would be probably cheaper to introduce the sub-transformer system in all the principal streets from the beginning, in order to avoid the expense of twice taking up roads paved with asphalte or wood blocks.

Coming to the economics of this sub-transformer station system, it will now be advisable to endeavour roughly to ascertain how the cost of such a system compares with the present methods of placing transformers in each house, or with the supply of current at low pressure from central stations working on the direct current system.

It goes almost without saying that the character of the secondary mains emanating from the sub-transformer stations will be almost precisely similar to those which are used with a low tension direct current system of supply, the only difference being that, as the transformer sub-stations are situated fairly close together, it would never be necessary to employ copper conductors of very large section, especially as the secondary mains from the various sub-stations, would be connected together at various points so as to equalise the pressure on the mains all over the system as far as possible. This is leaving out of the question the propriety of having more than one primary connection to each transformer sub-station, but this is an engineering matter which would have to be dealt with in accordance with the local circumstances of each particular case.

The first point to consider with respect to this low tension system of secondary distribution is whether it should be on the two wire or three wire plan. For districts where the population is dense, and there are a considerable number of houses supplied from the mains, no doubt the three wire system is much the most advantageous; and in the case which it is proposed now to present it will be assumed that the three wire system is used, and that secondary mains are connected to two transformer sub-stations situated 300 yards apart.

Now, as we have already seen, the maximum current which will ever be supplied from any sub-station at any time will not exceed the equivalent of 3,000 eight candle-power lamps taking 33 watts each. That is, supposing for argument's sake, that the lamps installed need a pressure of 100 volts, the maximum current sent out from the sub-station will be roughly 1,000 amperes. I shall also assume that the voltage is not to vary more than one volt on either side of the standard pressure anywhere on the secondary system. The maximum loss therefore between the sub-station and the most distant lamp must not be greater than two volts during the hours of maximum lighting. At a pressure of 1,000 amperes per square inch section of conductor on the two wire system the loss of pressure is about one volt for every 20 yards the mains extend. In the present case I shall not consider the mains as extending more than 200 yards on an average, because they would, at about that average distance from one substation, be joined to mains coming from another station, so that, except for purposes of regulation, current would very seldom have to flow over distances of more than 200 yards on the secondary mains.

On the two wire system, therefore, and according to the basis given above, the loss in the secondary mains would be in 200 yards, 10 volts, supposing that the mains were reduced in size as they extended further from the sub-stations, so as always to keep the current density at 1,000 amperes per square inch, but on the three wire system this loss would be reduced to about one-third, or let us say to 4 volts in the 200 yards, the same amount of copper being used. But it is not quite practical to put the question in this form, because it would be very inconvenient to constantly reduce the size of the mains as they extended from the sub-station, and in practice it would probably be found easiest to run them of the same section or nearly the same section direct from substation to sub-station, or at any rate to arrange so that the section of copper in the portions of the districts furthest from the sub-station should be so large that the current passing through such portions of the main would not equal more than 500 amperes to the square inch during the hours of maximum lighting.

At any rate, a little consideration of the above figures will show that if a densely populated area 300 yards each way were lighted from transformer sub-stations situated about 300 yards apart and with a secondary system of distribution on the three wire principle with the secondary mains connected together at various points, the secondary mains branching from any one sub-station would not in the aggregate equal much more than one square inch of copper in section, or $2\frac{1}{2}$ square inches for the three conductors, and the loss over the whole system would not be greater than 2 per cent., or 1 per cent. on each side of the standard.

As probably at least four sets of mains would branch from each sub-station going in different directions, and as, moreover, branches would again be taken from these mains down side streets, it will readily be apparent that the copper sections of all this system will be of very small areas, that they will not take up much room under the street, and will at the same time be easily laid.

Such systems of mains can of course be laid, using any of the methods which have found approval with engineers so far, but it is doubtful if anything much better and cheaper than the system of drawing cables into cast iron pipes can be devised. It must be borne in mind that the amount of insulation which will be required on these cables will be very much less than what is now necessary for high tension cables; so that the secondary cables themselves would be very much cheaper section for section and length for length. With a transformer sub-station system the length of the primary mains would be greatly reduced, and also, consequently, their cost. Even at present it is always necessary to lay down, for facility in working, considerably larger pipes or culverts than are actually necessary in order to carry the primary wires. In fact, when the expense of taking up the streets and opening up the ground is considered, the making of some sort of culvert, and the covering of it up again and making good the roadway, the difference in cost of one section of pipe or culvert over another, within moderate limits, is a matter of very secondary consideration, so that I think

Digitized by Google

that it might be reasonably taken that the cost of laying secondary mains from transformer sub-stations throughout a district would not be more than would have to be spent on laying primary mains throughout that district for the supply of the houses therein by converters installed in each house separately.

In this comparison I have said nothing about the reduction in transformer capacity obtained by using sub-stations, and, again, the greatly decreased cost per unit of large transformers over small ones; and, further, the immense saving in carrying secondary wires direct into a house without any special safety appliances beyond the ordinary switch and cut-out, over the introduction into each house of primary wires with all the elaborate precautions necessary to protect them, besides high tension switches and cut-outs, the cost of which is out of all proportion to those needed for currents at a pressure of only 100 volts.

It will thus be seen that the transformer sub-stations system compares directly and most favourably with the supply of direct currents at low tension from central stations, while it has the advantage that the central station or stations themselves may be situated at any distance which is most convenient from the centres of supply, and can be located where the smoke made will be no nuisance, where the delivery of coals will be cheapest, and where, in most cases, water can easily be secured for condensing engines. Although, therefore, at present it may seem in many ways that the advocates of low-tension have scored largely against their alternating-current opponents, and that much reconstruction work must be done in order to bring the economy of the alternating and transformer system into comparison with that obtained with low-tension direct-current stations, yet, in the end, if such a system as that I have indicated above is adopted, both in actual first cost, in convenience of working, and in safety, the alternating system will not only compare favourably with, but will surpass its rivals.

## PHYSIOLOGICAL EFFECTS OF ALTERNATING CURRENTS OF HIGH FREQUENCY.

BY ELIHU THOMSON.

The following is an abstract of a Paper of which an advance proof was kindly sent us by Prof. Elihu Thomson:—

In connection with an experimental investigation of the properties of alternating currents of high frequency, and the phenomena which they present, it had occurred to me that it would be desirable to obtain data concerning the physiological effects of these currents as compared with the effects of currents of ordinary frequency. I had constructed a machine on the type of my new alternating dynamo, accounts of which were published some time last year. In this machine an iron mass only is revolved, the central portion of which carries projections which pass near to the coils in which the currents are induced, which may be termed the armature coils, carried on the inner face of a laminated structure, in turn supported by the outer frame work of the machine. The machine, with 100 armature coils and a speed of 5,000 revolutions per minute, gives a little over 8,000 alternations per second. The publication of brief notices of some of the results obtained in the operation of this machine led Dr. Edward Tatum, of Yonkers, N.Y., to correspond with me with the view of finding out whether I had intended to conduct any physiological experiments with the currents, and indicating his desire to experiment in this direction if the machinery for obtaining the currents could be placed at his disposal for a short time. Accordingly the machine was sent to Dr. Tatum some time last fall, and was used by him in making a series of experiments, the results of which cannot fail to be of the highest interest to electricians and physiologists.

"The most definite and perhaps the most striking, as well as physiologically instructive result has been in regard to the fatal efficiency of such rapidly alternating currents. When the circuit is formed through the head and body (of dogs) death occurs in the same manner as with other sources of current (which are made strong enough to kill by a closure lasting not more than two or three seconds)—that is, by primary arrest and paralysis of the heart; but, taking the fatal efficiencies of different sorts of currents as inversely proportional to the current strengths required to kill under otherwise similar conditions, a rate of 4,500 per second is not only far less efficient than rates of a few hundred, but it is distinctly less efficient than a continuous battery current. It is remarkable that rates of 300 and of 120 alternations per second are fatally efficient at very nearly the inverse ratio of the numbers; but, still more remarkable, that the very highest rates should also present a strikingly near approach to a similar ratio. It must be noted, however, that no such ratio can hold throughout the whole range, for 36 alternations per second (from the same machine as furnished 120 and the 300 rates) are again distinctly less efficient than 120—something like two-thirds as efficient."

Dr. Tatum goes on to point out that a potential of 450 volts was survived at the high rate of alternations, and the fatal current reached only at 495 volts, while 45 volts at 120 alternations similarly applied to the dog suffices to pass a fatal current. Dr. Tatum also determined the ratio of pressure or potential to current in the dog just after the cessation of respiration, using in rotation, twice repeated, first, a continuous pressure or potential; secondly, an alternating one at a rate of 120; and, thirdly, an alternating potential at a rate of 4,500 per second, at about 100 volts, and states:—"This ratio was so uniform (the extremes observed differing by less than 3 per cent.) as to dispose of any suspicion that the high-period currents distributed themselves essentially different from others in the animal's body.

". . . In regard to the physiological as distinguished from the fatal characteristics of the high-period machine, I am only able to state the results in terms of pressure instead of terms of current, as I should prefer. The limits of voluntary toleration for alternating pressures (applied with sponge electrodes) seems to depend very little on the frequency of alternation. For all the frequencies I have mentioned the limit has been found between 10 and 15 volts for applications about the face and head, and between 40 and 50 volts between the hands, without any decided preference in either case for one rate more than another.

"The cause of the pain which limits voluntary toleration seems to be in all cases chiefly in the muscular contraction produced. At 4,500 this muscular contraction is usually free from the thrill experienced even at 300; resembling, on the temples, nothing I can think of so much as firm pressure with the knuckles.

"The cutaneous nerves are distinctly less painfully affected at the high rate. The visual mechanism cannot be excited at the high rate, even by a pressure of 15 volts, so as to cause a sensation of flashes of light, although two or three volts similarly applied at 120 alternations causes such flashes very energetically. Sensations of taste are also absent."

In presenting these results I take occasion to express my sincere regret that his ill-health has prevented the continuance of the work in the direction laid out by the Doctor himself, and to express, also, the hope that he may be able to take up the further investigations at some other future time.

## THE FRANKFORT INTERNATIONAL ELECTRICAL EXHIBITION.

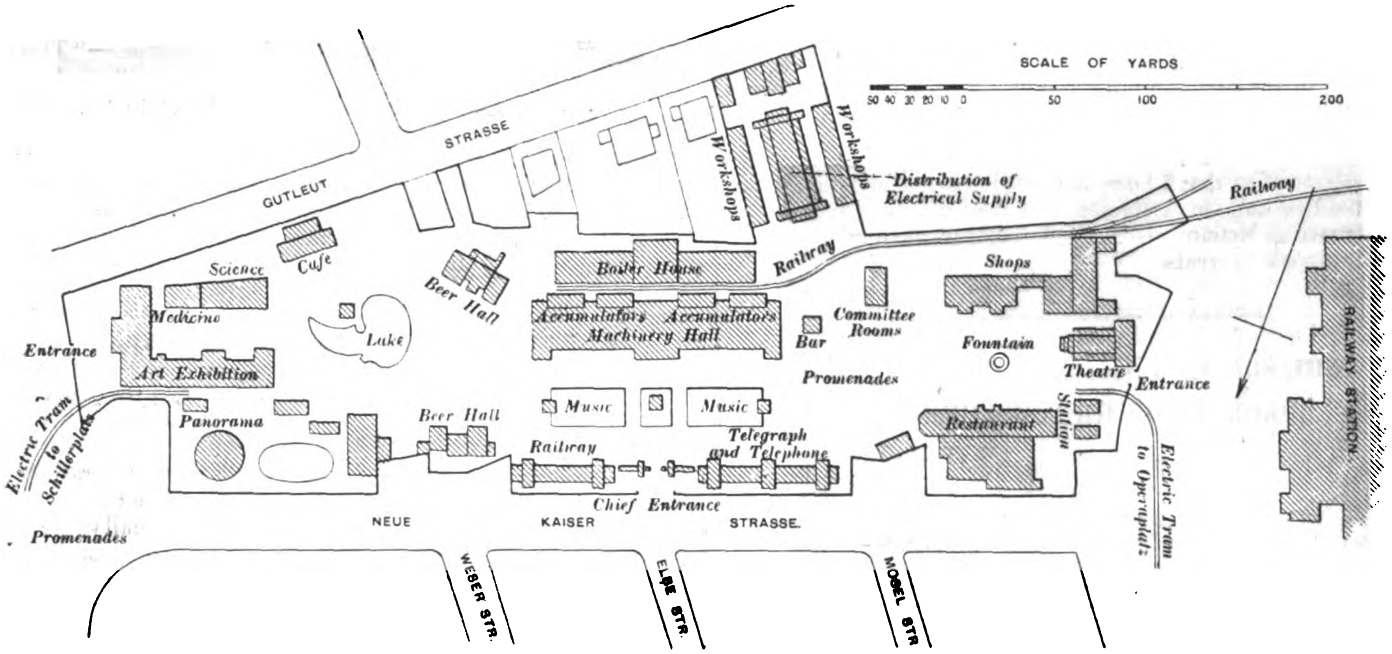
The great attraction afforded by the department of the Paris Exhibition dealing with electricity and its industrial applications seems to have suggested the idea of holding an International Electrical Exhibition in Germany, and the scheme found all the more favour here from the fact that at Paris the German electrical industry was not adequately represented. A proposal to undertake the Exhibition last year fell to the ground, as the notice given was too short, and it was accordingly determined to defer it to 1891. Considerable anxiety was naturally felt lest

Digitized by Google

the great firms and the capital itself would look with jealousy on an Exhibition of this magnitude held away from Berlin. Such fears have proved groundless, and the decision of Frankfort to undertake and promote the Exhibition has been received on all sides enthusiastically.

The easy access to this town and its air of wealth and convenience have always made it the resort of numerous visitors in the summer, and English people staying at Homburg greatly add to the number by their almost daily visits. It is certain that the first sight a visitor to Frankfort this year will have will be the Exhibition, for it lies exactly opposite the railway station. The site chosen for the buildings is very advantageous. The railway station, one of the finest and most imposing on the Continent, is separated from the chief part of the town by a large open piece of ground over which the lines used to run to the old railway station, which was further in the town. This space happened, luckily, this year to be still unoccupied, and the owners have liberally placed the south side at the disposal of the promoters of the Exhibition. Here the buildings are rapidly rising, and some 300 workmen busily engaged. The exhibits will, as far as possible, be classified not so much according to firms, but according to the technical head under which they fall. Thus, there is a great machinery hall, forming the central power available from this source will be 400 H.P. A building on the right of the machinery hall, but lying further back, will be devoted to the display of the various methods by which the electric current is supplied in the streets of a town. Other buildings on the right of the machinery hall are devoted to materials and appliances for electric lighting. There will be seven shops electrically lighted, and a theatre, where the visitor will have the opportunity of hearing operas telephoned from Wiesbaden and Munich, and of course from the opera here.

There will be four different kinds of electric railways connecting the Exhibition with the Opera House, the Schiller Platz, which is in the centre of the town, and the Main. A tower will be erected by the river, on which large reflectors and powerful electric lights will be provided. Excursions on the river by electric launches will add to the numerous entertainments provided for the visitors. A large grotto, lighted with glow lamps, is also being built. A captive dirigible balloon is announced, which from its novelty is sure to awaken considerable interest. It is to ascend to a height of 600 metres, and experiments are being made for preparing the necessary hydrogen by electrical means. The electrical transmission of power will be strikingly illustrated by the application of water-power developed at Lauffen, on the Neckar, for driving machines,




Ground Plan of the Frankfort Electrical Exhibition.

part of the Exhibition, behind which the boilers will be found in a separate house. Telegraphy and telephony, model electric light installations, electro-chemistry, and all possible branches of electro-technology will have their separate departments and in many cases separate buildings. The structures are entirely of wood, and those that are completed or nearly so, strike one as particularly graceful, and well adapted for their purposes.

The machinery hall is very nearly ready, and preparations are already being made and foundations laid for the reception of the machines. In the boiler-house behind four boilers are now being laid down, three from Paucksel, of Landsberg, and one from Berningshaus, of Dursburg, the last working at a pressure of 12 atmospheres. There will be in all 20 of different kinds, with 2,400 square metres heating surface. The total power developed by the motors in the machinery hall will reach over 4,000 H.P., the separate motors varying from ½ H.P. to 600 H.P. The number and variety of dynamos shown at the Exhibition promises to be very large. Altogether, in the machinery hall and boiler-house, 60 firms will be represented, of whom 22 will exhibit dynamos. The direct-current machines will require 600 H.P., while the alternators will require 400 H.P. Accumulators will be found at the back of the machinery hall. Six firms are exhibiting, and the or giving electric light at the Exhibition. The distance is about 100 miles, and the water-power at Lauffen 300 H.P. Of this only 2 per cent. is to be lost in the transmission. A pressure of 20,000 volts will be used. The cable will be made by Siemens Bros., of London. The interest which is taken in this particular project in the highest quarters has just been shown by a gift of 10,000 marks from the Emperor himself, and a similar one from the Frankfort Chamber of Commerce. In addition, power will be electrically transmitted from Offenbach—about five miles—and from a steam engine in the Palm Gardens, at the north side of the town. Twenty-two workshops of different trades are being set up in the Exhibition, having their lathes and other machines driven by electric motors, varying from $\frac{1}{20}$ H.P. to 6 H.P., thus showing the possibility of supplying small power cheaply and conveniently to the mechanic and others to whom a steam or gas engine would be inconvenient, or out of the question.

The list of names forming the organising body numbers more than 150. The honorary presidents are Finance Minister Dr. Miguel and Herr Heldberg, the Postmaster-General of Frankfort. Then come as honorary members Dr. Werner von Siemens, Professor A. von Waltenhofen, Professor Silvanus P. Thompson, Marcel Deprez, and Thomas A. Edison. The chairman of the

Digitized by Google

committee is Herr Leopold Sonneman, and the honorary secretary Herr Carl Stiebel.

The Exhibition is to be opened on May 16th, it is hoped by the Emperor, and will close towards the middle of October.

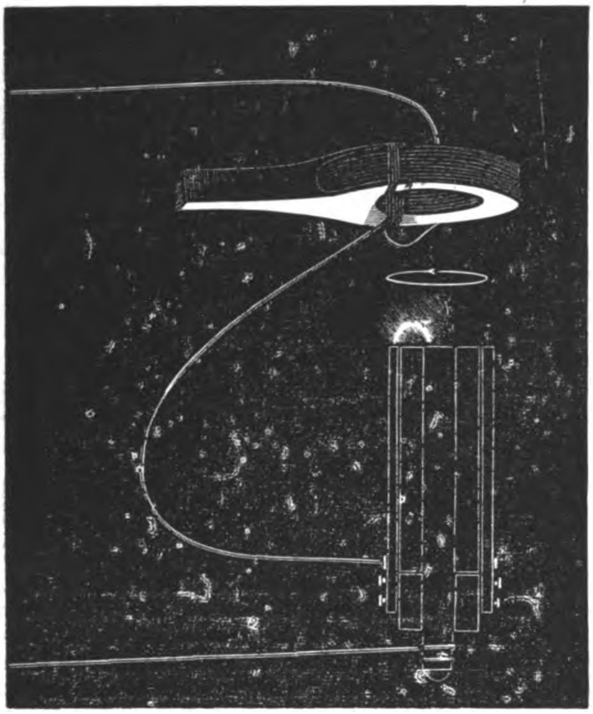
The accompanying plan will give some idea of the size and relative positions of the buildings. It has been impossible, of course, in this preliminary article to more than mention some of the more important features of the Exhibition; but we hope, later on, to deal with those separately and at greater length.

## AN EXPERIMENT WITH THE ELECTRIC ARC.*

BY WM. STANLEY, JR.

Prof. Thomson's Paper on arc lights calls to my mind an experiment in the laboratory some time ago with an alternate current arc, which presented a very beautiful illustration of the deflecting power of a strong magnetic field. Inside a hollow carbon tube about 2in. in diameter was placed an ordinary seven-eighths inch carbon, separated from the tube by about one-quarter of an inch air space all around except where it was held in place by an insulating ring, as shown in Fig. 1. A coil of wire connected in series with the carbons, and with a constant current transformer by a flexible cord, was mounted to a handle for convenient handling.

If an arc was started between the inner carbon and the concentric tube, and if the coil was approached parallel to the face of the carbons, the arc revolved around the centre carbon after the manner of a pin-wheel. Reversing the face of the coil—that is, the direction of the field threading the arc—caused an instantaneous reversal in the direction of rotation of the arc.



F.G. 1.—Rotation of the Electric Arc.

When the coil was placed around the concentric carbons and near the arc, the latter became distorted, as shown in Fig. 2, while it continued to revolve about the axis of the coil.

Many modifications will suggest themselves to any one attempting the experiments. One point observed by Prof. Thomson was very clearly evidenced, which was that, when the arc was whirling (and it might be made to whirl so rapidly as to appear continuous about the centre carbon), the potential required to maintain a constant current rose enormously, so high, in fact, that the transformer was often unable to supply the demand for increased potential necessary to maintain the arc, although it was constructed to deliver a constant current from short circuit to 800 volts; as a consequence, the whirling arc would repeatedly blow itself out with a loud report if the deflecting coil was approached very near the seat of the arc. Of course, the arc revolves and becomes distorted, because of the reactions between the field produced by the coil and the weaker field about the arc, and an apparent continuous effort exists between the two fields to coincide or join together. Many beautiful lecture and

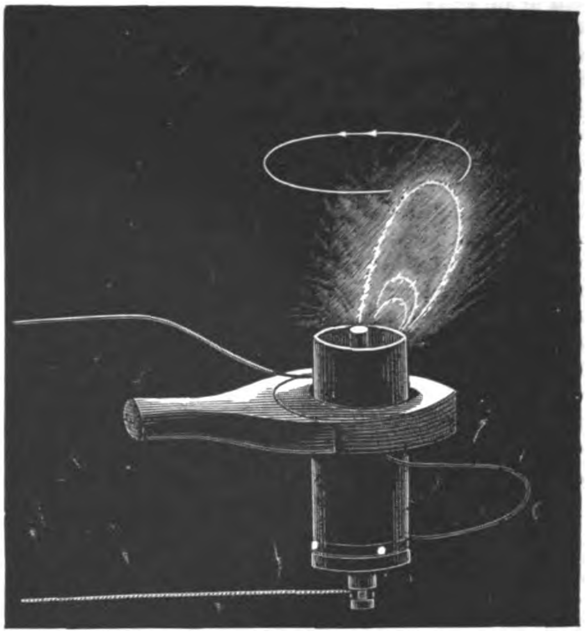


FIG. 2.—Simultaneous Repulsion and Rotation of the Arc.

demonstration experiments for classes may be obtained from this same simple apparatus, which, of course, may be operated with equal success by either alternate or direct currents.

* From *The Electrical World* of New York.

## NOTE ON THE DESIGN OF DYNAMOS.*

BY FELIX MELOTTE.

The method of calculation which I propose to describe does not lay claim to any novelty in principle. It is only the result of my endeavours to arrive at the result in the simplest way from a given set of initial conditions. I shall not concern myself with the choice of the proper type of machine, but suppose this already decided upon from economical, or other reasons.

There is no denying that the design of a dynamo presents considerable difficulties. The constructor should produce an economical machine; but we may understand by economy either high efficiency or cheapness. These qualities are each highly desirable, but it is difficult to unite them in the same dynamo.

When it is determined to design a dynamo of a given horse-power, certain initial conditions are usually imposed, such as the efficiency, the number of turns, and the voltage or the output in amperes. From these data we can deduce successively all the dimensions of the machine if, at the proper time and place, we make use of certain coefficients, and other results of experience. The result may not be altogether satisfactory at first, but is so after a few trials.

The number of revolutions determines the diameter of the armature if the peripheral speed is fixed. This speed should be as great as possible, as the useful power increases with the speed; but it is necessary to keep within the limits determined by the relation of the centrifugal force to the strength of the revolving material. Generally 12 to 15 metres per second may be taken as the proper peripheral speed for drum or ring armatures. For flat rings and discs the speed may be as great as 25 metres per second, but for ordinary armatures 15 metres per second is a good limit. Taking this number we have, if N is the number of revolutions per minute, and D is the diameter in metres of the armature,

$$D=\frac{15\times 60}{\pi N} \quad . \; . \; . \; . \; . \; . \; . \; . \quad (1).$$

The next question is to determine the size of the wire and the number of convolutions on the armature. In choosing these data we may be guided by the following considerations. The fewer the

* Abstracted from a Paper read before the Montefiore Institute, Old Students' Association, in January, 1891.

Digitized by Google

number of turns the less the reactive influence of the armature, and the less the loss in wasteful heating, so that the section of the wire which can be used is relatively small. On the other hand, the diminution of the number of turns necessitates a corresponding increase in the flux of magnetic lines, and in consequence an increase of section at every part of the magnetic circuit. This involves an increase in weight of the castings, of the iron, and of the copper required for exciting purposes.

It is well to adopt a current density of about four amperes per square millimetre. This rule is not rigorous, and admits of wide variation, but we shall adopt it as a first approximation, and shall assume that the wire is round in section and has a diameter $d$. If then D is the external diameter of the iron, we have for $n$, the number of convolutions,

$$n = \frac{\pi (D + d)}{d} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2).$$

For machines of small output it is possible to wind several layers of conductor on the armature core, especially if the voltage is high. On the contrary, for powerful machines only one layer of conductors is used.

The number of turns being fixed, the next thing is to calculate the data of the magnetic field. If $\phi$ is the magnetic flux proceeding from one pole, a single armature conductor in the course of a revolution cuts 2 $\phi$ lines. The flux in each half of the ring is $\frac{1}{2}\phi$, and this is sometimes positive and sometimes negative, the total change being $2\phi$. The electromotive force per conductor is, therefore,

$$E = \frac{2\ N\ \phi}{60} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

or, if we reduce E to volts, and multiply by $n$ (the number of turns in series between the two brushes) to get the total electromotive force, we have, on the assumption of a uniform field,

$$E = \frac{2\,N\,n\,\phi}{60}\,10,^{-8} \text{ or } \phi = \frac{E.60.10^8}{2\,N\,n} \quad . \quad . \quad . \quad (4).$$

The same expression is true of drum armatures, only $n$ refers no longer to turns, but to conductors counted separately round the periphery of the armature. For multipolar machines the equation is still true if we substitute for the factor 2 the number of poles in the machine in question.

As regards the proper induction density to adopt, it is well to choose values lying between 12,000 and 18,000 lines of force per square centimetre. These values refer naturally to the space actually occupied by the iron. Thus for iron wire cores, as in the classical Gramme ring, it is necessary to remember that the space filled by the metal is only about $\frac{3}{4}$ of that which it occupies, while for sheet iron discs from 10 to 15 per cent. of the space is occupied by the insulating medium, and this must be taken into account.

The axial length of the armature varies according to the type of machine. In drum armatures it is greater than the diameter (twice or even more), while in ring armatures the two dimensions are about equal.

It is desirable to avoid too great an induction density in the air space, for an abnormal amount of excitation will otherwise be needed. According to M. Amoux it is best to design the polar surfaces so that the induction density in the air space is from 2,500 to 4,000 lines per square centimetre.

The radial thickness of the armature core should not be too small, or else the length of armature conductor for a given section of iron will be too large, and the wasteful heating will be increased. These losses, increased by Foucault currents and hysteresis, cause a heating of the armature, the harmful effect of which on the insulation can only be prevented by providing a radiating surface sufficiently great to dissipate the heat by radiation and convection.

Mr. Esson, in his Paper on "Some Points in Dynamo and Motor Design,"* gives an empirical formula connecting the elevation of temperature C° which an armature exhibits when constantly absorbing W watts. This formula is

$$C^0 = \frac{225\ W}{S} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

where C° is in degrees centigrade, and S is the cooling surface in square centimetres. The coefficient 225 relates to ring armatures whose peripheral speed is about 15 metres per second.

These different considerations must influence the choice of the length of armature conductor. Let $\lambda$ be the length of an armature convolution, $n$ the number of convolutions in series between the brushes, $s$ the section of the wire, C the coefficient of conductivity, and $r$ the resistance of the armature. Then

$$r = \frac{n\,\lambda}{2\,C s} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6).$$

The voltage lost in the armature is A times this, where A is the current in amperes. In the engine-room, where the temperature is often as high as 30deg., it is not at all unusual for the armatures to attain a temperature of 65deg. At this temperature the coefficient of resistance is nearly two, and the coefficient of conductivity is ·5. The specific resistance of copper at 0deg. is 1·62 microhms per cubic centimetre. By substitution, and by expressing $n \times \lambda$ in metres (denoted by M) we have for E the loss in volts,

$$E = \frac{M\ A}{50\,s} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7).$$

This gives the loss in the armature, and if it does not differ too much from what is assumed to take place, we can adopt it provisionally and proceed with the calculations.

The next thing to do is to determine the conditions relating to the production of the magnetic field. Here we shall follow the Hopkinson method. The leakage coefficients must be determined from experiments on analogous machines, and the relative section of the different portions of the magnetic circuit can then be calculated. The lengths of these different portions are partially determined by the type of machine chosen, but there are certain limits between which variations are possible. Theoretically the shortest possible circuit is the best, but it is necessary that the magnet limbs should be more than a certain length in order that their cooling surface should be sufficient. From 10 to 12 square centimetres of cooling surface are required per watt, and it is necessary that the current density should not exceed two amperes per square centimetre. Mr. Esson has given the formula

$$C^0 = \frac{355\ W}{S} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

expressing the heating in degrees centigrade in terms of the number of watts divided by the dissipating surface in square centimetres. The constant 355 is supposed to apply to bobbins of medium thickness, and my experience goes to show that the formula is practically correct.

Having determined the dimensions of the different parts of the magnetic circuit, the Hopkinson method must be applied to determine the number of ampere turns needed to produce the required magnetic flux. The Hopkinson equation, applied to a single magnetic circuit, is equivalent to

$$n\,a = \frac{1}{1{\cdot}256}\,\Sigma\,\frac{\phi\,l}{\mu\,s} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

where $n$ is the number of turns, $a$ the current in amperes, $\phi$ the magnetic flux, $\mu$ the permeability, $l$ the length, and $s$ the section of the part of the magnetic circuit considered.

This application of the equation gives the number of ampere turns, and from this we can get the section of the wire by use of the formula

$$E = \frac{M\ A}{50\,s}, \text{ or } s = \frac{M\ A}{50\,E} \quad . \quad . \quad . \quad . \quad . \quad (10)$$

The product M A is known, for it is the product of the total number of ampere turns, multiplied by the length in metres of an average convolution round the magnet limbs. We also know E, the electromotive force at the terminals of the dynamo. It is thus easy to calculate the section of wire to use.

It is seen that this section only depends on the number of metre-amperes required, and on the disposable electromotive force. The number of ampere turns does not vary. If the number of convolutions is increased, the resistance augments and the current diminishes in the same ratio. As the temperature of the magnets is generally a little lower than that of the armature, the number 50 in the denominator of the expression for E should be increased to 52 or 53.

In what precedes we have not taken account of the reaction of the armature currents on the field. In order to counterbalance this reactive influence it is necessary to supplement the exciting current by 25 to 35 per cent. in ring armatures, and from 10 to 15 per cent. in drum armatures. Some of the preceding calculations will be modified owing to the neglect of this reactive influence of the armature. Thus we must take a number of metre-amperes 30 per cent. greater than that previously found, and by substitution for M A in the formula $s = \frac{M\ A}{50\,E}$ we can find the proper section of the wire.

* See *The Electrician*, March 14, 1890, p. 476.

---

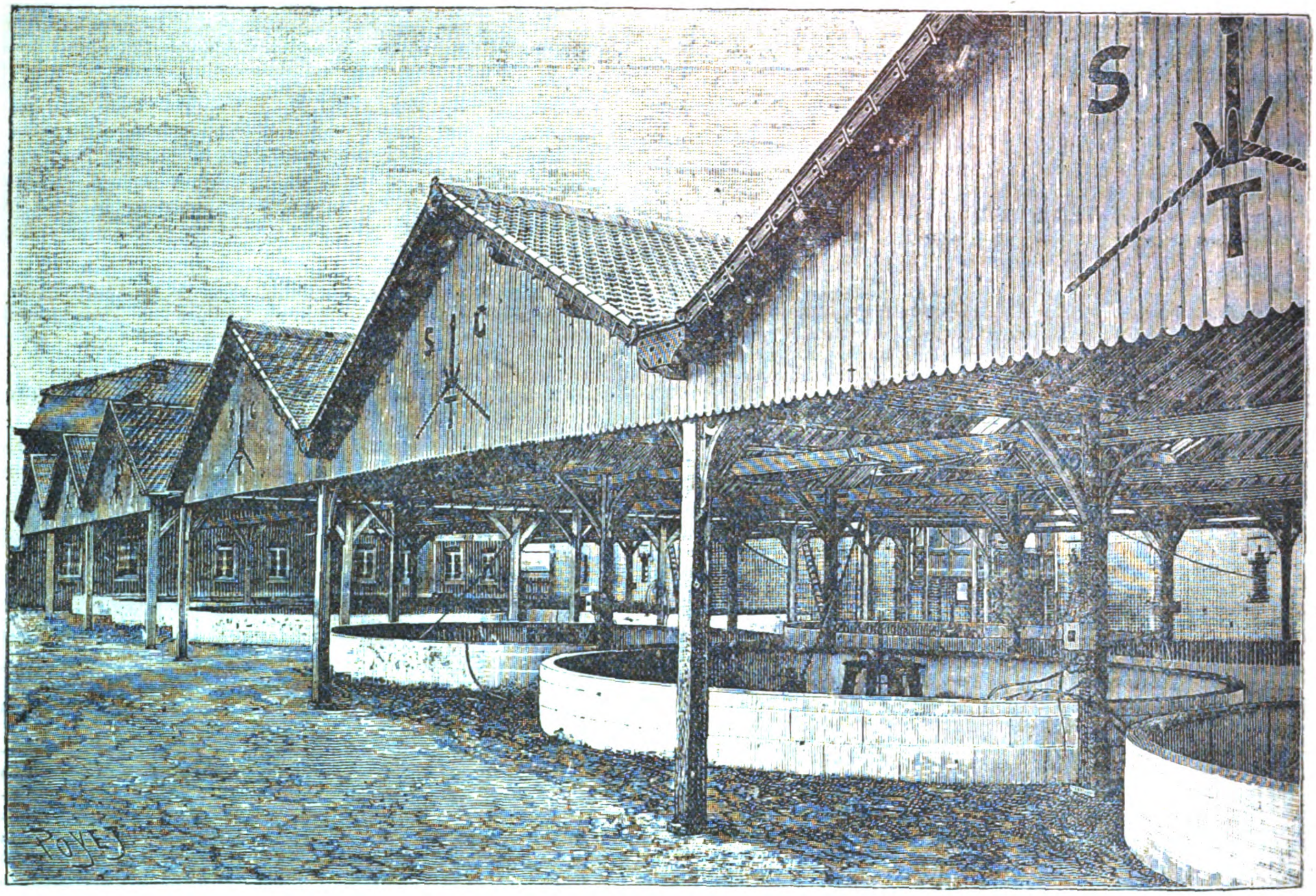
**Royal Institution.**—The following Friday evening lectures dealing with electricity will be delivered after Easter. April 10th, "Electric and Magnetic Screening," Sir William Thomson; April 17th, "Magnetic Rocks," Prof. Rücker; May 22nd, "The Molecular Process in Magnetic Induction," Prof. Ewing. A course of four Saturday afternoon lectures on "The Dynamo" will also be delivered by Prof. Silvanus Thompson. The course will commence on April 11th.

Digitized by Google

## THE MANUFACTURE OF SUBMARINE CABLES IN FRANCE.*

BY MAX DE NANSOUTY.

The Société Générale des Téléphones deprived in 1889 of the telephone system which it had introduced into France, turned its attention to the manufacture of submarine cables, an industry previously unknown in France. The moment was opportune and even propitious. The auspicious extension of our colonial dominions rendered it necessary that France should not remain at the mercy of a Power, friendly, it is true, but which might require its laying and repairing ships to be at the Antipodes. Moreover, in England, in contrast to the spirit which prevails with us, it is held that the State should neither manufacture nor own submarine lines. We had therefore only to deal with private firms. Now, the few who remember the incidents immediately preceding the commencement of hostilities in 1870 will recollect what a price our Department of Posts and Telegraphs had to pay for a cable laid down the Seine, between Paris and Rouen, and what mishaps might have been avoided, and what services rendered, if this cable had been leisurely and coolly laid.



Submarine Cable Works of the Société Génerale des Téléphones.—Tanks for storing the finished Cable.

The Société Générale des Téléphones, encouraged we may at least suppose by the State, decided, therefore, to enter the lists against the one Italian and the three or four big English works. In Italy the firm of Pirelli, brought forth, supported and subsidised directly and indirectly by the State, enjoys at the expense of the Budget, a somewhat artificial prosperity at Spezzia, and, owing to the intelligent activity of its founder, it cuts a very creditable figure.

For some time past the Société des Téléphones had made the cores of coast cables at Bézons, which were armoured in the small Government shops at Seyne. The Société des Téléphones eagerly took advantage of the first propitious opportunity for heavier work, namely, the 100-knot cable from Martinique to Guadaloupe. This cable, which was a great success, and a useful piece of experience for the Bézons works, was laid in 1890. The cable had to be taken to Havre on barges, where it was placed on a German steamer (no English vessel being anxious to undertake the job) and carried to Halifax, where it was deposited on the quay and was subsequently placed on board the French cable ship Pouyer-Quertier. So little was cared in France about the success of this enterprise that, contrary to what was done in Italy and even in England at the time of their first cables, no representative of the State was present during the operation. Possibly no one was aware that it was taking place.

This first success settled the question. The Bézons-sur-Seine site was, however, speedily seen to be unsuitable for the new industry; what with the rise and fall of the river, droughts in summer, and ice in winter. After much study Calais was fixed on. The new harbour, so easy of access, the Carnot basin, with its depth of 26½ feet, the price of land, the facilities for obtaining English, French, or Belgian coal, the abundance of labour in the north, were all arguments in favour of Calais. At Calais, therefore, the works were erected, and they are, from every point of view, at least as well situated as the English ones, which have the disadvantage of being situated on a tidal river instead of alongside a dock. A site was purchased in August, 1890, and the construction of the works was commenced. Boilers were ordered from MM. Weyher et Richemond, and three 90 H.P. engines and the necessary shafting from V. Brasseur, of Lille. The machines for sheathing the cables were ordered in England. So carefully were the specifications, &c., drawn up, that the Société des Téléphones, at the moment when it bought the Calais site, boldly accepted a £3,200,000 order for the Cayenne-Brazil, Martinique-Cayenne network, to be delivered partly in March and partly in June, 1891. By December the works were in full swing, and at the present moment the first order is completed and the cable will be shortly shipped.

The cores are manufactured and tested at Bézons, where the plant is equal to a monthly output of more that 600 knots, and they are then sent by rail to Calais, wound in three-knot lengths on specially constructed drums. As soon as the core arrives at Calais it is stored in tanks capable of taking 800 knots. After having been served with jute and armoured, the cables are coiled in the immense concrete tanks, 33ft. in diameter, shown in the accompanying figure. The works of the Société des Téléphones are very roomy and are methodically arranged, the main workshop consisting of 14 bays 46ft. high and 231ft. long. The monthly output of the works is estimated at 500 knots. What this means may be realised by quoting the figures connected with the 1,000 knots of cable now coiled in the tanks at Calais :—

| | Tons. |
|---|---|
| Core (copper and guttapercha) | 130 |
| Jute serving | 400 |
| Sheathing | 1,000 |
| Bituminous and other compositions | 400 |
| Total | 1,930 |

* From *Le Génie Civil.*

Digitized by Google

Some 300 men and 50 women are employed at the works. In order to facilitate the shipment of cables, the Société des Téléphones have run a tunnel from the factory to the Carnot dock, some 165 yards distant.

The above slight sketch only gives a feeble idea of the Calais works, but unfortunately, as in England, the public is rigidly excluded. The few competent persons who have visited both the English and the Calais factories assert unhesitatingly that neither from the point of view of economy nor from the point of view of output, can the rival works compare with our own. We are thus at last freed from the tax levied on us by England. During the past 30 years we must have paid her from £1,600,000 to £2,000,000 for submarine cables. We must not forget, however, that if we have been successful from the start, we owe it to the intelligence, the perseverence, and the money spent long ago by our English rivals and competitors. The credit of this factory is due to M. E. Vlasto, who has acquitted himself most meritoriously in the carrying out of this patriotic and useful undertaking; the technical organisation and the special machinery, the details of which are kept secret by the English, all had to be thought out by him.

## ELECTRIC LIGHTING LEGISLATION IN GERMANY.

The following are the regulations regarding electrical installations contained in a Bill which is at present before the German Parliament:—

### PREAMBLE.

The application of electricity for lighting and other technical objects has latterly assumed so much importance that it has become necessary in order to remove the dangers connected with electric installations to issue regulations concerning the erection, arrangement and working of such installations. Under this head are to be included current supply stations, conductors, installations and electrical factories. The dangers connected with these installations consist in the possibilities of accident in consequence of the human body coming into contact with the electric apparatus and conductors, in the danger of fire, in the possible interference with the working of the public telegraph and telephone by the conductors erected for other purposes, and in the chance of a thick tightly strained wire carried over streets and houses becoming broken.

In order to guard against these dangers precautions must be taken that all electric installations are provided with such arrangements as are capable of entirely averting danger to human life and of fire, and that all conductors are so disposed as to cause no interference, and that the breaking of a wire is so far as possible prevented, or in any case rendered harmless.

The proposal to insist upon the adoption in the specifications for all electric installations of § 16 of the police industrial regulations was set aside, as it was considered that this course would carry with it difficulties and hardships out of proportion to the danger connected with the industry, and the public interests brought into question, whilst at the same time it would operate to hinder the development of the electrical trades. In every case, therefore, special regulations will have to be observed, which will vary according to the danger involved in the scheme, &c. General police regulations will be issued with reference to the various classes of electric installations, which will be equally binding on all. The following out of these regulations will be enforced by the infliction of fines in cases of contravention thereof. An exception from this rule will be made in the case of installations in the arrangement of which public commerce, &c., are taken into consideration, or which are specially dangerous. In the one case the carrying out of the project will depend upon the granting of the police permission; in the other the work may be commenced when it is officially ascertained that the project is in conformity with the general police regulations.

§ 1. The erection and working of installations for producing, distributing, and applying electric currents for lighting, transmission of energy, and other purposes (electric installations) are subject to the general police regulations sanctioned by Parliament.

§ 2. Electric conductors, which are carried on, under, or over public land, must be so laid as not to interfere with the working of existing electric installations, nor to render impossible the utilisation of public land for the further erection for public use of electric telegraphs, telephones, or signalling installations.

3. For the erection of electric installations for which public land is to be used, the previous permission of the administrative authorities is necessary. Electric installations which have been erected before the publication of this Act and are brought to the notice of the administrative authorities within six months, by a description of their present state with the necessary explanatory particulars, do not require this permission.

§ 4. Three copies of the application for the permission, together with the necessary explanatory information and descriptions, have to be submitted. A copy of the application with drawings has also to be laid before the Imperial or State telegraph authorities. In the application it is to be stated that copies thereof, together with sketches, have been laid before the authorities of other telegraph, telephone, or signalling installations serving public purposes, as well as before the owners of electric installations already sanctioned, or notice of the erection of which has been duly served as required by § 3. Such authorities and owners of installations may, within four weeks of the filing of such application or notice, oppose the carrying out of such installation on the grounds set forth in § 2.

§ 5. If within the above term no opposition is made, the administrative authorities have power, subject to the regulations of § 2 and the decision of Parliament with regard to § 1, as well as to the existing street-railway, fire-alarm and police regulations, to examine the project, and on the result of this examination, either to grant the permission or to impose such conditions as may appear to them to be necessary. Their decision must be given in writing and must contain the conditions imposed. It must give the reasons if the permission is refused or only granted subject to conditions. If doubts arise as to the advisability of granting an unconditional permission, opportunity of verbal discussion is to be allowed the applicants before the decision is arrived at.

§ 6. If the application is opposed, the objection is to be discussed verbally by the administrative authorities with the applicants. In case the objection is answered by the applicants, the opinion of an expert on the project is to be obtained. In this case the experts' opinion is to be allowed to be examined by the applicants before a final decision is arrived at. At the conclusion of the discussion the project is to be examined and decided upon, as enacted in § 5. Notice of the decision is to be given to both the applicant and the opposer.

§ 7. Appeal to the Central Land Court against this decision is permitted. To be valid the appeal must be made within two weeks of the decision. The decision on the appeal must be delivered to the parties in writing, and the reason for such decision must be therein stated. If the telegraph authorities are concerned in the decision, they have the right of appeal against the Central Land Court to Parliament within two weeks. The Parliament will arrive at their decision after hearing the Central Land Court.

§ 8. The increased costs due to groundless objections are to be borne by the opposer, all the remaining costs entailed by the procedure falling upon the applicant. In an application for permission for a new installation, the question as to the division of the costs will be at the same time decided upon.

§ 9. The permission for projects included in § 3 remains in force so long as no alteration thereof takes place, and no new application is necessary if the project is handed over to a fresh applicant. Every alteration to any project requires a previous permission, as set forth in §§ 3 to 8. The preceding regulations also hold good in the case of installations falling under the head of § 3.

§ 10. The use of additional land in one of the projects referred to in § 3 is not to be considered as an alteration for the purposes of § 9, and does not require the permission if the additional land immediately adjoin such public land as is to be utilised for the installation. At least a week's notice has to be given to the local police authorities of the intention to use such additional land. The same holds good with regard to the fixing of lamps on the exteriors of buildings and their conductors.

§ 11. The regulations contained in §§ 3 to 10 do not apply (1) to electric installations to be erected on ground belonging to railway companies, provided no other public land is to be utilised for the same, and (2) to electric installations belonging to the Imperial and State Telegraph Department. The authorities and owners of installations referred to in § 4, section 2, are authorised to bring before the administrative authorities objections against the projects put forward by the Imperial and State Telegraph Department within four weeks after they have received notice thereof. In the event of such objection being made, the administrative authorities are to decide, in case they do not reject the objection as being groundless, whether the project is to be abandoned or modifications are to be made therein. §§ 6, 7, and 8 then apply as to the procedure.

§ 12. Installations of the kind referred to in § 1 for rooms intended for holding public exhibitions, festivals, or meetings as well as for rooms in which explosive materials are manipulated, stored, manufactured, or can collect, must only be put into operation after it has been ascertained and certified by the local police authorities that they have been erected in accordance with the terms of the regulations.

§ 13. A fine not exceeding 300 marks (£15) will be imposed on any person who (1) contravenes the regulations issued under § 1, (2) erects or carries on an installation requiring the permission referred to in § 3 without having obtained such permission, or who does not adhere to the conditions subject to which the permission was granted, or who effects alterations in such installation without the above-mentioned permission, or (3) contravenes the regulations contained in § 12. The police authorities may in cases (1) and (2) order the project to be abandoned or to be modified so as to comply with the rules and requirements, or in case (3) may require the cessation of working.

§ 14. Any person who has omitted to supply the notice required in § 10 is liable to a fine not exceeding 150 marks (£7. 10s.)

§ 15. It is to be determined by the Central Land Court what authorities are to be considered as "administrative authorities" for the purposes of this Act.

## BOOKS, &c., RECEIVED.

"Telephone Directory, 1891." National Telephone Company's Central Scotland District.

"Proceedings of the Royal Society of Edinburgh." Vol. XVII., pp. 401-432.

"Decorative Electricity." By Mrs. J. E. H. Gordon. (London: Sampson Low, Marston, Searle. and Rivington.)

"Massachusetts Institute of Technology. Annual Catalogue 1890-91." (Cambridge, U.S.A.: John Wilson and Son.)

Digitized by Google

## LONDON CHAMBER OF COMMERCE.

### MEETING OF THE ELECTRICAL TRADES SECTION COMMITTEE.

A meeting of the Committee of the Electrical Trades Section of the London Chamber of Commerce was held on the 20th inst., at the offices of the Chamber, Botolph House, Eastcheap, Mr. Emil Garcke being voted to the chair.

The SECRETARY (Mr. Kenric B. Murray) having read the minutes,

The CHAIRMAN stated that Mr. Crompton had asked him to express his regret at his inability to attend the meeting, owing to his being ill in bed. Continuing, the Chairman stated that, to meet the convenience of some of the members present, it was proposed to vary the order of proceedings as set out on the agenda paper. They would remember what occurred at the last meeting, and the minutes which Mr. Murray had read recapitulated the circumstances. There had, moreover, been a very full report of the proceedings in *The Electrician*, and a memorandum had been printed by the Chairman of the Committee by which, he thought, anyone could inform himself in regard to the matter. He, therefore, thought it would be best to at once read the report of the sub-Committee, who had met several times:

The SECRETARY read the following report.

Your Committee have to report that in pursuance of the resolution of the Electrical Section of January 26, 1891, they have met and considered the matters referred to them. Your Committee find that the history of the telephone clauses in connection with the Electric Lighting Acts is as follows :—

In the Session of 1889 the first large batch of Provisional Orders were applied for consequent upon the passing of the Amendment Act of 1888. The question of the protection to be given by the Orders to the telephone companies was naturally raised, and in order to settle the matter a meeting was held at the Board of Trade, when there were present, on behalf of the Board of Trade, Mr. Courtenay Boyle (the Assistant-Secretary), Sir Thomas Blomefield, Major Cardew, as the Electrical Adviser of the Board of Trade, and Major Marindin, who had held the local inquiry in London and upon whose report the Board of Trade have throughout acted. The Telephone Companies were represented by Mr. Winterbotham, of Messrs. Waterhouse and Co. ; and the Electric Light Companies by Mr. Medcalf, agent for the London Electric Supply Corporation, and by Mr. Bonner-Maurice, agent for the Metropolitan Electric Supply Company. At this meeting the clause inserted by the Board of Trade in all Electric Lighting Orders of 1889 was settled after discussion. This clause was the result of a compromise, but was considered by the parties present, including the Board of Trade, to be the best that could be adopted in the conflicting interests of the parties. It may not be improper, however, to state here that your Committee understand that *it was not deemed wholly* satisfactory by either the telephone companies or by the electric lighting companies, but it was inserted in all the 1889 Provisional Orders, all but three of which related to the metropolis. This clause of 1889 was subsequently adopted by the Board of Trade in the Model Order issued by them in 1890.

During the Session of 1890, a very large number of Provisional Orders were granted by the Board of Trade. In the great majority of these the 1889 clause was inserted by the Board of Trade, and no objection was taken to that clause by any of the parties promoting the Orders, or by the Telephone Company. Certain of the local authorities, however, tried to amend the clause in their own favour, and the Board of Trade (which authority, it may be stated, has made it part of its policy to pay the greatest deference to the wishes of the local authority), without expressing any opinion on the merits of the difference, decided not to take the responsibility of determining the difference, but to refer the matter to Parliament. The machinery by which this was done was by altering the clause and leaving the Telephone Company to petition, but the Board of Trade distinctly disclaimed having settled the clause in the altered form, and explained this to the Chairman of the Committee. The question thus raised came up first before the Committee on the Electric Lighting Provisional Orders Confirmation (No. 6) (Birkenhead Electric Lighting Order) Bill, on July 3, 1890. The night before that Bill came into Committee, the Board of Trade wrote to the various agents representing the promoters of Provisional Orders, stating that the question was coming before the Committee on the Birkenhead Order (without saying when), and that the clause settled by the Committee would be inserted by them in all Provisional Orders of the Session. Your Committee understand that this notice was received by some agents so late that they could not get to the Committee Room in time even to be present at the discussion, or until after the question had been decided. Moreover, it is clear that the question was merely one between the promoters of the Birkenhead Order and the other promoters who had objected to the clause as agreed in 1889 (all of whom were represented by the same agents) and their opponents, and that neither the representatives of the London Companies nor the promoters of other Orders had any locus to be heard by the Committee. This Committee, however, settled a clause which is *admittedly more favourable* to the Telephone Companies than the clause of 1889, and the Board of Trade, in pursuance of the determination, of which notice was so tardily given by them to the other promoters, took steps to insert this clause in all pending Provisional Orders.

Your Committee desires that the Section should clearly understand that when a Provisional Order Confirmation Bill comes to Parliament, the promoters of a Provisional Order have to promote *it in the form in which it has been granted by the Board of Trade*, that they have no power to ask the Committee to alter the form of the Order in any manner, and that no question can be raised by any one upon the Order except with the consent of the Board of Trade, or upon petition presented by parties having a locus *against* the Order. Your Committee are informed that it so happened that a great many Orders affecting London and other places had been granted by the Board of Trade, with the telephone protection clause of 1889 inserted, and that the confirming Bills had been introduced into Parliament prior to the date when the Committee considered the Birkenhead Order. Many of these Bills, however, were not opposed, and none of them by the Telephone Company (who had throughout expressed their readiness to abide by the settlement made in 1889), and came therefore before Mr. Leonard Courtney, the Chairman of Committees, as unopposed Bills. The Board of Trade gave notice of their intention to request the Chairman to inserted the Birkenhead Committee clause in lieu of the clause inserted in the Order as granted. When the question came before Mr. Leonard Courtney, he decided that, in the face of opposition by the promoters of the Order, he could not make any substantial alteration, even at the instance of the Board of Trade ; and in those cases, therefore, where the Order had been granted previous to the decision of the Birkenhead Committee, and objection to the proposed alterations was made by the promoters, the 1889 clause remained. The Board of Trade, however, inserted the 1890 clause into the Orders subsequently granted by them, and (notwithstanding the opposition of the Promoters, and the fact that the Telephone Companies did not ask to have the clause of 1890 inserted, but expressed their concurrence in the agreed clause of 1889 being adhered to), declined to make any alteration. Your Committee, however, are informed that in the case of the City of London Provisional Orders, the last two granted by the Board of Trade, during the session of 1890, the Board of Trade, at the request of the Commissioners of Sewers for the City, agreed to the 1889 clause being inserted in the House of Lords in these Orders in lieu of the clause of 1890, which they had inserted in the Orders when granted. For the convenience of the Section, printed clauses of the Sessions of 1889 and 1890 are attached to this Report.

Your Committee understand that the Board of Trade's action in the matter was governed by the following considerations :—They say that in 1889 the responsibility of dealing with the question *had been taken out of their hands* by the agreement come to between the parties. The Board of Trade therefore determined to insert such agreed clause in all orders. They departed from this, however, at the request of a Local Authority, with the result that a Committee of the House settled the clause. The Board of Trade thereupon came to the conclusion that their proper course was to put the Committee's clause into all pending Orders, without reference to locality or to the expressed wishes of the Telephone and Electric Light Companies. At the request of a Local Authority the Board returned to the 1889 clause in the case of the City of London Orders. The Board of Trade have, however, not acted consistently to the course of procedure thus laid down by them. During the present Session some 70 to 80 Provisional Orders are being promoted, and the Board of Trade in the Model Order which they have issued have put forward a third clause on this subject differing from the clauses of 1889 and 1890, and again altering the rights of the two sets of parties.

Your Committee feel strongly that while the Board of Trade are the protectors of the rights of the public in dealing with these matters, and are perfectly justified in altering the conditions which they think necessary to impose upon undertakers in the interests of the public, or of the safety of buildings or otherwise, or as to the prices to be charged, and so on, should not lightly take away from two sets of people the right to contract as to the relative positions of such parties in carrying out their undertakings. It is true that the electric light companies only carry on their operations under statutory authority, and that the telephone companies have no statutory authority. The telephone companies were, however, so to speak, in the field and carrying on a lawful business when the electric lighting companies were promoting their Orders. The Telephone Company, therefore, had a right to say : You shall not injuriously affect our business, but we will be satisfied if you will give us certain clauses for our protection, and the electrict light undertakers had also the undoubted right to say we will give you such protection, but no more. Your Committee moreover admit that in cases where there is a contest as to the proper clauses to be inserted, the Board of Trade was no doubt justified in abiding by the precedent set them by a Committee of the House under similar circumstances. But your Committee cannot understand why the Board of Trade should think it necessary to intervene between the only parties interested, and say that those parties shall not be entitled to settle by agreement the quantum of protection to be given by one to the other. It has been suggested that the Board of Trade in this matter are protecting the rights of the Postmaster-General, as the Telephone Companies carry on their business under a license from the Postmaster-General. The rights of the Postmaster-General are however expressly reserved by the Orders granted, and anything that is arranged between the undertakers and the Telephone Companies can in no way affect these rights.

It would therefore seem to your Committee that the Board of Trade in dealing with this question are unnecessarily curtailing the rights of Electric Lighting and Telephone Companies, to agree amongst themselves how far one is to take precautions against interference with the property of the other. For, as already stated, the essence of the clauses is protection to the Telephone Companies. In the Birkenhead case, moreover, the two parties did not agree, and the Committee was asked by the parties to settle their dispute.

Your Committee feel that it is most desirable that steps should be taken by the Chamber of Commerce on the question of principle, as they feel it is most desirable in the interests of those who have invested and are investing capital in these undertakings, that they should not be put to the continual expense of discussion every Session, both with the Board of Trade and Parliament, how far one of them is or is not to be protected, that there should in fact be some finality to the discussion, and that the rights of the parties to contract with each other should not be disturbed.

Your Committee feel that it is not for them to suggest what steps the Section of the Chamber of Commerce should take upon this report, but

Digitized by Google

they do feel very strongly that the representations should be made to the Board of Trade based upon the principles to which they have here referred.

The CHAIRMAN stated that the report was signed on behalf of the Telephone Companies by Colonel Jackson and Mr. William Winterbotham, and on behalf of the Electric Light Companies by Mr. Sydney Morse and himself. The report rendered it unnecessary for him to say anything on the subject beyond this, that they were both agreed that the 1889 clause would meet their case, and that the Board of Trade were proposing to adopt some other course. It therefore devolved on them to consider what they would do on this report of the Committee. It might be convenient, in discussing this matter, that the further developments which had occurred since the report was drawn up should be communicated to them, and he would therefore ask Mr. Sydney Morse to address the meeting.

Mr. MORSE read a letter which he had received that morning from the Board of Trade, which, he said, was evidently a circular which had been sent to all promoters of Electric Lighting Provisional Orders this Session. In pursuance of the agreement come to by the report which the Secretary had just read, he wrote to the Board of Trade on the Orders in which he was interested. Seeing that they contained the clause known as the clause of 1891, as in the Model Order, and not the clause of 1889, he wrote to the Board of Trade and stated that there was an agreement existing between the telephone companies and his clients that the 1889 clause should be inserted, but not the 1891 clause. The Board of Trade thereupon stated that they had considered the matter, that they could not insert the 1889 clause, and that they must insert the clause of 1891. Now, this was a refusal to the electric light companies to insert an agreed clause. Probably they were aware that it was a common practice in private legislation for the opponents of a Bill to approach the promoter, and say: We will withdraw our opposition if you will agree to certain clauses, and when that is agreed to the petition of the opponents is always withdrawn, and the clause is then inserted in the Bill when it comes before the House, unless it is something contrary to public policy. He had, therefore, concluded that the Board of Trade would follow such a course in connection with these Provisional Orders. He would like to mention that the promoters of an electric light Provisional Order were in a great difficulty when they came to the House. The Board of Trade granted it in such a form as seemed best to the Board of Trade, and the promoters were unable to alter any word in the Order, whereas anyone else could come and oppose the terms of the Order. He went to the Board of Trade and said there was an agreed clause; but the Board of Trade said they did not care—that he was only a promoter. The telephone companies, however, said to the Board of Trade that if they did not put in a clause more satisfactory to them they would oppose every Order that came before Parliament, which meant 70 or 80 oppositions of Bills. The Board of Trade then said: As the telephone companies can oppose us, we must do what they ask us to do. We won't even go so far as to give the electric light companies the clause which the telephone companies have agreed to give them, but will only give a clause which is satisfactory to the telephone companies." When the Board of Trade sent the Model clause to him as the promoter of an Order for this year, he took the trouble to get full instructions, and he wrote fully to the Board of Trade, but they absolutely paid no attention to the letter beyond adhering to their original clause. Having regard to the alteration made by the clause of 1891, as compared with the clause agreed upon in 1889, he stated that the telephone companies had signed the report which had been read, and were prepared to join with the Chamber of Commerce in approaching the Board of Trade and pressing for the 1889 clause being inserted. The telephone companies, however, most unfortunately, as he thought, had already intimated to the Board of Trade that the Model clauses of this year would satisfy them.

Colonel JACKSON said that it would be almost suicidal for the telephone companies to say to the Board of Trade: Now that you have altered the Model Order so as to suit the representations first made, we still decline to accept that Order. The telephone companies indeed thought that the Board of Trade should accept the clause agreed upon between the electric light and the telephone companies in 1889, and if the former could induce the Board of Trade to adopt that generally the telephone companies were prepared to do so; but he did not know that Mr. Morse could ask them to do more than this. What argument could they advance in Committee when they were offered the clause which protected their interests as thoroughly as the clause they had asked the Committee to insert? They quite agreed that the Chamber should be entitled to use its influence in the direction agreed on between them, and the telephone companies could do the same, but the latter could not refuse to accept the Orders. They would probably lose both the Model Order and the new Order by such a course of action.

The CHAIRMAN: I think it is a pity that the position has been somewhat complicated by the telephone companies approaching the Board of Trade practically at the same time as this Committee was sitting.

Colonel JACKSON: No; we approached the Board of Trade before the Committee took up the matter at all.

The CHAIRMAN: Probably the right course then would have been to stay negotiations with the Board of Trade pending the report of the Committee in view of joint action, if the report of the Committee was to have any effect at all.

Colonel JACKSON: I do not see how we could refuse the clause, which gives us all the protection we require.

The CHAIRMAN said he thought they now recognised what the position of this important but complicated clause was. It seemed that the Board of Trade were now suggesting that which was satisfactory to the telephone companies but not by any means to the electric light companies. It was now for the meeting to decide on the course that should be adopted. He was glad to hear Colonel Jackson say that, notwithstanding what had taken place, he would use his influence in the direction of this report.

Colonel JACKSON: Certainly.

The CHAIRMAN: The electric light companies did not desire any more than Colonel Jackson did that there should be any opposition to the promotion of Orders. He would have thought that their going on a common course of action would have avoided that.

Colonel JACKSON: We had hoped so, too, but we cannot control the Board of Trade. If the Board of Trade refuses to adopt the clause of 1889, and insists on an Order of its own, we cannot alter that, and that is the position in which we are placed. We say still that we would prefer the adoption of the clause of 1889.

The CHAIRMAN said it seemed to him that the best course that could now be pursued was to ask the Chamber of Commerce to take some step with a view to this report being made effective; and if Colonel Jackson would not object, he (the Chairman) would propose a resolution asking the telephone companies to support the report by joint action with the electric light companies before the Board of Trade.

Colonel JACKSON stated that he had no objection to a resolution being passed to that effect—speaking for himself; but he had several colleagues on their Board, though he had no doubt they would confirm his action.

The CHAIRMAN pointed out that this was a course which Colonel Jackson, as member of the Committee, had suggested. For the rest, the question at issue afforded only another illustration showing how great were the difficulties of the electric lighting companies before the Board of Trade. He did not believe that any other industry had been hampered in the same way.

After a short further discussion,

Mr. C. J. WHARTON moved the following resolution:—

*"That the report of the Committee of January 26, 1891, be hereby adopted, and that the Council of the Chamber be requested to embody the substance of the report to the Board of Trade by letter, supported by a deputation attended by both interests."*

Colonel JACKSON seconded the resolution, which was adopted.

The CHAIRMAN stated that the next matter on the agenda paper was to consider the desirability of co-operation between the telephone and electric light companies, for the purpose of placing wires underground in future. He had understood that Mr. Crompton had desired to bring this matter before the meeting. He did not know whether any other gentleman would take up the question.

Colonel JACKSON stated that the telephone companies would be ready to discuss the subject with the representatives of the electric light companies, but the Section could not do more than bring the interests together. To give effect to Mr. Crompton's suggestions, certain negotiations would have to take place between the electric light and the telephone companies.

It was decided to postpone the consideration of the question.

The CHAIRMAN stated that the report on overhead wires from the Sub-Committee was on the agenda paper. He believed that the report had been circulated. It was a very long report, and it was not necessary to read it. Those who had read it would recognise how very unfairly the electric light companies were treated by the Board of Trade in this matter. He thought they could only pass a resolution in the same sense as in the case of the telephone wire—that they should make a strong representation to the Board of Trade on the subject.

The proceedings shortly afterwards terminated.

## AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *March* 13, 1891.

**Electric Motor Accident.**—Yesterday another was added to the list of fatal accidents from electricity that have attracted an unfortunate amount of attention in this city. The present, however, is unique, in that the fatal contact was received from a defective motor. The scene of the accident was a silver-plating establishment, recently started in this city. A 6 H.P. Baxter motor for arc circuits had been put in for operating the necessary machinery. It was comparatively a new machine, having been sent from the factory a little over a month ago. Like other similar establishments the factory has a sheet-iron floor for the readier collection of silver dust. The first sign of trouble appeared yesterday morning, when the superintendent of the factory went to the motor to measure its speed, and although he was standing on a board his feet were damp, and on approaching the speed indicator to the armature spindle he received a severe shock. This put him on his guard, and all the *employés* were warned not to go near the machine. As the factory was shutting down for the evening, a lad employed as bookkeeper attempted, contrary to instructions, to shut off the current from the motor. The machine is at about the level of one's head, and as the young man, standing on the iron floor, reached for the switch, he accidentally brought his forehead in contact with the flange of the motor pulley, and was instantly killed by the shock received. The newspapers are only too quick in taking up such a case and gloating over its details.

Digitized by Google

**Electric Railway Activity.**—There is promise of great activity in electric railway circles as soon as spring opens and the weather is sufficiently good for construction work. All the large companies are overburdened with orders, and probably even a larger number of roads will be equipped during the coming season than last year. Several long roads are talked of, two of them 50 miles in length. Neither of these, however, proposes to be anything more than an exaggerated street car line connecting a considerable number of towns. It is to be hoped that before long some steps will be taken towards a genuine electric railroad operated at sharp speeds. The Weems Electric Railroad Company, under whose auspices Mr. Crosby's beautiful experiments with high speed traction were tried, is said to be preparing to carry out an extensive experiment that was postponed by unfortunate financial embarrassments. One or two other high speed schemes are on the *tapis*, but whether anything practical will come from them remains to be seen.

**Rapid Transit in New York.**—The rapid transit excitement in this city has not in the least abated its fervour, and plans are constantly being brought before the rapid transit commissioners for their careful consideration. The general consensus of opinion now seems to be that a viaduct is impracticable on account of the enormous expense, if the route should be laid through the central portion of the city, where it is needed. The public will no longer tolerate the elevated roads, and consequently the only refuge is underground roads. The two underground systems that are most favourably looked upon are the Greathead, too well known in London for me to say anything further about, and the Reno, which has some strong advocates on account of its great simplicity. The Reno plan is to run in beton side walls for the tunnel, from narrow open cuttings, keeping as near the surface as possible, and then to roof it in with steel channel irons resting on the tops of these walls, and shielded by cement. A cutting edge bearing on the top of the walls will be forced ahead to clear away the material, and the proposed tunnel is large enough for four tracks, two express tracks below, and two way tracks above. This form of tunnel is said to cost less than a four track tunnel of the Greathead system, which latter loses much of its characteristic advantage in working in rock, through which any underground system in New York will have to be cut almost continuously above Fourteenth-street.

## CORRESPONDENCE.

### ELECTRICITY IN RELATION TO THE HUMAN BODY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: My colleague (Dr. Harries) and I would esteem it a favour if you will grant us space to reply to the remarks of the unknown correspondent whose letter forms the subject one of the leaderettes in this week's issue of your journal.

The tone of the extracts from his remarks appears to us to lack both courtesy and good taste. He commences by a covert sneer at our experiments relative to "cataphoric medication," goes out of his way to insult the Society of Arts, and finishes up by misquoting our words. On his misquotation he bases an inference that we had no ground for speaking of the "indifference, suspicion and conservatism" of the medical profession.

1st. As to the cataphoric medication experiments—their "crudeness" consists, we suppose, in the fact that they are (so far) qualitative and not quantitative. We only put them forward as evidence of an early stage of an investigation confessedly incomplete, but we have good reason to suppose them conclusive as far as they go. If they be in any sense true, it can hardly be denied that they form a very important advance in the uses of electricity to the body, and we are therefore justified in bringing them forward. Should your correspondent be able to prove that we are wrong, we will not hesitate to acknowledge our error; but till he has at least attempted to do so we think a more courteous tone of criticism would have been more becoming. From the wording of the communication it seems probable that your correspondent was present when the Paper was read, in which case it seems strange that he should have failed to avail himself of the opportunity of relieving his feelings in the discussion which followed.

2nd. We did not make the statement attributed to us, "that the health of the body *is* largely dependent upon electricity." Our words (taken from the official journal of the Society) were, "The health of the body *seems* to be intimately connected with, and *perhaps* to a large extent dependent upon, electricity, or the immediate results of electrical action both internal and external." We specially guarded against expressing any such absolute opinions, and confined ourselves to stating the probabilities based upon such information as we have been able to obtain from others and to observe for ourselves.

His other quotation, "very probably life does not exist without electricity," is rendered unnecessarily bald by being robbed of the remainder of the sentence of which it forms a portion only. The complete sentence is: "Electricity is useful to us in health; it is so closely connected with vital function and sensation that very probably life does not exist without it; it is capable of producing such changes in the body, that it takes rank as one of the best remedies in disease, and it is also of immense value in many branches of surgery." In support of this conclusion we had brought forward a fair amount of evidence, but that we laid no claim to complete proof thereof is clearly shown by the next sentence, which runs:—

"The true relationship between this marvellous and many-sided agent of Nature, and the various complicated phenomena which together make up the sum of our individual existence, *has yet to be found*." We have no desire that medical men (or any others) should, in considering our work, accept as proved what we do not claim as such, but we are surely justified in drawing conclusions from our experiments and observations, and in setting forth those conclusions before such a body as the Society of Arts in order that they may be criticised and discussed, and thereby established or destroyed.

Our reference to the "indifference, suspicion and conservatism of the medical profession *as a body*" was made a ground for complaint not because they declined to accept any theories we may have put forth, but because they have so strangely ignored the whole subject of the uses of electricity to the human body. On this point we spoke strongly, because we feel strongly, and we are further quite prepared to stand by and show evidence for all that we said thereon.—Yours, &c.,

March 23, 1891. H. NEWMAN LAWRENCE.

### CAPACITY MEASUREMENTS OF CABLES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: An examination of Mr. Dearlove's recently published Paper, illustrating a correction for capacity tests, calls for the following remarks.

The method of correction in question, as described in Messrs. Glazebrook and Muirhead's communication to the British Association last autumn, would appear to include an allowance for leakage, as well as for absorption, in the comparison of condensers; but we fail to see how it applies to a submarine cable in respect to leakage. In this case the charge lost by leakage cannot be measured. For, supposing, for the sake of argument, that in the figures given in Mr. Dearlove's Paper there is *no* absorption effect, but only leakage on the cable side, then there ought to be no correction deflection on earthing the point K (*The Electrician*, March 6th, p. 537) and discharging the point J through the galvanometer to earth. Consequently, the value of the capacity obtained would be wrong. The results on the cables cited are perhaps not wholly conclusive, but have a general tendency to too high a value for the corrected capacity, as might be expected from the operation of leakage on the cable. This tendency seems to have been accentuated when the "earthing period" was made more commensurate with the time of charge.

We are of opinion that it is necessary in all capacity tests to apply the formula we published in *The Electrician* of 12th

Digitized by Google

December last, or some similar one, except where the loss of charge can be measured by accumulation. But, as we remarked in the same place, in connection with the absorption effect, if the time of charge does not exceed about three seconds the only correction which need be taken into account is that for leakage. We also ventured to point out that if by "capacity" be understood the instantaneous charge, then no existing cable would require more than three seconds for the establishment of a practically uniform potential throughout its conductor.

We note that Mr. Glazebrook, in his Paper referred to, speaks of "instantaneous" and "full" capacities. Would it not be more satisfactory if, when dealing with the subject of capacity, it were decided whether the former or the latter of the two values is to be understood? In practice it often happens that by varying the conditions of measurement, especially as regards time of charge, neither one nor the other is arrived at.—Yours, &c.,

Harold W. Ansell.
Julian E. Young.

Cable steamer "Chiltern," London, March, 1891.

## TRADE NOTES AND NOTICES.

Tenders Wanted.—The telegraph authorities at Stockholm require tenders for the supply of telegraph and telephone insulators, iron, copper, bronze, bimetallic and insulated copper wire, line connections, glass tubes, hooks, &c. Particulars will be found in our advertisement columns. Tenders must be in by noon on April 4.

——— The Urban Sanitary Authority of Harwich require tenders for the public lighting of their district by Electricity, gas, oil, or any other method, from August 1, 1891. Particulars may be obtained from Mr. A. J. H. Ward, town clerk, to whom tenders must be sent by April 4th.

Tenders Received.—The following tenders have been received for the wiring of the Blue Posts Tavern, Old Bond-street, London, W. The number of lamps was 52 of 16 c.p. and 2 of 200 c.p. The estimates were made to the specification of Mr. R. Willy, F.R.I., B.A. Crompton and Co., £111. 14s.; Strode and Co., £99. 14s.; B. Verity and Sons, £97; Brush Electrical Engineering Company (Limited), £96; Woodhouse and Rawson United (Ltd.), £61. 3s.; Dobson and Co. (accepted), £47. 10s. It may be noted that the average of the first four is £101. 2s. The highest exceeds this average by only 10½ per cent., while the lowest falls 5 per cent. below it. The two other tenders differ from it by about 40 and 53 per cent. respectively.

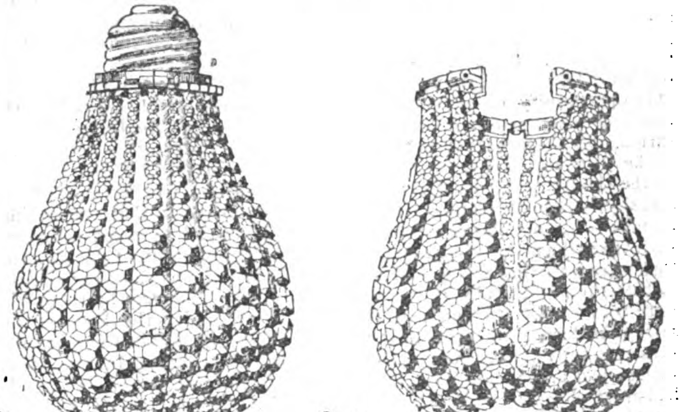
——— The following tenders have been received for laying electric bells between police station and residences of members of fire brigade, Coventry:—Radcliffe, Birmingham, £139. 14s. 3d.; Blenheim and Co., Egham, £85; Matthews, Ball, and Preston, Leicester, £80. 10s.; Gillett, Richmond, £68; National Telephone Company, £20.

Measuring Instruments.—MM. Richard Frères send us their catalogue of measuring instruments. Their *specialité*, as is well known, is for recording apparatus, and these, with a revolving drum, they apply to a very large number of purposes. Among others, we find recording ammeters and voltmeters. The latter appear to be the most useful, since they are only required to work through a small range. They are in use in many central stations for recording the insulation of the mains by showing the volts between the mains and the earth. The ammeters cannot be expected to register correctly with small currents. All these recording instruments would be much improved by the addition of a simple parallel motion. The power absorbed by the Richard meter described in our last issue is 2 watts, not 20.

Livonia Flashing Letters.—We were recently shown a working model of Messrs. Cox, Robinson & Co.'s "Livonia" flashing letters, specially designed for outdoor advertising purposes. These letter signs and devices are thoroughly weatherproof. The inside of the letters consists of a number of various coloured incandescent lamps which can be changed at will. The body of the letter consists of an iron case, in the base of which is placed an insulated lining for mounting the lamps upon. The outer iron bodies are lined throughout with reflecting sides arranged at an angle enabling each lamp to be multiplied. The whole is enclosed in a case having a transparent front which is hinged to the body of the letter, forming a weather-tight cover for the lamps. The connections are made inside the body of the letter, and are brought to insulated terminals. Taking the letter "A" as an example, 12 lamps are sufficient to light up the letter with considerable effect. The motor (a combined gravity clockwork and electro-motor, very simple and having few working parts) by which the alternations are worked permits the whole of the main circuits to be made and broken without sparking. At 60 feet from the ground 30 watt lamps, we are assured, have been found quite sufficient to ensure a good light. The cost of running is small, and, considering the effect, after the initial expense only a very trifling outlay per lamp is entailed. We understand that Messrs. Cox, Robinson & Co. put up these flashing letters and maintain them by the hire system, if necessary. They certainly make an effective advertisement. In London they are used at the Trocadero, Piccadilly-circus; in Manchester at Messrs. Lewis's; and in Liverpool at Messrs. Lewis's and at the Prince of Wales Theatre.

Turbines.—The catalogue of Mr. F. Nell, of 16, Mark-lane, contains a great deal of useful information about the Victor turbines. These are arranged on horizontal or on vertical shafts, and are well adapted for low heads of water.

The Bead Ray Diffuser.—Those who like cut-glass shades for electric light, should examine the very ingenious fitting to which we alluded in the description of the St. Pancras Electrical Exhibition, and which is illustrated by the accompanying figures. The makers claim a little too much for it, as they imagine that no light is wasted. The loss is probably less than with ground glass, as there are spaces between the beads. The chief merit of the invention appears to lie in the compact manner in which the bag of beads encloses the lamp. In a large room, and with a number of lights,



With Electric Lamp Ray Diffuser Attached. Sketch Showing Simplicity of Attachment.

where the spotty shadows which are inevitable with such an arrangement would not be noticed, these diffusers would be excellently adapted for use with cut-glass chandeliers.

Munro's Electrical Manufacturing Company.—We are notified that this Company have made arrangements with Messrs. Höfler and Company, 45, Jewin-street, E.C., to act as their sole representatives for London and district.

A Printers' Exhibition.—There is now being held at the Agricultural Hall, Islington, an exhibition which will probably interest many of our readers. A number of labour-saving machines are on view, and gas-engine makers are, as usual, well to the fore. Messrs. Crossley Bros. have on show several of their most recent makes, and, in particular, have a very fine 9-horse engine exhibited. The Trent Gas Engine Company have on view some good engines, but the absence of anything electrical is again noticeable.

The Opening of the Mutual Telephone Exchange.—In reference to our note on the subject of the opening of the Mutual Telephone Exchange, in which we stated that the transmitters were of Messrs. Siemens' manufacture, we are asked by the International Electric Company to state that they also have supplied the Mutual Telephone Company with their spoon-shaped receivers, which have proved a decided success, and for which they have recently received a very flattering report as to efficiency, &c.

## COMPANIES' MEETINGS.

### Brighton and Hove Electric Light Company (Limited).

The annual meeting of this Company was held on Wednesday at the offices, Gloucester-road, Brighton, under the presidency of Mr. Robert Hammond, the Chairman of the Company.

The CHAIRMAN, in moving the adoption of the report and balance-sheet (an abstract of which appears below), said it was a very gratifying thing to point out to the shareholders that the system which the Company adopted some two years ago, the alternating current high tension transformer system, was now almost universally acknowledged as the only possible system for supplying electricity over an extended area by the

Digitized by Google

leading electricians not only in this country but throughout the world. All the new work in America was being carried out on this high tension system, and practically one might say that only very old-fashioned engineers, who had not kept pace with the times, found themselves advocating the low tension system, which had its day and finished its career in the minds of serious people some six or eight years ago. For instance, during the past few months the City of London decided to grant powers to two companies, and in both cases the system which was practically worked out by this Company in Brighton had been adopted. The same remark applied to Dublin, Cambridge and Bristol. He, therefore, did feel that he was safe in speaking very confidently as to what would take place if they were forced to go into competition with the Corporation. Of course the Corporation purse was a much longer one than theirs, and if it came to a question as to who could lose the most money he quite acknowledged that the ratepayers of Brighton would be able to beat them on that score but in actual and fair working competition they (the Company) would gain the victory. The Company were doing their very best to come to an amicable arrangement with the Corporation, and he personally had felt confident for some time past that it was greatly to the Corporation's interest to come to an arrangement with the Company. By the system which the Corporation had adopted it was only possible to supply a limited area. By the Company's system a very extended area could be supplied, so that by coming to an arrangement with the Company the Corporation would have the advantage of having a pioneer system by which they could put on customers in the most distant parts of Brighton and Preston, while they were gradually consolidating their business in the choice area they had carried out in the front of the town. If the Corporation were to meet a committee of this Company, he was quite certain that the result would be a friendly arrangement which would be to the advantage of both the Company and the Corporation. It would be noticed that the amount of capital at present invested in the Company was £17,500, of which £2,500 was held in debentures. It was proposed to increase the debenture capital by a further £3,000, bringing up the total to £20,500. He would like to take this opportunity of correcting a misapprehension which existed in the minds of many ratepayers of Brighton, and which had been referred to in various observations that had been made in the Corporation with regard to the Company. There was an impression that the £17,500 share capital of the Company was largely made up of promotion money, and did not actually represent plant. He could only say in reply that the original founders of the Company bought a limited amount of plant compared with that which the Company at present held for the sum of £2,000, and that after a further £2,000 had been spent upon it it was valued at £8,000, so that the profit made in the formation of the Company by those who were bold enough to purchase the old concern under the hammer was £4,000 in shares. But the plant that was taken over by the Company was valued at fully the £8,000 paid for it. Since then various important additions had been made, bringing up the present total to £17,500, and he had great pleasure in assuring the shareholders that during the past year the plant had been kept in repair out of revenue, and that for every penny that appeared on the balance sheet the Company could show a satisfactory asset.

Mr. CASH seconded the motion, which was carried.

Mr. Kimber having been re-elected a Director, and Messrs. Ball, Baker, Rowe, and Co. reappointed auditors, the CHAIRMAN, replying to a vote of thanks, said that he hoped to continue Chairman of the Company for a very long time. Some folk had tried to drive them out of the field, but, considering he had the honour of having founded in Brighton the first electric light company that took up the industry of the house-to-house supply, they could easily understand that he felt a much greater interest in Brighton than that which would depend on his share of the small Directors' fee which the Company paid. He had felt very keenly the opposition of the Corporation in view of that fact. At a time when the distribution of electricity from house to house was an absolutely unsolved principle in England—he might say in any part of the world, for Brighton was the earliest place in the world where the distribution of electricity by means of high tension currents was carried out—that system, which ten years' experience had proved to be the best, was founded in Brighton, and history no doubt would write their names very large. The item of £3,361. 11s. 9d. (net revenue from supply of electricity) did not by any means represent the total amount of revenue which they could have obtained from the plant they had at work. Although for the greater part of the year they were completely full, yet during the past two or three months they felt a falling off of revenue, inevitable from the cessation of those customers who preferred to wait for the Corporation supply, and refused to enter into a three years' contract with the Company. These adverse circumstances caused their business to be temporarily reduced in the winter quarter, when it should have been the largest. He was glad, however, to say that the lights released by the recalcitrants were being rapidly taken up, and there was every reason to believe that their net revenue from the supply of electricity in the year ending December, 1891, would be largely in excess of that which figured in the present balance sheet.

---

The following is an abstract of the Directors' report:—

"The Directors have pleasure in submitting to the shareholders the report of the operations of the Company from January 1st to December 31st, 1890. The profit and loss account, after writing off an ample sum for depreciation of plant (which has, however, been kept in thorough repair out of revenue), shows a balance of profit for the year of £768. 2s., from which has to be deducted interest on debentures £123. 6s. 7d., leaving a net amount of £644. 15s. 5d., which, with the balance brought forward from last year's accounts, makes the sum to the credit of profit and loss account £1,202. 15s. 1d. The Directors recommend that this shall be dealt with as follows:—Written off from 'Suspense Account, Garman Case' (one third of £697. 6s. 10d.), £232. 9s.; dividend, 5 per cent., £750; carried forward, £223. 6s. 1d.; total, £1,202. 15s. 1d.

"The Directors greatly regret that in consequence of the continued opposition of the Corporation of Brighton they were last year again disappointed in their efforts to obtain a Provisional Order under the Electric Lighting Acts, 1882-1888. They have, however, this Session applied to the Board of Trade for power to lay underground mains in that portion of Brighton which is not embraced in the area which the Corporation at present proposes to supply. In the event of this Provisional Order being granted they are willing to withdraw their overhead wires from the Corporation area. Should the application for the Provisional Order not be successful the Company will continue to supply throughout the whole of Brighton, including the area served by the Corporation, by means of its overhead wires; and it hopes to be able, by means of its greater economy of working, to make satisfactory headway against the competition of the Corporation. During the past year every effort has been made by the Company to come to terms with the Corporation, and the Directors cannot help feeling that eventually the Corporation will acknowledge the desirability of making some arrangement with the Company. The Company has during the past year proceeded with the alterations referred to in former reports, and at the present time the whole of the Company's supply is on the most modern system known, *i.e.*, The Alternating Current High-Pressure Converter System, by means of which the excessive waste connected with the use of accumulators is avoided, as well as the heavy cost in mains, necessitated by the low-tension system. Failing coming to an arrangement with the Corporation, it is the intention of the Directors to lay down additional plant in order to cope with the pressing demand from consumers outside the Corporation's proposed area of supply, and the attention of those shareholders, who wish to subscribe a portion of the additional capital, is drawn to the advantages offered by the Company's debenture stock.

"The Hove Commissioners, who now hold a Provisional Order, have decided not to do the work themselves, but to let it out to a company;

PATENT
SILICIUM BRONZE AND SILICIUM COPPER WIRE.
The best for overhead Telephone and Telegraph Lines,
AND ALL ELECTRICAL PURPOSES.
Hard Drawn High Conductivity Copper Wire.
ROLLED AND DRAWN PHOSPHOR BRONZE.
PHOSPHOR BRONZE BEARINGS, BUSHES, AND OTHER PARTS OF ELECTRICAL MACHINERY
SOLE PROPRIETORS of the British, Indian and Colonial Patents,
THE PHOSPHOR BRONZE COMPANY (Limited),
87, Sumner Street, Southwark, London, S.E.
WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

Digitized by Google

and in view of the fact that this Company is already meeting all the present demands for electric lighting in Hove, the Directors hope to get the preference with the Hove Commissioners for any extensions of electric lighting which the Commissioners may require.

"During the past year, Mr. Albert Gay has resigned his position as manager, having been offered the important post of manager of the House-to-House Electric Company's Works, West Brompton. Mr. Gay gave the Directors great satisfaction, and they are sorry to part with him. Mr. Alfred Hodgson, who has been for the past four years secretary of the Company, has been appointed manager in his stead. During the past year, Mr. Frank Wilden Bentley has ceased to be a Director, and the shareholders are invited to nominate some one—a local gentleman by preference—in his place. If the Company obtains its Provisional Order, or comes to a fair working arrangement with the Brighton Corporation, it will be desirable and agreeable to your Board to invite the Corporation to appoint a Director to represent its interests and those of the ratepayers generally. The retiring Director is Mr. Arthur Kimber, who offers himself for re-election. The meeting will have to elect an auditor or auditors for the ensuing year."

## The Telephone Company of Egypt (Limited).

The eighth ordinary annual general meeting of this Company was held on Tuesday at the offices of the Company, 14, Austin Friars, under the presidency of General Alex. Fraser, C.B., R.E.

The SECRETARY (Mr. A. B. Chalmers) having read the notice calling the meeting,

The CHAIRMAN said: I assume, gentlemen, that the report and accounts having been already before you may be taken as read. The business has during the past year been kept up to a fair point of prosperity, though, in fact, so far as the accounts are concerned, the profit in this last year has been about £340 less than in 1889, but the benefits from the establishment of the exchanges at Port Said and Assiout will only be felt in this and following years, while the working expenses have necessarily increased on this account. Any large extension of the business must wait on the reviving financial condition of the country. Our wires are for the most part being renewed with phosphor bronze, and the replacing of some very large poles has also added to the expenses which have all been charged to revenue, and as the manager reports all the lines in excellent condition the Directors have not thought it necessary to charge anything to depreciation. It may be that the charges against revenue may from time to time be large on account of maintenance, but so long as the lines and instruments are kept in perfect order from revenue there is no reason for making another charge for depreciation. You are, no doubt aware that much of the trade has been transferred from Alexandria to Port Said and Suez, and as a consequence our business at the former place has to some extent fallen off, but from what I know of the Port of Alexandria I should say it will always remain a place of importance, and any falling off there will be fully compensated by increasing business at Port Said and Suez. We have already as you are aware opened at Port Said, and we hope to conclude negotiations for opening at Shez this year. We have had, from time to time, negotiations with the Egyptian Government as to the establishment of telephonic communication between Cairo and Alexandria, but considering the circumstances of the latter, to which I have alluded, the Directors have not been able to come to the conclusion that such a line, which would cost not less than £12,000 to be efficient, would give even a moderate return to the Company. Perhaps, as the financial condition of the country improves, it may be worth while for the Government to erect the line, retaining the Company to work it in connection with its exchanges at either end, or to make some arrangement whereby the expenditure shall not be altogether at the Company's risk. The matter will continue to have your Directors' attention. Your Directors believe that our service is carried on with the greatest efficiency. We have had, at all events, no complaints on that score, and as this is due to the careful supervision of Mr. Evans and his staff, I hope the shareholders will be able to express their satisfaction with the services of the Egyptian staff. Our staff and expenditure in Egypt is also kept on a most moderate scale by our able secretary, who is quick to bring any abnormal outlay to the notice of the Board, and your Directors are not dilatory in requiring full explanation before authorising it. While our expenditure is at the lowest point consistent with efficiency, and our dividend remains at the moderate sum of 6 per cent., our subscribers in Egypt cannot fairly expect that the moderate charges for the services rendered can be reduced. The Committee in Egypt lend their aid to our superintendent in any matters of importance which may arise in which their advice is desired by the Board, and our thanks are due to the members of the Committee for thus giving their time. I beg to propose—

"*That the report and accounts for the year ended December 31, 1890, b and are hereby approved and adopted, and that a dividend be paid of 6 per cent. on the preferred shares, free of income-tax.*"

Mr. HENRY GREWING seconded the motion, which was carried unanimously.

The CHAIRMAN next moved:—

"*That Henry Grewing, Esq., be and he is hereby re-elected a Director of the Company.*"

Mr. LLOYD seconded the motion, which was carried unanimously.

On the motion of Mr. ADDISON, seconded by Mr. HENTSCH, the auditors, Messrs. Price, Waterhouse, and Co., were reappointed; and the Chairman having been thanked for presiding, the proceedings terminated.

## CITY NOTES, &c.

**BRAZILIAN SUBMARINE TELEGRAPH COMPANY.**—The receipts of this Company for the week ended March 20th amounted to £6,174.

**CITY AND SOUTH LONDON RAILWAY COMPANY.**—The receipts of this Company for the week ended March 21st amounted to £766.

**ELMORE'S FOREIGN AND COLONIAL PATENT COPPER DEPOSITING COMPANY (LIMITED).**—The Directors have called meetings for April 6th, to alter the articles of association to enable them to distribute amongst the shareholders the assets held by the Company, and represented by shares and debentures of the French and Austrian companies. If these clauses are altered so as to enable the Directors to distribute the above securities as though they were dividend in specie, they will immediately propose a distribution equivalent to £6 per priority share and £5 per founders' share, reckoning the securities to be divided at their par value.

**THE NEW YORK BELTING AND PACKING COMPANY.**—The first ordinary general meeting of this Company will be held on Tuesday, April 7th next, at the Cannon-street Hotel, E.C., at 2 o'clock.

**STOCK EXCHANGE.**—The Stock Exchange Committee have appointed Thursday, April 2nd, a special settling day in Elmore's Austro-Hungarian Patent Copper Depositing Company (Limited), shares Nos. 1 to 50,000.

**TELEPHONE COMPANY OF AUSTRIA (LIMITED)**—This Company have declared the usual half-yearly dividend to the 30th inst. on the preference shares, at the rate of 6 per cent. per annum, payable, less income tax, early in April.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY.**—The traffic receipts of this Company for the week ended March 20, 1891, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £5,105.

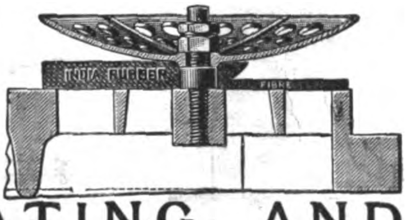
## NEW COMPANIES REGISTERED.

**ALEXANDER MATHIESON AND SONS (LIMITED).**—Registered in Scotland, with a capital of £120,000 in £10 shares. Object, to purchase and carry on the business of the firm of Alexander Mathieson and Sons, merchants, manufacturers of planes, mechanical and engineering tools and machines at the Saracen Tool Works, East Campbell-street, Glasgow, as well as in Edinburgh, Liverpool, and elsewhere.

**JARROW FORGE AND ENGINEERING COMPANY (LIMITED).**—Registered with a capital of £80,000, in £10 shares. Objects: To carry into effect an agreement made Feb. 27th, between "The Jarrow Forge Company (Limited)," of the first part, Matthew Dent and Edward Wilson, of the second part, and John Price, on behalf of the Company, of the third part, and to carry on generally the business of forge proprietors, engineers, shipbuilders, mechanical engineers, &c.

NEW VALVE

No Rubber, Percha, or Leather.




One-half the price of Rubber or Metal.

FOR CIRCULATING AND AIR PUMPS.

Unaffected by any Lubricating Oils. Does not Expand in diameter. Feed Water may be worked at any temperature Suitable for any shaped guards. Only one quality manufactured.

"13, John-street, Sunderland, 26th Sept. 1885.

"DEAR SIRS,—In reply to your letter of the 25th inst., the Valves I got from you have done their work well, and ARE AN UNQUALIFIED SUCCESS. I will continue get them from you as required.—Yours faithfully, JAMES WESTOLL."

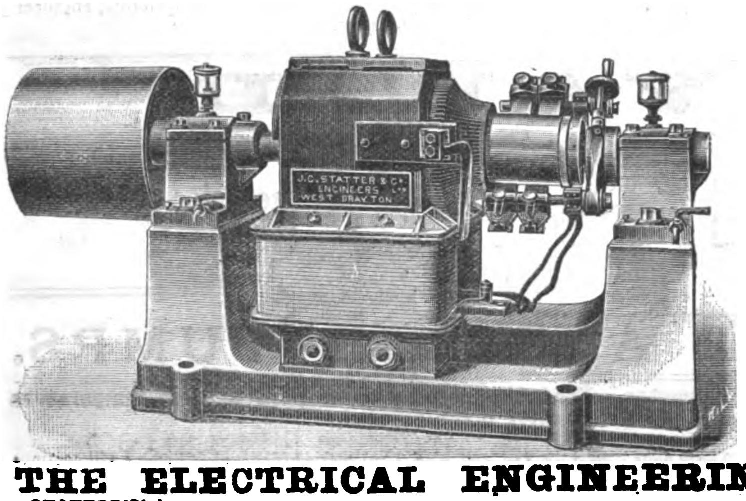
For further Testimony and Prices, apply to MOSSES & MITCHELL, 68-71, Chiswell Street, London.

Digitized by Google

## COMPANIES' SHARE LIST.

| Present Amount. | Amount Share. | Last Dividend. | Name. | Previous Week's Price, March 18. | | Price Tuesday, March 25. | | Rate per Cent. Yielded. £ s. d. | Dividend Due. | Business Done During Week Ending Mar. 25. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **TELEGRAPHS.** | | | | | | | | |
| £1,381,380 | Stock | 15/0 | Anglo-American | 47½ | 48½ | 47 | 48 | 6 0 0 | Jan., Apr., July, Oct. | 48 | 47⅝ |
| £2,809,310 | Stock | 30/0 | Do. Preferred | 84½ | 85½ | 84 | 85 | 6 15 4 | " " | 85½ | 84¾ |
| £2,809,310 | Stock | .. | Do. Deferred | 11 | 11½ | 11 | 11½ | .. | " " | 11¼ | 11 1/16 |
| £250,000 | 100 | 4% | African Direct, Telegraph 4% Debentures | 99 | 102 | 99 | 102 | 3 18 5 | January and July .. | .. | .. |
| 180,000 | £10 | 3/0 | Brazilian Submarine | 11¾ | 12¼ | 11¾ | 12¼ | 6 2 5 | Mar., June, Oct., Dec. | 12⅛ | 11⅞ |
| £84,500 | £100 | 5% | Do. 5 per Cent. Bonds | 100 | 103 | 100 | 103 | 4 17 1 | January and July .. | .. | .. |
| £75,000 | £100 | 5% | Do. 5 per Cent. Bonds (2nd Series, 1906) | 103 | 107 | 103 | 107 | 4 13 6 | June and December | .. | .. |
| $7,216,000 | $100 | 7% | Commercial Cable Capital Stock | 108 | 110 | 108 | 110 | 5 18 2 | April and October .. | .. | .. |
| 16,000 | 10 | 8/0 | Cuba Submarine | 10½ | 11½ | 10½ | 11½ | 6 19 2 | February and August | 10⅞ | .. |
| 6,000 | 10 | 10% | Do. Preference 10% | 16½ | 17½ | 16½ | 17½ | 5 14 3 | " " | .. | .. |
| 12,931 | 5 | 2/4½ | Direct Spanish (£4 paid) | 3¾ | 4¼ | 3¾ | 4¼ | 6 11 9 | April and October .. | 4⅛ | .. |
| 6,000 | 5 | 10% | Do. Preference 10% | 9½ | 10½ | 9½ | 10½ | 4 15 3 | " " | 10 | .. |
| 60,710 | 20 | 3/6 | Direct United States | 10¼ | 10¾ | 10¼ | 10¾ | 6 15 0 | Jan., Apr., July, Oct. | 10¼ | 10½ |
| 400,000 | 10 | 2/6 | Eastern | 14⅛ | 14⅜ | 14⅛ | 14⅜ | 4 10 5 | " " | 14 5/16 | 14 1/16 |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference | 15¼ | 15¾ | 15¼ | 15¾ | 3 16 2 | " " | 15¼ | .. |
| £1,200,000 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock | 107 | 110 | 107 | 110 | 3 12 9 | May and November | 108¾ | .. |
| £200,000 | 100 | 5% | Do. 5 per Cent Debentures, 1899 | 107 | 110 | 107 | 110 | 4 10 11 | February & August | .. | .. |
| 250,000 | 10 | 2/6 | Eastern Extension | 14¾ | 15¼ | 14¾ | 15¼ | 4 13 4 | Jan., Apr., July, Oct. | 15 | 14 13/16 |
| £320,000 | £100 | 4% | Do. 4 per Cent. Debenture Stock | 105 | 108 | 104 | 107 | 3 14 9 | .. | 106 | .. |
| £91,800 | 100 | 5% | Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900 | 103 | 106 | 103 | 106 | 4 14 4 | January and July .. | 104 | .. |
| £145,300 | 100 | 5% | astern & S. African 5 per Cent. Mor. Deb., 1900 | 103 | 106 | 103 | 106 | 4 14 4 | " " | .. | .. |
| 180,227 | 10 | 1/9 | lobe Telegraph and Trust | 9¼ | 9½ | 9⅜ | 9⅝ | 5 4 0 | Jan., Apr., July, Oct. | 9 7/16 | 9⅜ |
| 180,042 | 10 | 6% | Do. 6 per Cent. Preference | 15 | 15½ | 15 | 15½ | 3 18 8 | " " | 15½ | 15 |
| 150,000 | 10 | 5/0 | Great Northern | 17 | 17½ | 17 | 17½ | 3 8 7 | Jan., April, and July | 17⅛ | .. |
| £230,000 | 100 | 5% | Do. 5 per Cent. Debentures, 1883 | 103 | 106 | 103 | 106 | 5 13 2 | March & September | 106 | 105½ |
| 17,000 | 25 | 12/6 | Indo-European | 38 | 40 | 38 | 40 | 6 5 0 | May and November | 39⅞ | 39⅞ |
| 38,348 | 10 | 4/0 | London Platino-Brazilian | 6½ | 7½ | 6½ | 7½ | 5 14 4 | " " | .. | .. |
| £100,000 | 100 | 6% | Do. 6 per Cent. Debentures | 105 | 108 | 105 | 108 | 5 11 1 | March & September | .. | .. |
| 9,000 | 8 | 4/0 | Reuter's | 8½ | 9 | 8¾ | 9¼ | 5 8 8 | April and October .. | .. | .. |
| 3,381 | £100 Cert. | 6% | Submarine Cables Trust 6% | 115 | 120 | 115 | 120 | 5 0 0 | " " | .. | .. |
| 15,609 | 10 | 4/0 | West African Telegraph | 8 | 9 | 8 | 9 | 5 11 1 | January and July .. | .. | .. |
| £290,900 | 100 | 5% | Do. 5 per Cent. Debentures | 97 | 100 | 97 | 100 | 5 0 0 | March & September | .. | .. |
| 30,000 | 10 | 3/0 | West Coast of America | 2 | 3 | 2 | 3 | .. | January and July .. | 2 9/16 | .. |
| £150,000 | 100 | 8% | Do. Debentures 8% 1902 | 92 | 97 | 92 | 97 | .. | June and December | .. | .. |
| 88,321 | 10 | .. | West India and Panama | 2¾ | 3 | 2¾ | 3 | .. | .. | 3 | .. |
| 34,563 | 10 | 6/0 | Do. 1st Preference 6% | 11½ | 12 | 11½ | 12 | 5 0 0 | May and November | 11 13/16 | 11⅝ |
| 4,669 | 10 | £3 | Do. 6 p. c. 2nd Pref. | 11½ | 12½ | 11½ | 12½ | 4 16 0 | " " | .. | .. |
| 64,174 | 15 | 6/0 | Western and Brazilian | 12 | 12½ | 12 | 12½ | 4 16 1 | " " | 12⅜ | 12⅛ |
| 27,873 | 7½ | 6/0 | Do. 5 per Cent. Cumulative Preferred | 6¾ | 7¼ | 6¾ | 7¼ | .. | – | 6¾ | .. |
| 27,873 | 7½ | 4/6 | Do. 5 per Cent. Deferred | 5¼ | 5¾ | 5¼ | 5¾ | .. | .. | 5⅝ | 5 5/16 |
| £200,000 | 100 | 6% | Do. 6 per Cent. Debs., Series "A" 1910 | 103 | 106 | 103 | 106 | 5 13 2 | February & August | 106 | 105 |
| £250,000 | 100 | 6% | Do. 6 per Cent. Mort. Debs., Series "B" 1910 | 103 | 106 | 103 | 106 | 5 13 2 | " " | .. | .. |
| $1,336,000 | $1,000 | 7% | Western Union 7 per Cent. 1st Mortgage | 120 | 125 | 120 | 125 | 5 12 0 | May and November | .. | .. |
| £175,100 | £100 | 6% | Do. 6 per Cent. Sterling Bonds | 100 | 104 | 100 | 104 | 5 15 5 | March & September | .. | .. |
| | | | **TELEPHONES.** | | | | | | | | |
| 224,850 | 14/0 | 0/4½ | Consolidated Telephone Const. & Maintenance. | 7/16 | 9/16 | 7/16 | 9/16 | .. | May and November | .. | .. |
| 220,000 | £1 | 3% | Oriental (11s. paid) | 5/16 | 7/16 | 5/16 | 7/16 | 4 8 7 | Yearly | .. | .. |
| 438,984 | 5 | 2/6 | National | 4¼ | 4½ | 4⅜ | 4⅝ | .. | June and December | 4⅝ | 4⅝ |
| 15,000 | 10 | 6/0 | Do. 6 per Cent. Cumulative 1st Pref. | 12¾ | 13¼ | 12¾ | 13¼ | 4 10 7 | " " | 15 3/16 | .. |
| 15,000 | 10 | 4/9⅜ | Do. 6 per Cent. Cumulative 2nd Pref. (£8 pd) | 10 | 10½ | 10 | 10½ | .. | " " | .. | .. |
| 209,750 | 1 | ½% | South of England, Ordinary | ⅛ | ¼ | ⅛ | ¼ | .. | – | .. | .. |
| 20,000 | 5 | 2/1 | Do. 6 per Cent. Cumulative Pf. (£3 10s. pd) | 2¾ | 3¼ | 2¾ | 3¼ | 6 9 0 | .. | .. | .. |
| 58,000 | 5 | 1/0 | United River Plate | 3 | 4 | 3 | 4 | .. | January and July .. | .. | .. |
| £146,128 | Stock | 5% | Do. 5 per Cent. Debenture Stock | 85 | 95 | 85 | 95 | 5 5 3 | .. | .. | .. |
| £3,200 | 100 | 7% | Do. 7 per Cent. Debentures | .. | | .. | | .. | – | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | | | |
| 19,900 | £5 | .. | Electricity Supply Co. of Spain | 4½ | 5 | 4½ | 5 | .. | .. | .. | .. |
| 111,000 | 5 | .. | London Electric Supply | 2 | 2¼ | 2¼ | 2½ | .. | .. | .. | .. |
| 43,900 | 10 | .. | Metropolitan Electric Supply (£9 paid) | 8¾ | 9¼ | 8¾ | 9¼ | .. | – | 8⅞ | .. |
| 7,730 | £5 | .. | St. James' and Pall Mall | 6⅛ | 6⅝ | 6¼ | 6½ | .. | – | .. | .. |
| 42,853 | 5 | .. | Westminster Electric Supply (£4 paid) | 3¾ | 4 | 3⅞ | 4⅛ | .. | – | .. | .. |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | | | |
| 63,416 | 3 | .. | Brush Electrical Engineering | 2¼ | 2½ | 2¼ | 2½ | .. | .. | 2⅝ | 2¼ |
| 63,416 | 2 | 1/1 | Do. 6 per Cent. Preference | 1½ | 2 | 1½ | 2 | 6 0 0 | June and December | 1 11/16 | .. |
| 20,000 | 5 | 3/6 | Crompton and Co., 7 per Cent. Pref. Shares | 5 | 5½ | 5 | 5½ | 6 7 3 | January and July .. | .. | .. |
| 17,130 | 5 | .. | Edison and Swan United | .. | | .. | | .. | .. | .. | .. |
| 45,000 | 10 | 6% | Electric Construction | 5 | 6 | 5 | 6 | .. | .. | .. | .. |
| 70,000 | 2 | 10/0 | Elmore's Patent Copper Depositing | 3 | 3½ | 3 | 3½ | .. | .. | 3¼ | 3 |
| 20,000 | 5 | .. | Fowler-Waring Cables (£4 paid) | 2½ | 3½ | 2½ | 3½ | .. | .. | .. | .. |
| 41,600 | 10 | 10/0 | India Rubber, Gutta Percha & Telegraph Works | 19 | 20 | 19 | 20 | 5 0 0 | February & August | 19½ | 19 |
| £200,000 | 100 | 4½% | Do. 4½ per Cent. Debentures, 1896 | 104 | 106 | 104 | 106 | 4 4 11 | March & September | 7 | .. |
| 11,334 | £10 | 6/1 | International Okonite Limited Ordinary | 7 | 8 | 7 | 8 | .. | .. | .. | .. |
| 11,334 | £10 | 5/0 | Do. Preference | 9¼ | 9¾ | 9¼ | 9¾ | 8 4 1 | .. | .. | .. |
| 78,949 | 5 | 4/10½ | Swan United (£3. 10s. paid) | 4½ | 5 | 4½ | 5 | 6 19 10 | May and November | .. | .. |
| 37,350 | 12 | 36/0 | Telegraph Construction and Maintenance | 45 | 47 | 45 | 47 | 5 0 0 | March and July | 46 | 45½ |
| £150,000 | 100 | 5% | Do. 5 per Cent. Bonds, red. 1894 | 102 | 105 | 102 | 105 | 4 15 3 | January and July .. | .. | .. |
| | | | **RAILWAYS.** | | | | | | | | |
| 50,000 | £10 | .. | City and South London Railway | 5½ | 6½ | 5½ | 6½ | .. | .. | .. | .. |


# IMPROVEMENTS IN DYNAMOS




# STATTER-BRUNTON DYNAMO.

**The latest design in the market, made with all the advantages of the latest scientific knowledge and the highest mechanical skill.**

The woodcut represents our B TYPE DYNAMO. A most efficient machine, working noiselessly, and without sparking or overheating; is highly finished and well proportioned. The output is so rated in our Catalogue that the machines may be worked very much in excess of their stated full output for short periods.

**STOCK SIZES UP TO 77 KILOWATTS.**

**MACHINES BUILT TO 500 KILOWATTS.**

**THE ELECTRICAL ENGINEERING CORPORATION, LIMITED,** [UNITED STATTER'S]

68, Victoria Street, London, S.W. WORKS:—ALLIANCE ENGINEERING WORKS, WEST DRAYTON, NEAR LONDON.


Digitized by Google

# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 672.—Vol. XXVI. FRIDAY, APRIL 3, 1891. Price Fourpence.

## NOTES.

Attention was called on a recent occasion in the House of Commons to the small attendance at the British Museum in the evening, and it appears that while 7,224 persons visited the galleries on Easter Monday, only 342 went there after eight o'clock, when the Museum was reopened. It is a great pity that the lighting was not thoroughly done at first, since one may go there with the intention of studying early English sun-dials, and have to put up with mummies; for only one portion is lit at a time. A far more serious mistake has been made in closing the Museum at dusk and reopening it from eight to ten. We recently visited the gallery in which a most interesting selection of drawings from the Print Room has been arranged. There was a very fair attendance, but at five o'clock the politely-worded cry of "All out!" resounded through the rooms, and the whole place was cleared forthwith. As an evening paper says, the visitors cannot be expected to cool their heels from five till eight o'clock. There is no apparent reason why a large attendance *should* be looked for on a Bank Holiday evening. Those who are bent on some form of entertainment at the end of a holiday can hardly be expected to turn out at eight o'clock to go to a museum. It was obvious enough on the occasion of our recent visit that many others besides ourselves would have stayed if permitted, and the electric light being very well done as far as it goes, they would have gladly continued to instruct or to amuse themselves.

To call a Society "International" which regularly year after year chooses all its officers from a single nation, is obviously a misnomer; yet a glance at our columns will show that this is the course pursued by the Société Internationale des Electriciens. A genuinely International Society might serve as a sort of permanent International Congress, and would possess considerable influence. As it is, the Société Internationale remains a purely French institution with little or no prestige.

In the January number of the Royal Society's *Proceedings*, Prof. J. J. Thomson describes some experiments to determine the velocity of the electric discharge through rarefied gases. It is strange that, since Wheatstone's first attempt, in 1835, to measure this velocity by means of a rotating mirror, no experimenter seems to have thought the matter worth re-investigation. Not only does the knowledge of the velocity render it necessary to discard at once several theories which could be advocated in explanation of the phenomena of electric discharge, but any method of measuring it must also show whether the discharge starts from the positive or negative electrode. The velocity found by Prof. Thomson by the revolving mirror method, is approximately half the velocity of light, and is given as $1{\cdot}6 \times 10^{10}$ centimetres per second. This is so great that the discharge cannot possibly take place by mere convection of the luminous molecules of the gas; for, if this were the case, the velocity of the molecules would be enormous, and the spectrum of the gas, when analysed with the telescope pointing along the direction of discharge, would, according to Doppler's principles, exhibit lines displaced from their proper position in the spectrum. No such phenomenon is found to occur, so that a different explanation must be sought. The idea that discharge takes place by the successive interchange of atoms between adjacent molecules is equally untenable, as the average distance between the molecules is far too large.

If one could regard the phenomenon of gaseous discharge as being mainly due to an action in the ether, there would be nothing extraordinary in such a high velocity as is actually found. The velocity with which an explosion travels in an explosive mixture of gases, such as hydrogen and oxygen, is known to be about the velocity of sound; and, from analogy, one would imagine that anything in the nature of disruptive discharge, would be propagated with the velocity of light, since that is the velocity appropriate to the ether. Prof. Thomson, however, takes the view that the passage of electricity is always effected by the dissociation of molecules, and ingeniously accounts for the high velocity by assuming that chains of contiguous molecules are formed, capable by electrolytic action of transferring an atom, and hence an atomic charge, from one end of this chain to the other, practically instantaneously. The spaces between the chains are traversed more slowly, but, by supposing them comparatively short, it is easy to account for the high velocity. This assumption leads at once to an interesting theory of the well-known striæ occurring in vacuum tubes, and the fact found by Prof. Thomson that the discharge proceeds from the positive to the negative electrode, can be shown to imply certain properties of the striæ which they are known from experiment to possess.

In the March number of the *Philosophical Magazine* appear two valuable Papers dealing with the subject of specific inductive capacity. The determination of this quantity is of interest, from both a theoretical and a practical point of view.

Digitized by Google

In the first place, it is a well-known deduction from MAXWELL's theory, that the square of the index of refraction of a substance is equal to its dielectric constant. This law is far from holding good in many cases, and it is accordingly desirable to test substances by various methods, to determine the influence of secondary actions in altering the apparent value of the inductive capacity. In view, also, of the prospective importance of condensers in alternate-current work, it is specially desirable to thoroughly examine the behaviour of the dielectrics under the action of alternating potentials; because the differences found in the value of the dielectric constants of bodies, when tested by different methods, correspond with the waste of energy which would occur in condensers formed with these substances as the insulating medium. Thus, the phenomena of residual absorption, when occurring with alternating currents, must produce effects closely analogous with those caused by hysteresis in iron, and must give rise to a loss of power and heating in the condenser.

MR. LECHER, the author of the first Paper, investigated the constants of ebonite, glass, petroleum oil, and water, by three different methods, in which the time of charge was varied from half a second down to one hundred millionth part of a second. For the high frequencies HERTZ oscillations were used, while an influence machine, and an induction coil were employed for the slower charges. The result, contrary to the experience of Prof. J. J. THOMSON, who had also determined dielectric constants by HERTZ oscillations, is to show that the inductive capacities apparently increase with the rapidity of charging; and the author considers that the electric oscillation method is unreliable, owing to the great damping which occurs. The second Paper on this subject is by Mr. ROSA, of John Hopkins University, and deals more especially with conducting electrolytes. The inductive capacity was calculated from measurements, by a torsion balance, of the force exerted between two balls immersed in the fluid under test and charged to various potentials. The voltage applied, the frequency of alternation, the temperature, and the conductivity of the liquid, were all varied to test their influence on the constants found. The method of test was specially suitable for eliminating the effects of conduction; and the result of the numerous measurements made, is to show that a conducting liquid has a definite specific inductive capacity independent of the current flowing through it. The values found for the specific inductive capacities of water and alcohol are extremely high, being 75·7 and 25·7 respectively.

**Societe d'Encouragement.**—This Society has published a long list of small prizes for electrical inventions to be awarded in 1892-93-94.

**Brussels.**—The municipal authorities have requested M. Wybauw to draw up a specification for tenders for the erection of a 20,000-light plant.

**Honours.**—Sir F. Abel was invested by Her Majesty, on the 18th March, with the insignia of the Civil Division of the Second Class of the Order of the Bath.

**Portsmouth.**—At a recent meeting, the Town Council decided to undertake the electric lighting of the borough, and that Mr. Shoolbred should be engaged to prepare plans and specifications.

**Telegraph Extension in Orkney and Shetland.**—The Government have agreed to the extension of the telegraph to Westray Island, Orkney, and to two places in Shetland. It is expected that the cable will be laid very shortly.

**Capacity Measurements of Cables.**—Mr. Dearlove informs us that he proposes to reply next week to the criticisms of Messrs. Ansell and Young, which appeared in our last issue, upon his communication which was published on March 6th.

**The Manufacture of Submarine Cables in France.—A Correction.**—In our last issue, on p. 648, we were made to say, owing to a printer's error, that the Société des Téléphones accepted a £3,200,000 order for cables. The figure should, of course, be £320,000.

**Institution of Electrical Engineers.**—A general meeting of the students was held on March 20th, when the following Papers were read :—"Gutta Percha," by Mr. H. C. Haycraft; "Commutators," by Mr. J. H. Garret. At the next meeting, on April 10th, a Paper will be read on "Photometry," by Messrs. Matthew and Seaman.

**Royal Victoria Hall.**—The following are the arrangements for science lectures at this hall during April:—Tuesday, 7th, Prof. Rupert Jones on "Minute Things in Nature;" 14th, Dr. Crosskey on "Extinct Volcanoes of France;" 21st, Mr. Dent on "Mountain Exploration in the Caucasus;" 28th, Mr. Kennedy, "Fighting the Indians" (experiences of a war correspondent).

**The Old Students' Association.**—On Wednesday, March 25th, an interesting Paper on "Coals, Coal-Mines, and Coal-Mining," was read before this Association at Finsbury Technical College by Mr. Albion T. Snell, following which an interesting discussion took place. A Paper has been promised for this session by Dr. Silvanus Thompson on "Recent Advances in Optics."

**Electric Traction in Berlin.**—At the recent general meeting of the Grosse Berliner Pferdebahn an exhaustive report was submitted regarding the financial and technical results of electric street railways on the overhead, underground, and accumulator systems of traction in Europe and America. The directors are negotiating with the Berlin municipal authorities for a concession to work experimentally one of the above-mentioned systems on their tramways.

**Reduction of Telephone Charges.**—It is announced that the charges to the public for the use of the Post Office Telephone Exchanges in various towns throughout the country have been reduced. For subscribers within a quarter of a mile of the exchange, £8 a year; half a mile of the exchange, £10 a year; three-quarters of a mile of the exchange, £12 a year; one mile of the exchange, £14 a year. At the same time a reduction has been made in the charges for ordinary private wires.

**Presentation to Mr. A. D. Stevenson.**—The partners and *employées* of the firm of Messrs. Drake and Gorham on Thursday last week presented a Wheatstone bridge and a stationery cabinet to Mr. Stevenson on his resignation of the post of manager. We understand that Mr. Stevenson has been compelled to resign on account of failing health, and has been recommended by his medical advisers to go to South Africa, where he will start in business in partnership with Mr. Edlin, for some years the representative in this country of Messrs. Lacombe and Co.

**The Telegraph Revenue for 1890-91.**—Although the receipts from the telegraph service continue to show an increase, it is by no means so large as that of the preceding financial year. The receipts for the year ending March 31, 1890, amounted to £2,320,000, or £240,000 more than the previous total. The receipts for the year ending March 31, 1891, are £2,380,000, an increase of only £60,000 over the previous total. All the quarters of the year 1890-91 show an increase, when compared with the corresponding quarters of 1889-90, except the last, in which there is a decrease of £45,000.

**Societe Internationale des Electriciens.**—The Council of this Society have decided that all presidents shall be nominated one year in advance. The Council's candidates for 1891, elected at the annual meeting on Wednesday, were as follows: President, M. Joubert; Vice-Presidents, MM. H. Baron, H.

Digitized by Google

Menier, de Romilly; General Secretary, M. R. V. Picou; Treasurer, M. Dumoulin-Froment; Secretaries, MM. Hospitalier, Max de Nansouty; Members of the Committee, MM. E. Cael, J. Carpentier, Chapron, Clérac, Darcq, Ducretet, Gariel, Harlé, Huet, Magne, Mouchel, de Parville, Pellat, Rouart, Sartiaux, Sciama, de la Touanne. The President elect for 1892 is M. Carpentier.

**Electric Lighting in Connection with Railway Disasters.**—The electric light is used to a large extent on American railways for lighting up "wrecks" or night construction work. For this purpose the Pennsylvania Company and the Cumberland Valley Company have a car fitted up with boiler, dynamo, engine, water tanks and coal bunker, and all the tools necessary for a central station. After the Johnstown flood six men put up six arc lamps, ran the wire, coupled up the lamps, and had the lamps going in 35 minutes from the time the car, lamps, poles, and wire arrived on the ground. The lights were distributed some distance, one being about one third of a mile away.

**Exports of Telegraph Apparatus.**—The Board of Trade Returns continue to show very irregular movements in the value of our exports of telegraphic wire, and of apparatus connected therewith. The February exports were small, but the aggregate this year is still large compared with the corresponding figures for 1889 and 1890. The following are the details for the two months:—

| | 1889. | 1890. | 1891. |
|---|---|---|---|
| January ......... | £113,230 ...... | £71,686 ...... | £238,223 |
| February ......... | 32,086 ...... | 201,594 ...... | 22,306 |
| Total......... | £145,316 ...... | £273,280 ...... | £260,529 |

**Electric Light Mains in the West End.**—At a recent meeting of the St. George's (Hanover-square) Vestry, Lord F. Fitzroy called the Surveyor's attention to the irregularities of the electric light companies who had been engaged in laying cables in the more fashionable parts of St. George's for some months past. One company, he said, would take up the paving-stones, and directly they were re-laid the other corporation would lift them again. He asked if the Vestry could take no action in the matter to put an end to the inconvenience inflicted upon the public?—The Surveyor said he was sorry to state that the Vestry was almost powerless in the matter. The companies had left several streets and squares in a very bad condition.

**Accumulator Traction.**—On p. 563 of our issue of March 13th, we stated, on the authority of the *Elektrotechnisches Echo*, that the firm of Hostmann and Co., of Hanover, who had been carrying on traction experiments with Schoop gelatinous accumulators in the neighbourhood of Hildburghausen, had decided to abandon the use of these accumulators. This is an error, and the real facts are as follows:—The experimental line at Hildburghausen was regularly worked from August last until the end of March, when the charging station was dismantled and the accumulator car was got ready to be taken to Frankfort. During the Exhibition this car, and a large 34 passenger car will run regularly. Messrs. Hostmann and Co. state that the results of their experiments have so far been satisfactory.

**The Victoria Patents Office.**—The Commissioner of Patents for the Colony of Victoria has issued the following circular to inventors, manufacturers, and others:—"With a view to obtaining the fullest information for the library of the department, I have the honour to solicit a copy of catalogues, leaflets, &c., with sectional illustrations, describing and illustrating as fully as possible your products and manufactures. It is hardly necessary to point out that, as a means, not only for the better dissemination of knowledge and information for the public, but also for protecting manufacturers and inventors, to whom letters patent have been granted, and thus preventing the piracy of inventions already published or in operation, such documents are invaluable, and are necessary as evidence of publication prior to an application being made to this office for letters patent.

**The Westminster Electric Supply Corporation.**—All the three Stations of the Westminster Electric Supply Corporation are now at work. The Millbank Street Station was permanently started in November last. The station at Eccleston Place was started on the 2nd March; and that at Davies Street, which supplies Mayfair (down to Piccadilly), was started on the 24th March. In the two cases last named the permanent machinery is enclosed in a temporary iron building, covering over a portion of the engine and boiler rooms, while the building of the rest of the station proceeds. The time which elapsed between the signing of the building contract and the delivery of current from permanently installed plant, was seven months and three days in Eccleston Place, and exactly six months in Davies Street, although work was practically stopped for nearly two months in the winter, owing to the severe frost.

**"The Optician."**—A copy of the first number of this weekly paper has been sent to us, and it certainly has a useful field before it. "The ordinary dealer," says this new journal, "with a few notable exceptions, is profoundly ignorant on all optical questions affecting his photographic apparatus, although his assurance will never fail him in replying to any inquiry involving the optics of photography, or the principles of the lantern. . . . . . We shall endeavour, by providing scientific articles, written in a comprehensive and popular style, to educate him up to a higher standard. . . . . . The day will be welcomed by all when the covert sneer contained in the epitaph 'Shoptician' shall have been, once and for all, wiped out." A few hints as to the choice of batteries for particular purposes, and the use of vacuum tubes and coils and other electrical playthings would be useful also.

**The Telephone in Spain.**—The Spanish Government has published the conditions under which tenders will be received for the construction and working during a certain number of years of a complete network of telephonic lines, to be established between the principal towns in Spain. For this purpose the country will be divided into four districts. Telephonic communication must be established between the principal towns designated in each district, within ten months after the date of the concession; with other towns of less importance, within a year from the same date; and with other places, within three years. All the apparatus employed must be of the most perfect description. The maximum charges to the public are fixed by Government, and the holders of the concessions will pay an annual sum to the State for each kilometre of line. The full conditions under which tenders will be received are published in the *Madrid Gazette*.

**A French Electrical Mining Plant.**—The Compagnie Continentale Edison installed an electric haulage plant last year in the Mines de Marles, and it has given such satisfaction that the original plant is now about to be considerably enlarged. The generator is a 26 unit Edison machine, giving 400 volts at 900 revolutions. The pit is nearly 1,000 feet deep, and the line runs along a gallery 1¼ miles in length. The locomotive is 7ft. 3in. long, 2ft. 4in. broad, 4ft. 11in. high, and weighs 2 tons, 6cwt. The motor, a 10 unit machine, is arranged lengthwise and drives on to both axles through double helicoidal gearing. A speed of over 9 miles an hour is attained, and 10 B.H.P. is developed when hauling a train of 25 fully loaded skips, each weighing 14cwt. The conductors in the gallery are two Vignole rails suspended from porcelain insulators fixed in the roof, and the current is taken off by two travelling carriages fitted with brushes and connected to the locomotive by flexible conductors. The plant efficiency is stated to be 75 per cent.

**The London Electric Supply Corporation.**—"Probably no Board of Directors ever had to bear a heavier responsibility than has weighed upon Mr. Forbes and his colleagues during the past year; and no engineer," says the *Journal of Gas Lighting*, "has ever had either greater difficulties or a finer opportunity than their young Engineer, Mr. S. Z. de Ferranti. But the Directors believed in their Engineer, and stuck to him through everything; and he has justified their confidence by triumphantly doing what nearly all other electricians have declared to be impossibilities. Whether or not the Company will ever make a good profit, of course remains to be seen; but, in the meantime, the splendid spirit displayed by both Board and Engineer in grappling with their troubles, and agreeing to sink

Digitized by Google

or swim together, deserves recognition. If they were gas people, we should be proud of them; and we do not see why we should not cordially admire them because they happen to belong to a different industry."

**Underground Telephone Cables in the City.**—Colonel Haywood has reported to the Commissioners of Sewers upon the application of the National Telephone Company for permission to place some telephone cables beneath the public ways of the City. At present, he states, all their cables are overhead, and what is immediately sought is permission to lay underground trunk lines to connect the principal exchange with the smaller exchanges. About 31 streets altogether, and many of them important and leading streets of the City, would be disturbed for the purpose. The total length of public way sought to be opened was nearly three miles. Colonel Haywood points out that the inconvenience caused to the public by carrying out the work would be considerable, and in some cases the laying of additional tubes in the network of gas, water, and telegraph pipes would be impossible. He advises the Commissioners to defer their consent until the conductors for lighting the City by electricity are laid. At the same time he expresses a strong opinion in favour of all wires being placed under the streets in subways of ample size. This report will shortly come up for consideration.

**The Dawn of Telegraphy in France.**—The use of the electric telegraph, says *l'Electricité*, was first thrown open to the public on March 1, 1851, the first official recognition of its existence having been a royal decree, dated November 13, 1844, placing £9,600 at the disposal of the authorities for experiments on the line between Paris and Rouen. Three years later every departmental capital was in telegraph communication with Paris. In 1852 the receipts amounted to more than £20,000; in 1853 they had increased to £60,000, and in 1854 they exceeded £80,000. An early cause of the inferiority of the French telegraph service, was the endeavour of the authorities to use a method of signalling similar to the time-honoured semaphore system, in order that the staff might have little new to learn. It is needless to say that the tariff was exorbitant, 4fr. being the minimum charge for a message to Rouen, and no rebate was given to pressmen. Tedious proofs of identity were also demanded from every individual who despatched a telegram. A noteworthy feature of the early days of French telegraphy, was the great relative importance of the Paris receipts. In 1852, 43 per cent. of total receipts were due to Paris; in 1853, 40 per cent.; in 1854, 41 per cent.; and in 1855, 40 per cent.

**The Founders of Electric Lighting.**—The following remarks made by Prof. Elihu Thomson in his "Pioneers' Day" address to the National Electric Light Association, may be of interest:—"It was my privilege in 1889 to visit the Royal Institution in London, and there inspect the original manuscript records made by Sir Humphrey Davy and by Faraday—the two great names lying, as it were, at the foundation of the sign, at least, of electric lighting—to inspect also the apparatus and even to handle the apparatus which Faraday used in his early experiments. I can say that I did it reverently. These two names are coupled with the beginnings of our great industry. Sir Humphrey Davy was the first man who ever saw the electric arc; the first man who put two wires together tipped with carbon, drew them apart and got the flame which we now call the electric arc. He called it the electric arch, I believe, or an arch of flame. I saw the record of this in Davy's rapid hand, that this was a gorgeous experiment. It was quite a contrast—the difference between Davy's style of recording his experiments and Faraday's—and there is that contrast even to be seen in their work. Davy was, as it were, brilliant, jumping from one thing to another and getting thereby a great leap; while Faraday's was the painstaking work of the scientific investigator, who thought out carefully what he was about, and when he had concluded his experiments, wrote out just as carefully what he had obtained. The records of Faraday's are models of neatness; they are models of precision in every way."

**Magnetic Rocks.**—In a letter to *Nature* the following instance of extraordinary local magnetic disturbance, due to the presence of magnetic rocks, is cited by Commander Creak:—In September, 1885, when H.M. surveying vessel "Meda" was passing Bezout Island, near Cossack, North-West Australia, a steady deflection of her compass of 30deg. was observed. This remarkable result has, however, since been exceeded by observations made in the "Penguin" on November 6, 1890, the "Penguin" being two miles N. 79deg. E. from Bezout Island, a deflection of 22deg. was observed. The ship was immediately anchored, and some hours of the next day were spent investigating the matter. On Bezout Island itself the absolute values of the variation and dip were normal, the dip being 50deg. 1'·7 S. But at a position N. 79½deg. E. distant 2·14 miles from that on Bezout Island, the observed dip on board was 83deg. S., with a very small deflection of the compass. At 900 feet to the westward of this the dip was normal, and it decreased rapidly as the centre was quitted in any direction. At about 100 feet south of the centre of disturbance, the compass was deflected 55deg. This was the largest deflection observed, but the compass was disturbed over an area of about a square mile. The general depth of water in this area was nine fathoms, and the quality of the bottom quartz sand. The observations of the magnetic elements at Cossack and the neighbourhood showed little or no disturbance from local magnetic effects. It is therefore evident that the disturbances were due to magnetic minerals at the bottom of the sea.

**Night Signalling at Sea.**—Experiments in new methods for night signalling at sea are now being conducted on board the ships of the United States Navy. With the present system, there are three electric lights, green, red, and white, of 16-c.p. each, fitted in a vertical line on a jackstay, about six to eight feet apart. They are worked by an ordinary telegraph key, one of the long line keys of the Western Union Company being employed. The green light means a dash, the red a dot, all three lights briefly a space, or all three for a more extended period signify the end of a word. The distance at which this system can be used is about three miles. To communicate beyond three miles the "Very" system is used. This consists of pyrotechnical displays of red and green stars, by combinations of which certain numbers are represented, having their own signification in the code. The English Navy system, as is well known, is on the flashing plan. Another system for long-distance signalling at present under experiment in the United States Navy, and frequently employed with success in the Chilian-Peruvian war, is to throw the electric search light directly overhead and make dashes and dots with it against the sky, so that they may be read for many miles by the whole fleet. A new French system, called the "Ardois," has been fitted on the "Chicago" for experiment on her present cruise, and will be tested on favourable occasions. This system is made up of 10 lamps which hang vertically from a backstay, thus forming combinations which, being interpreted, make up the code. The combinations are worked from a keyboard having 62 different letters and signals.

**Hampstead Vestry.**—At the Easter meeting of the Hampstead Vestry, the Electric Lighting Committee presented a report on the subject of electric lighting for Hampstead. The committee stated that it had consulted Mr. W. H. Preece, who estimated the cost of installation for street illumination and private purposes at £81,000. He recommended the Vestry to undertake the work rather than permit a company to come in and do it, and to undertake the full scheme for the whole parish rather than the lighting of portions only. He estimated the working charges for a year as £15,800, yielding a revenue of £19,500; and after deducting £1,400 as the increase cost of public lighting over gas, the net result would be a profit of £2,300, while the total required to repay the loan and interest in 30 years would be £3,455. His figures were based on the supposition that the Vestry would charge 6d. per Board of Trade unit, as against a probable 7½d. charged by a company, and that 24,000 16-c.p. lamps would be rented by the ratepayers. The committee, in concluding the report, stated that, all other things being equal, it was evident that there would be this solid advantage, that the Vestry could, at any time, adopt any scientific improvements, and that the ratepayers would always have the means of procuring the redress of a grievance, and of insisting on efficiency of management. In the absence

Digitized by Google

of Mr. Baines, chairman of the Committee, a communication from that gentleman was read, as also another, offering special terms, from the Tottenham Company, and the Vestry finally decided to receive the report, but to postpone any decision to May 7th. An urgency proposal that a poll of the ratepayers should be taken was rejected.

**Aluminium.**—If anyone ought to know what aluminium is, and what it is good for, it should be, says the *Engineering and Mining Journal*, one of the leading manufacturers of this metal; and if such leading manufacturer deliberately and publicly says that aluminium is not the extraordinarily good metal that it is popularly believed to be, then we have good reason to suspect that he is right, and that popular belief in the matter wrong. According to our contemporary, Mr. A. E. Hunt, President of the Pittsburg Reduction Company, summed up the disadvantages of aluminium in a Paper recently read before the Boston Society of Arts. The *pure* metal is very soft, and not so strong as the impure. It becomes pasty at a temperature as low as 550°C., melts at 720°C., and loses its tensile strength and much of its rigidity as low as 200 or 250 deg. It is inferior to copper as a conductor of electricity, being in fact only half as good. Its lack of rigidity and hardness is an obstacle to its use for many purposes, such as castings. Alloys of the metal increase in brittleness more than they do in hardness. Its tensile strength per square inch is not greater than that of common cast-iron, and only about one-third that of structural steel, while its compressive strength is less than one-sixth that of cast-iron. The modulus of elasticity of cast aluminium is about 11,000,000, being only about one-half that of cast-iron, and one-third that of steel. It combines with iron in all proportions, but none of its alloys with that metal are of value, except those with very small percentages of aluminium. Other elements than aluminium can be better employed to harden iron, and its presence in iron is to be regarded as deleterious, and to be avoided if possible. The addition of aluminium does not lower the melting point of steel, as has been claimed, nor does it increase its fluidity.

**Specific Inductive Capacity.**—The following measurements of the specific inductive capacity of various media have been published in *Wied. Ann.*, Vol. XXXVI., by Herr Tereschin. The method used was that due to Cohn and Arons, and the temperature at which the observations were taken was in all cases about 14° centigrade.

| Substance. | K | Substance. | K |
|---|---|---|---|
| Methyl alcohol | 32·65 | Amyl acetate | 5·2 |
| Propyl ,, | 22.8 | Methyl benzoate | 7·2 |
| Amyl ,, | 15·9 | Ethyl ,, | 6·5 |
| Methyl formate | 9·9 | Isobutyl ,, | 6·0 |
| Ethyl ,, | 9·1 | Amyl ,, | 5·2 |
| Isobutyl ,, | 8·4 | Ethyl propionate | 6 |
| Amyl ,, | 7·7 | Ethyl butyrate | 5·3 |
| Methyl acetate | 7·75 | Ethyl valerate | 4·9 |
| Ethyl ,, | 6·5 | Aniline | 7·5 |
| Propyl ,, | 6·3 | Carbon tetrachloride | 2·2 |
| Isobutyl ,, | 5·8 | Xylol | 2·35 |

For water, the value of K found was 83·8.

Several measurements of specific inductive capacity have been lately published in the *Philosophical Magazine*. Herr Lecher finds that the value of K varies with the time of charge, the value of K for plate glass being 4·67 when the time of charge was half a second, and 7·3 when the charging was effected by electric oscillations occurring $10^8$ times per second. The values of K for ebonite varied under the same circumstances from 2·64 to 3·01. Mr. E. B. Rosa gives the following numbers for various conducting liquids:

| Substance. | K | Temperature. |
|---|---|---|
| Water | 75·7 | at 25°C |
| Alcohol | 25·7 | ,, 25°C |
| Sperm oil | 3·09 | ,, 20°C |
| Benzine | 2·45 | ,, 21°C |
| Turpentine, Commercial | 2·43 | ,, 18·°6C |
| Petroleum, "Neutral" | 2·26 | ,, 21°C |
| Headlight oil | 2·11 | ,, 24°C |

**Pioneer Electric Traction.**—The following are some of Mr. Frank Sprague's pioneer experiences, as related by him at the recent meeting of the National Electric Light Association at Providence, (R. I.) The contract for the road in Richmond was taken in 1887. I had never seen the road. When I went to Richmond I saw a grade of 10 per cent. My heart fell within me, and I said it was utterly impossible for any car to climb that hill. I came back to New York. Mr. Johnson then said, we had better find if we really could not get up the grade. Back to Richmond I posted. We started and mounted the hill. When we got to the top we had settled the question of traction on a 10 per cent. grade. It was settled likewise that the motors we had were too small and too light, they were hotter perhaps than the furnace in an electric welding apparatus. I was now brought face to face with the fact that it was necessary to make a complete change on sixty machines in Richmond in the matter of gearing. In the course of four or five weeks we started again in Richmond on February 2, 1888. The next thing we found was that the armatures were too large, and so we had to resort to electrocution—we had to cut off their heads. The machines were covered with water and mud. Every field-magnet had been wound and rewound three or four times. Our next experience was that our commutators were going to pieces. We had tried no less than 65 different kinds of trolleys and had not got one that would work reasonably satisfactorily. We were attempting to run motors in both directions. After trying a great variety of brushes, we finally settled upon square bars of brass about three-eights of an inch square. Subsequently we used carbon. That inside history of some of the work at Richmond has not been told before. I think the time has come now when there is no harm in its being made public. I think that people would have looked on electric railways as out of the question if they had known of the straits we were going through.

**The Cultivation of India Rubber.**—In a recent letter to *Nature* Mr. W. R. Fisher gives some interesting particulars with regard to rubber cultivation in Assam. After some preliminary experiments, the Government of Assam in 1873 determined to plant caoutchouc in the Charduar Forest at the foot of the Himalayas. This district is essentially damp, and the moist hot atmosphere in the summer months resembles that of a forcing house. The plan of concentrating rubber-trees in artificial plantations was carried out as follows:—At first attempts were made to propagate by cuttings, but it was soon discovered that rubber-seed germinated freely on well-drained beds covered with powdered charcoal or brick-dust, and that the seedlings, though at first small, became about 2ft. high in twelve-months, and were much hardier against drought than plants produced from cuttings. In order to imitate nature as much as possible, some strong seedling rubber-plants were placed in the forks of trees in 1874, but by 1885 only a few of them had reached the ground and were growing. Large nurseries were ultimately formed, in which the plants were retained until they were 10ft. high and then planted out in belts of 40ft., separated by alternating strips of untouched forest 60ft. wide. It was found that the rubber-plants did not get sufficient light with lines less then 40ft. broad, whilst the strips of forest kept the soil and atmosphere moist, and afforded side shelter to the plants, forcing them to grow upwards. As this method involved considerable expense in clearing the lines, and wasted the wood, which was frequently unsaleable, the Chief Commissioner of Assam, in 1874, directed that plantations of *Ficus elastica* should also be made in grass-land near Tezpur. The trees, however, when tapped yielded scarcely any rubber. An area of only eight acres was therefore planted out near Tezpur, whilst the area of the Charduar plantation in 1889 was 1,106 acres, and contained 16,054 plants, besides large nurseries with 84,000 seedlings. The present average annual growth in height and girth, taken from 350 plants, are respectively 5ft. 2in. and 8in. The up-keep of the plantation consists chiefly in clearing the lines round the plants, but four years after planting the under-growth is well kept down by the shade of the rubber-trees. Experimental tappings were made in 1883 and 1884 on 50 natural grown rubber-trees in the Charduar Forest, the total yield being 438lb. in 1883 and 206lb. in 1884, giving an average yearly yield of 6½lb. per tree.

Digitized by Google

## THE MAGNETIC CIRCUIT OF TRANSFORMERS: CLOSED VERSUS OPEN.

BY S. EVERSHED.

(*Continued from page 636.*)

§ 47. The waste of power may be obtained from the diagrams by taking the product of E and C at short intervals of time, and using these products as ordinates in a power curve, the

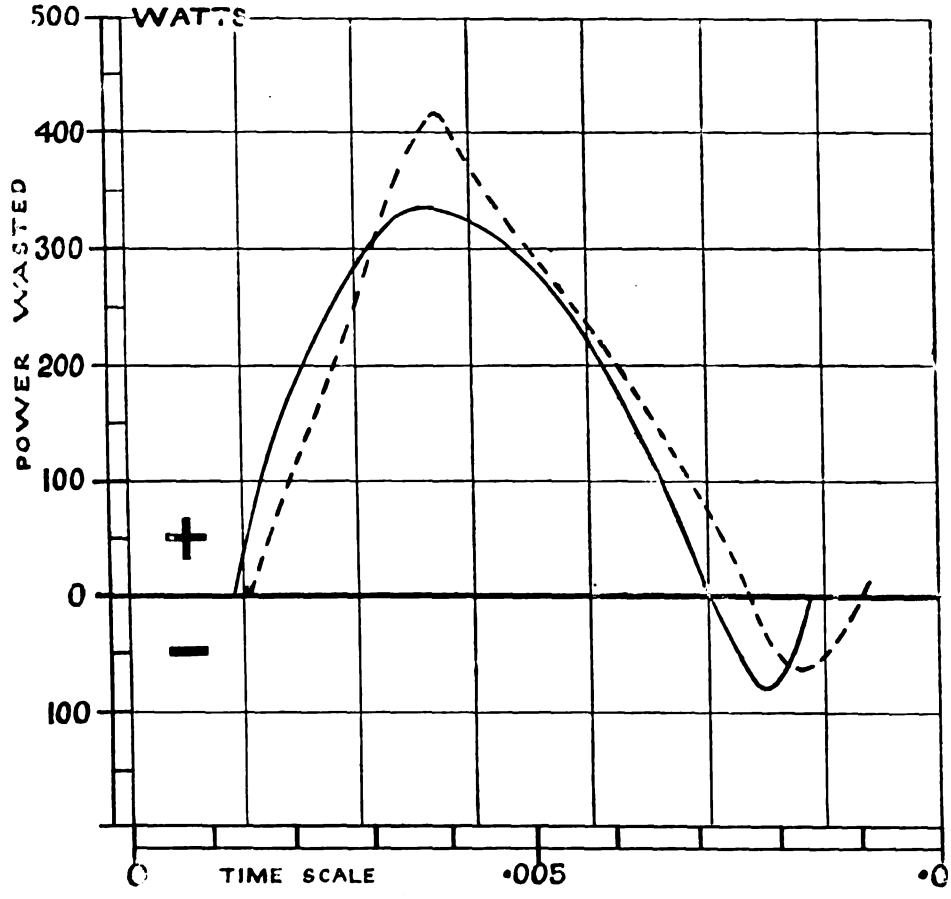



FIG. 13.—Curves shewing power wasted in the core of No. 2 Closed Transformer. The full line corresponds with sine E.M.F., and dotted line with zig-zag E.M.F.

area of which—best taken by a planimeter—divided by the time, gives the mean power wasted in the transformer core at *no* load. The power curves for No. 2 closed transformer run by a sine and a zig-zag E.M.F. will be found in Fig. 13. In each there is a time during which the power is negative the core giving back to the circuit a small

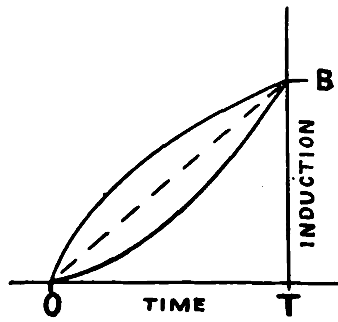



FIG. 14.—Three modes of raising the induction threading a circuit to value B in time T, that indicated by the dotted line wastes least power in eddy currents.

part of the energy previously put into it. The negative area must be deducted from the positive area before dividing by $\frac{1}{2}$T to obtain the mean power. These curves show that the *shape* of the E wave has very little influence on the total waste of power in the core, a result which the reader has doubtless foreseen from the beginning of this investigation, for the hysteresis loss depends only on the maximum induction and number of reversals per second, and the former having been kept constant and the latter only slightly varied, the variation in waste power from this cause can only be small. The hysteresis loss then varies *directly* as the frequency other things remaining constant. The eddy current loss for a given shape of E.M.F. wave also varies directly, but as the *square* of the frequency, for it will be remembered, that the expression for the power wasted in eddy currents contains the factor $\dot{B}^2$, which is proportional to the square of the maximum induction and square of the frequency. But the eddy current loss depends on something besides frequency. When a given total change of induction takes place within a certain area in a given time, the waste power in eddy current in conductors surrounding the

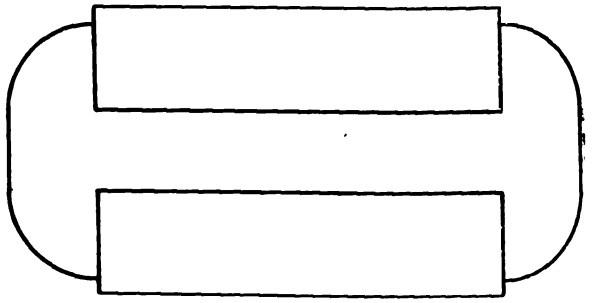


FIG. 15.—No. 2 as an Open Transformer, with small Hedgehog ends. One-tenth full size.

area depends on the law governing the rate at which the induction varies during the whole time occupied by the change.

§ 48. Let us examine this a little more closely. Imagine a bar magnet to be thrust into a conducting ring, causing eddy currents in it. In Fig. 14 the law by which the induction

Digitized by Google

threading the ring varies with the time as we push the magnet in is indicated by two curves, either of which is represented by the equation :—

$$B_t = \frac{\beta}{T} t + \frac{B' - \beta}{T} t^2,$$

where $\frac{\beta}{T}$ is the tangent of the angle made by the tangent to the curve at $t = 0$; and $\beta$ is obviously the value B would have when $t = T$, provided the induction continued to increase at its initial rate from 0 to T. The curve is convex or concave

into heat through the medium of electric currents in the ring—is

$$W = \int_0^T \frac{\dot{B}^2}{r} dt,$$

and, if the value of B is obtained from the equation just given for $B_t$, and the integration performed, we arrive at the following value for the work done :—

$$W = \frac{1}{rT}\left\{ B'^2 + \frac{1}{3}\left(\beta - B'\right)^2 \right\}.$$

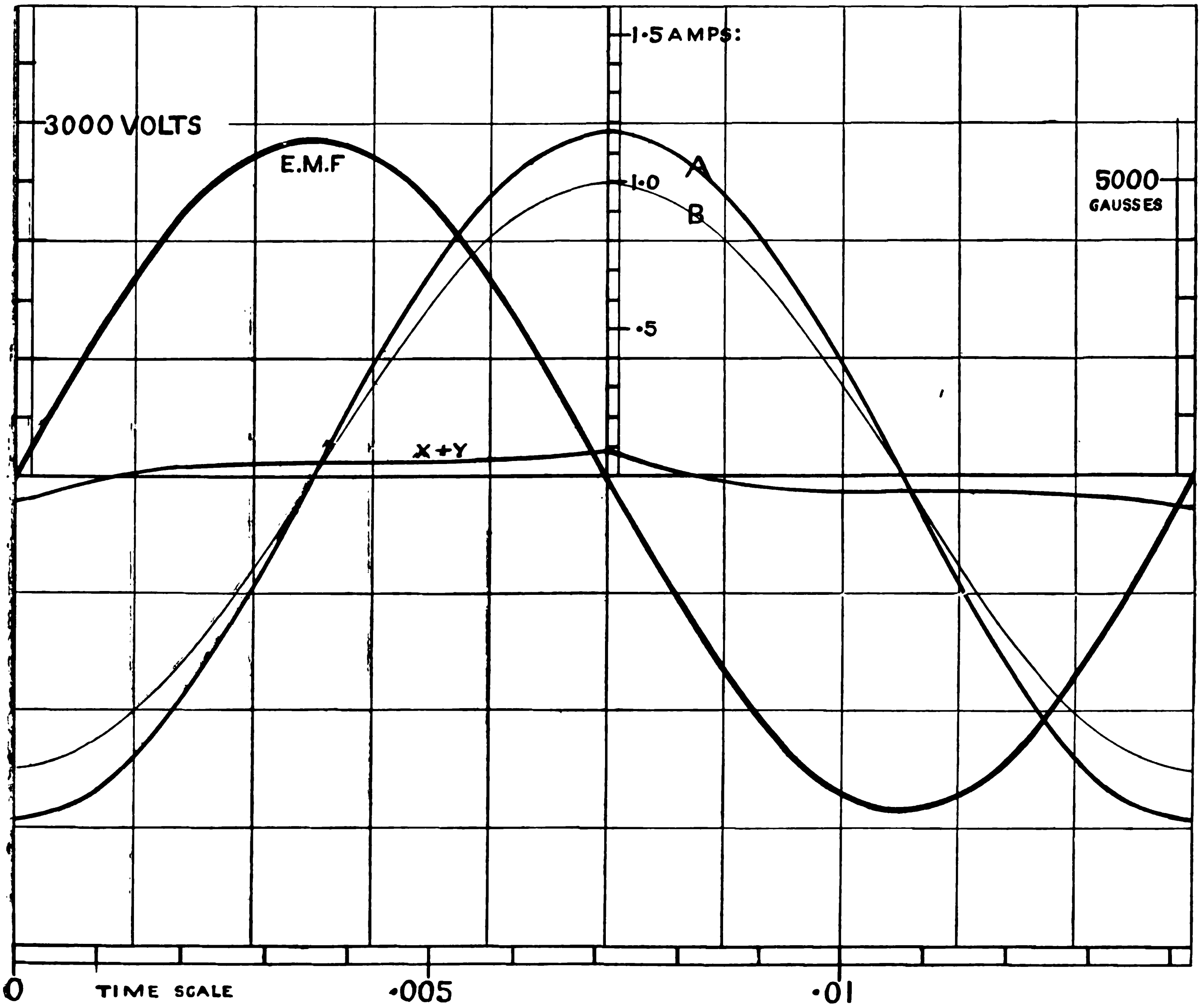



Fig. 16.—No. 2 as an Open Transformer with Small Hedgehog Ends (Fig. 15) run by a sine E.M.F.

X + Y = Total Exciting Current required by the Core.
A = Exciting Current required by the Air Path.
B = Induction Density in the Core.

F = 700.
Output = 0.
E = 2,000 volts.

to 0 T, according as $\beta$ is less or greater than B′, and when $\beta = B'$ it becomes a straight line. We can vary the rate at which we push the magnet into the ring in any way we please and so make B increase according to any law, and the problem being to determine which law will make the energy wasted in currents in the ring a minimum, we start by choosing an equation which practically represents any regular law. The electromotive force in the ring during the motion of the magnet is $\frac{dB}{dt} = \dot{B}$, the resistance of the ring being $r$ the irreversible work done by pushing the magnet into it—the work turned

Now as $(\beta - B')^2$ is always positive whatever value is chosen for $\beta$, it is clear that W is a minimum when $\beta = B'$; the second term then vanishes and the minimum work done is

$$W = \frac{B'^2}{rT},$$

and this is evidently when the law of increase of induction is

$$B_t = \frac{\beta}{T} t = \frac{B'}{T} t,$$

that is to say when the rate of change of induction is constant; a result entirely in accordance with our sense of the fitness of

Digitized by Google

things. To push the magnet in in *no* time would only end in melting the ring, and would require an infinite amount of work.

§49. Other things being the same then, the eddy current waste in a transformer, and generally in all parts of an alternate current apparatus, will have the least possible value when the *induction* follows a zig-zag law. Fortunately, large eddy current waste is usually so easily avoided by judicious lamination of conductors, cores, and other conducting parts of alternate current machinery, that there is no occasion to attempt the realisation of any alternator giving E.M.F. waves of the shape assumed in Fig. 12. The point was worth notice however. In most transformers the loss from hysteresis is so much larger than that arising from eddy currents that there is a distinct gain in efficiency when the impressed E.M.F. follows a zig-zag law, and the alternators would run at a slightly lower speed, so that in spite of the dictum of a well-known professor, to the effect that "if an alternator does not give a sine curve, it must be *made* to do so," the fact remains that there is a very small balance of advantages in favour of the zig-zag wave. It is obvious that the one essential condition for general efficiency of an alternate-current system is that the induction should be always *changing*; if it is constant during any fraction of the period, that fraction of time is wasted. So long as this condition is fulfilled the actual shape of the E.M.F. and current waves is of practically no importance.

§50. The broad lesson to be learned from the diagrams Figs. 10, 11, and 12, is that in studying the losses in the cores of transformers, we may neglect the slight differences due to widely differing E.M.F. wave forms; so that such diagrams may be drawn according to any simple method involving little labour. The zig-zag and the sine diagrams are about equally easy to work out, each being slightly more laborious than the alternating constant E diagram. As nearly all alternators gives wave forms something between a zig-zag and a sine function, preference must be given to them, and in drawing a diagram for No. 2 as an open transformer we shall choose the latter, but before doing so it will be best to make the modification alluded to in the note on page 599. It appears from the corrected figures for the dimensions and exciting currents for Hedgehog transformers, that the total effective surface of the spherically-spread wires of the core is considerably greater than our original estimate, and the exciting current correspondingly less—a fact which will be further discussed when comparing the results of our more or less theoretical investigation with actual results of observation.

§ 51. In actual work No. 2, Fig. 8, would require about ·7 ampere to excite it, so that the daily waste as $C^2R$ for exciting current would be $7{\cdot}6 \times {\cdot}7^2 \times 24 = 90$ watt hours nearly, instead of 182 as previously calculated; but the core waste was 2,470 watt hours per diem, so that it would evidently pay to cut down the spherical ends and save on the larger loss. If the total length of the core is reduced from 93 to 74 cms., the volume being proportionately diminished, the waste of power in the core becomes 82·3 watts; the exciting current will be about ·9 ampere, and the efficiency on the six hours load at 4,000 watts is as follows:—

**Table XV.**—*No. 2 as an Open Transformer with small "Hedgehog" ends.*

Maximum $B = 5{,}000$. $F = 70$.

Load as in Table V.

| | | |
|---|---|---|
| Total output | 24,000 | watt hours. |
| 24 hours' waste in core at 82·3 | 1,975 | ,, |
| 24 hours' waste $C_p^2 R_p$ for exciting current | 148 | ,, |
| 6 hours' waste $C^2 R$ for load | 372 | ,, |
| | 26,495 | |

$$\text{Efficiency} = \frac{24}{26{\cdot}5} = 90{\cdot}5 \text{ per cent.}$$

Resistance drop = 2·8 per cent. at full load.

§ 52. The diagram given in Fig. 16 is obtained in exactly the same way as was explained in connection with the closed transformers, but it is convenient in dealing with open transformers to divide the magnetising current in two portions, one being that required for the core alone, including anti-eddy current; the other being that required to magnetise the air-path from pole to pole. The total maximum induction being 5,000 x area of core, and the so-called magnetic resistance of the air-path being approximately calculated, the necessary air-magnetising component of the exciting current is easily ascertained and plotted in. It is, of course, co-phasal with the induction, and therefore exactly a quarter-period behind the counter E.M.F. The exciting current for the core is calculated and plotted just as in the case of the closed transformer, the same **B H** curve (Fig. 9) being used, and indeed the only change made is in the length of core, which is now 74 cms. as against 147 cms. for No. 2 closed transformer. In Fig. 16, the hysteresis and eddy current, X and Y components, are added before plotting in order to prevent confusion. The scale to which current is plotted in Fig. 16 is one-fourth that used in the previous diagrams.

§ 53. As has been noticed above, the exciting current for the air-path is exactly a quarter period behind the counter E.M.F. It is, therefore, very nearly $\frac{1}{4}T$ behind the impressed E; it would be exactly so but for the resistance of the primary coil, which leads to a little potential difference between its ends being required to maintain the exciting current in it. But the maximum value of C R is only $7{\cdot}6 \times 1{\cdot}26 = 9{\cdot}6$ volts, and this is entirely negligible compared with the maximum counter E—2,860 volts—so that the latter must be almost precisely in step with the impressed E. For every practical purpose the air-exciting current may be treated as being exactly $\frac{1}{4}T$ behind the impressed E, and consequently though "full of sound and fury" it signifies next to nothing, when reckoned as waste of power. It is, apparently, for this reason Mr. Swinburne speaks of it as "spurious" current. This is a needless epithet, for after all it is a real current, and it will be preferable to speak of a current which is $\frac{1}{4}$ T out of step from E as an *idle* current—a current that is, which does no work and requires no power to maintain it, beyond that wasted in heating the conductors. We have already noticed that the one defect introduced when transformer No. 2 was converted into a Hedgehog, was the large exciting current. It is now clearly established that a very large proportion of the whole of the exciting current is idle. The additional efficiency of an open circuit transformer costs nothing—less than nothing, for the material used is somewhat less, and the labour would also be diminished to some extent. But there is a useless encumbrance given away with the bargain, namely a large idle current, which may quite conceivably lead to a new metamorphosis. A supply company after putting in highly efficient open-circuit transformers over the whole of its system, might discover that it was harbouring white elephants disguised as hedgehogs.

*(To be continued.)*

## PHOTOMETERS.

Practical photometry does not enter into the ordinary work of an electrical engineer. Most of our readers are familiar with the general principles, and every technical college is provided to a greater or less extent with photometers "for educational purposes," and occasionally with a properly-fitted photometric bench. The eye is utterly unable to estimate illumination quantitatively. We cannot tell whether one light is twice as bright as another, or if it is only once and a-half times as powerful. Every electrical engineer knows that eight-candle lamps are more easily distinguished from sixteen-candle by the size of the bulb than by the light yielded. Photometrical measurements are therefore always made by the comparison of illuminations, and a null or zero method is adopted; the skill of the observer being directed to the adjustment of the apparatus until the two illuminations appear to him to be identical. This amounts to a relative

Digitized by Google

quantitative estimate of two sensations. Our various senses are very keen in detecting small *qualitative* differences. Thus the eye can detect, according to Aubert, at least one thousand different simple colours, while, allowing for mixtures, there must be between two and three million distinguishable tints. A practised ear, according to Weber, can recognise one sixty-fourth of a semitone, or a difference of one vibration in a thousand; but for all that it is impossible to say whether one sound is half as loud as another. The exactness of quantitative estimation becomes, then, generally merely a matter of the limit within which two sensations appear to be identical. If an unpractised observer puts two equal lights at the opposite ends of a photometer bar one hundred inches long, and places the screen one inch from the centre, he will probably fail to see any

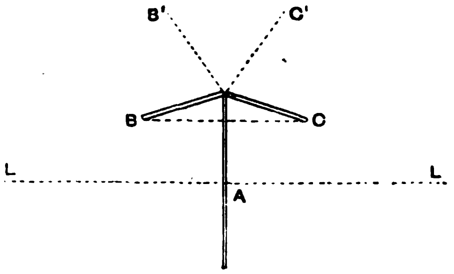



Fig. 1.—Arrangement of Bunsen Photometer. Plan.

difference in the two illuminations. The actual difference is equal to the difference between $49^2$ and $51^2$, or 8 per cent. Practice will soon reduce the limit or error to rather less than half this, but no elaboration of apparatus, whether as to facilities for adjustment, sensitive screens, or accurately standardised sources of illumination, will make the measurements more accurate. A large number of readings from different directions, with the graduated scale hidden from the observer until he has made the adjustment, will give an average to an imposing number of decimals, but the probable error must still remain large, as compared with most scientific measurements.

Photometric measurements up to about 6 to 10 per cent. are very easily made, and the apparatus required is of the most simple character. A greater accuracy is only to be attained by carefully-screened instruments or the use of a dark room, together with considerable practice and training.

The two most simple photometers are those of Bunsen and Rumford. The essential part of the former is generally a piece of white paper with a grease-spot. When this is brightly illuminated on one side, the grease-spot seen from that side appears to be darker than the rest of the paper. Seen from the other side, it appears brighter. In the former case the difference in tint between the spot and the surrounding paper

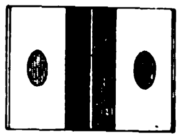


Fig. 2.—Images of Bunsen Screen as seen in the Mirrors.

is practically the same from whatever angle it is seen; but in the latter the spot appears brighter as the eye is brought into a line with the light behind it. It would seem at first as though the grease-spot would disappear when the illumination is the same on both sides. But it is clear that the light falling on the paper screen is affected in three different ways—reflection, absorption, and transmission; and it is the absorption which introduces the difficulty. In practice it is usual to arrange two mirrors inclined at such an angle that the two sides of the screen may be seen simultaneously. Then, whatever may be the relation between the reflection, the absorption and the translucency, it is sufficient to adjust the screen until the reflected images appear to be identical.

The plan of the arrangement is shown in Fig. 1. A is the screen, L L the axis of the light, or the line joining the two sources of illumination. B and C are two mirrors, in which reflections of the screen appear as if at $B^1$ and $C^1$. The projecting sides of B and C throw a shadow on the screen. Fig. 2 shows the appearance of the reflections, the two images of the grease-spot being separated by the shadow. In order to avoid this a prism has been used. Two images of the screen A (Fig. 3) are seen through the prism B, as shown by the dotted lines. The images are, however, necessarily very much foreshortened. In either case the arrangement is symmetrical, and the images are equally inclined to the eye.

For ordinary laboratory work the screen is enclosed in a blackened tube, which shuts out all stray light; and this tube is mounted upon a carriage sliding or running on wheels on a graduated bar. A pointer for reading the scale is covered by a hinged door, in order that the observer may not be biassed while making an adjustment. If the scale be visible

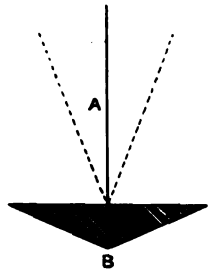



Fig. 3.—Prism for showing both sides of Bunsen Screen.

there is always a temptation to look at it and to make the reading approximate to a previous one, or to some preconceived value.

The illumination varies inversely as the square of the distance of the screen from the light. If the screen is found to make a balance when it is situated at 25 inches from one end of a 100-inch bar, the lights being 100 inches apart, one is nine times as powerful as the other, the screen being, of course, nearer the lesser light. If a balance was found at 20 inches, the ratio of the lights would be as 16 to one, or as the square of 80 is to the square of 20.

The Rumford photometer is not so common as the Bunsen, but it possesses several important advantages. It consists of a screen and a rod (Fig. 4). The two lights to be compared are so arranged that they cast two shadows side by side upon the screen. The distance of the rod from the screen does not affect

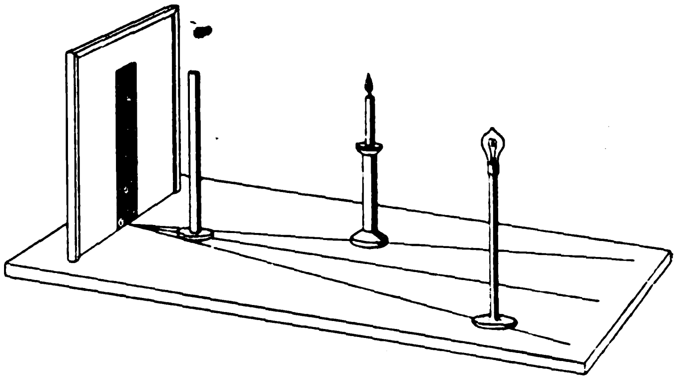


Fig. 4.—Rumford Photometer.

the calculation, and it should be so arranged that the shadows exactly meet without overlapping. The two tints to be matched falling next to each other, a considerable degree of accuracy is possible, and the observation does not depend on the angle at which the screen is seen, nor are any mirrors or restricted view necessary. A modification of this is the Bouguer or Foucault photometer, in which the rod is replaced by a partition, which allows one side of the screen to be illuminated by one light only. The partition is capable of adjustment, by which the junction of the shadows may be arranged. The screen is translucent, and may be made of opal glass or paper.

The Bunsen photometer is undoubtedly the favourite in England and Germany, while until recently the Rumford and Foucault was the most popular in France. One advantage possessed by the former is, that a diffused light can be compared with one of high intrinsic brilliance without difficulty. Indeed, it is impossible to tell, on a Bunsen screen, if the light is diffused

Digitized by Google

or not. Shadow photometers are easy to work with, since the screen can be observed directly, but if one light be more diffused than the other, the edge of one shadow will be more soft than that of the other. Instead of a round grease-spot, a star-shaped spot is often employed with a Bunsen photometer, and this may be easily made by soaking blotting-paper uniformly in white wax or paraffin. When cool, the blotting-paper may be cut into a star or other shape, and placed on a sheet of white paper, covered with another, and pressed with a hot iron. With a little practice very sharp-edged spots may be produced. With suitable paper a very perfect disappearance can be obtained, and so sensitive is an elaborate star-spot, owing to its extent of edge, that greater accuracy and certainly greater speed may be attained than with the mirror method. Complete disappearance,

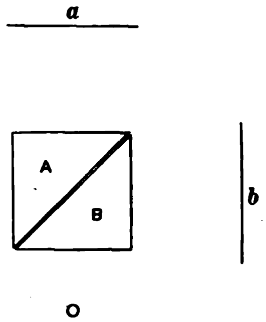



Fig. 5.—Elementary arrangement of Lummer and Brodhum Photometer with Prisms and Screens.

however sensitive the spot may be, does not mean a balance, and the photometer scale must be empirically graduated by means of two equal lights. The disadvantage of this method is that the graduation will differ with differerent spots and different papers. A very good screen, and one which may be easily reproduced if injured or soiled, can be made from two pieces of very translucent paper with an opaque white piece, having a star-shaped opening, between them. The middle piece of paper may be replaced by a sheet of tinfoil.

The principle of the Bunsen photometer is sufficiently obvious, but some mathematics have been expended on it. The spot is more or less transparent, the rest of the screen is more or less a reflector. Both the transparency and the reflection are necessarily imperfect or diffusive. A silvered glass with a portion of the reflecting surface removed, could not, under

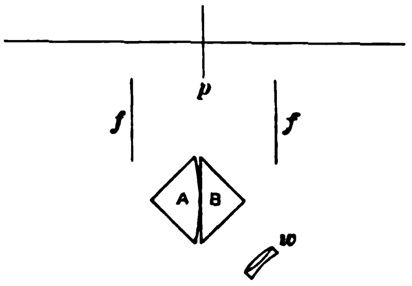



Fig. 6.—Practical arrangement of Prisms and Screen with Mirrors.

ordinary circumstances, be used as a Bunsen screen. But the imperfections of such a screen, the absence of simultaneous disappearance of the spot on both sides, the uncertainty of the line of separation on the edge of the spot, and the necessity for the use of mirrors, have led MM. Lummer and Brodhun, of the Physico-Technical Institute, of Berlin, to design a very sensitive photometer, in which they retain the main principle of Bunsen, but avoid the difficulties arising from the imperfect translucency and reflection.

In its most elementary form the photometer consists of two screens, *a* and *b*, Fig. 5, which may be either translucent or opaque. The former would be the best for very powerful lights, the latter would be suitable for ordinary purposes, and it would be much more easy to ensure the equality of their reflecting power than equality in the transparency of opal or semi-opaque screens. A pair of glass prisms, A and B, are placed face to face, and are united by a drop of Canada balsam or other transparent cement of about the same refractive index as the glass. From the direction O, the screen *a* is observed direct through the prisms, since they are brought into optical contact by the cement. The screen *b* is seen by reflection from the inner surface of the prism B. This surface may be silvered, and the silvering removed at the centre. A more perfect arrangement is shown in plan in Fig. 6, and a general view is given in Fig. 7, which is reproduced from an article by M. Palaz in *La Lumiere Electrique*.

The direction of the light through the prisms is such that total internal reflection takes place in prism B. The face of prism A is rounded, and is pressed firmly against B, bringing the surfaces into optical contact. To avoid Newton's rings a

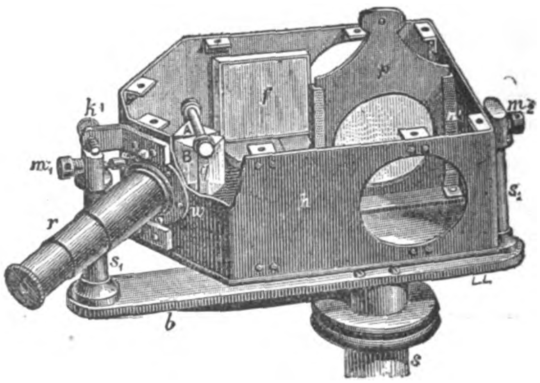


Fig. 7.—Lummer and Brodhun Photometer.

little Canada balsam may be used. A telescope is hardly necessary, but one has been provided by the inventors, and through it the prisms are seen. Instead of two screens, as in Fig. 5, a single screen, *p*, is employed. This is opaque, and should have a high reflective power, but this reflection must be diffusive. At *f* and $f^1$ are two mirrors placed symmetrically with respect to the screen *p* and the prisms A and B. The screen is placed on the usual photometric bench, the light from the two sources falling perpendicularly on it. The diffused light from the screen falls on the mirrors, and is thence reflected perpendicularly on the prisms. In its practical form the mirrors and prisms are enclosed in a box, *h*, mounted on an axis. The two pillars, *s* and $s_2$, support the box by means of the set-screws, *m*, allowing it to swing in a horizontal plane. The prisms A and B are pressed together by a clamp, *q*. The opaque screen, *p*, slides in a frame, and passes through a slot in the cover of the box. The light falls on the screen through the side openings. This photometer, on account of the absence of absorption, and the exact balance which can be obtained, is very much more sensitive than any form of Bunsen.

## A METHOD OF SIMULTANEOUSLY REGISTERING THE WAVE OF ELECTRICAL EXCITATION AND THE RESULTANT MUSCULAR CONTRACTION.*

BY A. D'ARSONVAL.

Currents of brief duration (condenser discharges, induction currents, etc.) are constantly employed in physiology and medicine, to excite the nerves and muscles. The reactions which follow from these excitations are intimately connected with the shape of the wave emanating from the electrical apparatus, as I have shown by numerous experiments, since 1881, to my classes at the Collège de France. It is, therefore, of extreme importance to be able to ascertain the shape of this wave which I have termed the *characteristic of the excitation*, and to be able to vary this characteristic at will. The curve which represents the *characteristic of excitation* is a function of three variables:—(i.) The maximum potential of the discharge; (ii.) the rate of variation of the potential; (iii.) the quantity of electricity traversing the organ excited. Each of these three factors modify the excitation in proportions which it is indispensable to study separately. Now, the method which I am about to

*From the *Comptes Rendus*, vol. cxii., No. 12.

Digitized by Google

describe, enables us to isolate each of the three factors in a continuous manner, and to combine the variations in twos or threes. It is a general method, by means of which it is possible to inscribe the electric wave-curve directly on a registering cylinder, and immediately under it, the curve of the muscular shock caused by the excitation. The comparison of cause and effect is thus rendered extremely simple.

In the accompanying diagram let P be a constant source of electricity (accumulators), the circuit of which is closed through a vertical column of mercury contained in a glass tube. The current enters at the top, and leaves at the lower end by means of appropriate nickel-copper contacts. The negative pole of the battery and the bottom of the column are connected to the earth at T, and are consequently at zero potential. On the other hand, the upper end of the mercury column is at a positive potential of, say, 10 volts. The potential decreases regularly from +10 volts to 0 volts down the mercury column according to a well-known law. Let us suppose that a metallic wire P′, insulated down to its lower extremity, can move up and down in the mercury. If the point is at the bottom of the tube, its potential will be zero; but, on lifting the wire, its potential increases regularly from zero to +10 volts. If, now, we attach this wire to one end of a lever, movable about the point L, the other end moving up and down a smoked cylinder F, it is easy to see that the displacements of the point of the lever L, along the cylinder F, will register the phases and amounts of variation of the potential of the plunger P′. In order to obtain a determinate curve, cause the lever L to be oscillated by the rotation of an eccentric E, the section of which is shown. In practice I attach the wire P′ either to a vibrating rod or to a pendulum, which gives me a sinusoidal variation

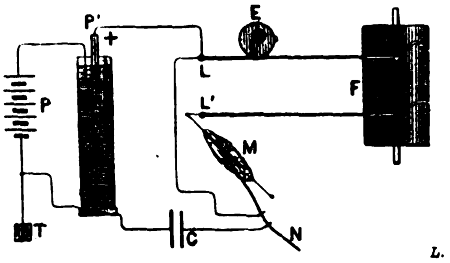



Diagram of Apparatus.

of potential. I can obtain any shaped curve by attaching this wire P′ to a spring which is more or less stretched (an indiarubber band), which I move mechanically in order to produce the necessary excitation. If the wire P′ were connected direct to the nerve N, which is in communication with the earth, it would be always traversed by a derived current, and this would impair its excitability; moreover, we should have no means of regulating the quantity of electricity passing through it. I avoid this by passing the current through the primary of a Du Bois-Reymond induction coil, or, as is shown in the diagram, I interpose a standard condenser, C, in the circuit. Thus, when P′ is at rest, no current traverses the nerve N, and for the same displacement of P′, that is to say, for the same variation of potential, the quantity of electricity traversing the nerve N is rigorously the same, and is known in advance. The muscle M, actuated by the nerve N, is attached to the myographic lever L′, which traces the curve of the muscular shock immediately under the *characteristic of excitation* traced by the first lever L.

The curve inscribed by the lever L gives, therefore, (i.) The quantity of electricity traversing the nerve at each excitation; (ii.) the variation of potential; (iii.) the phases of this variation; (iv.) the rate of variation. Moreover, it is possible to vary each of these factors independently; (i.) Quantity, by altering the surface of the condenser C; (ii.) Potential, by altering the movement of the lever L, or the number of cells of the battery P; (iii.) Mode of variation of potential, by altering the eccentric E; (iv.) Rate of variation, by altering the rapidity of the oscillations of the lever L.

The nerve is traversed by alternating currents, corresponding to the charge and discharge of the condenser, and it cannot therefore polarise. In the case of unidirectional excitation, I avoid polarisation by discharging the condenser C into the primary wire of an induction coil, in the way I have previously described to the Academy.* In a future communication I shall publish the results obtained with this method.†

## BOOKS, &c., RECEIVED.

"Sixth Annual Report of the Board of Gas and Electric Light Commissioners of the Commonwealth of Massachusetts." (Boston: Wright and Potter Printing Co.)

## MEETINGS OF SCIENTIFIC SOCIETIES, &c.

**FRIDAY, April 3rd** (To-night).

INSTITUTION OF CIVIL ENGINEERS.

*2 p.m.* Students' Visit to the Mechanical Laboratory of the City and Guilds of London Central Institution, South Kensington.

**MONDAY, April 6th.**

ROYAL INSTITUTION.

*5 p.m.* General Monthly Meeting.

SOCIETY OF ENGINEERS.

*7.30 p.m.* Ordinary Meeting. Paper to be read on "A Trial of a Refrigerating Machine on the Linde System." By T. B. LIGHTFOOT, M. Inst. C.E.

**TUESDAY, April 7th.**

INSTITUTION OF CIVIL ENGINEERS.

*8 p.m.* Ordinary Meeting. Paper to be read: "The Cost of the Generation and Distribution of Electrical Energy." By R. E. B. CROMPTON. M. Inst. C.E. At this meeting the monthly ballot for members will be taken, and after the adjournment at 9 p.m., the President and Council will hold a Reception.

**WEDNESDAY, April 8th.**

SOCIETY OF ARTS

*8 p.m.* Ordinary Meeting. Paper to be read: "The Durability of Pictures painted with Oils and Varnishes." By A. P. LAURIE.

**THURSDAY, April 9th.**

ROYAL INSTITUTION.

*3 p.m.* Afternoon Lecture: "Recent Spectroscopic Investigations." By Prof. DEWAR, F.R.S.

INSTITUTION OF ELECTRICAL ENGINEERS.

*8 p.m.* Ordinary General Meeting. Paper to be read: "The Design of Multipolar Dynamos." By W. B. ESSON, Member.

**FRIDAY, April 10th.**

INSTITUTION OF CIVIL ENGINEERS.

*7.30 p.m.* Students' Meeting. Papers to be read: "Modern Locomotive Construction." By W. W. F. PULLEN, Stud. Inst. C.E. "The Design of Locomotive Cylinders." By JOHN H. BARKER, Stud. Inst. C.E.

ELECTRO-HARMONIC SOCIETY.

*8 p.m.* Smoking Concert at St. James' Hall Restaurant.

ROYAL INSTITUTION.

*9 p.m.* Evening Discourse. "Electric and Magnetic Screening." By Sir WILLIAM THOMSON, P.R.S.

**SATURDAY, April 11th.**

ROYAL INSTITUTION.

*3 p.m.* Afternoon Discourse. "The Dynamo." By Prof. SILVANUS P. THOMPSON, D.Sc.

*** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

* *Comptes Rendus*, June 27, 1881.

† Conformably to the ideas interchanged at the 1881 International Congress of Electricians (Electro-Physiology Committee, meeting of September 22, 1881), between MM. Helmholtz, Marey, Joubert, d'Arsonval, du Bois-Reymond, Lippmann, &c. I tried at first to obtain the electric wave by turning a coil in a magnetic field, or *vice versâ*. I soon gave up this method, which presents many difficulties and causes of error, which I cannot detail here.

Digitized by Google

# The Electrician.

**Published every Friday, Price Fourpence; Post Free, Fourpence Halfpenny**
**Editorial, Publishing, and Printing Offices:**
**SALISBURY COURT, FLEET ST., LONDON, E.C.**
*Telephone No.* 2714. *Telegrams:* "ELECTRICIAN NEWSPAPER, LONDON."

*All Letters relating to Subscriptions, Advertisements and other business matters should be addressed to the Publisher, "THE ELECTRICIAN," Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to "THE ELECTRICIAN" Printing and Publishing Company, Limited, and be crossed "Coutts and Co." All other letters to be addressed to the Editor.*

*All letters intended for insertion in "THE ELECTRICIAN," or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

*"THE ELECTRICIAN" is published every Friday morning, in time for the morning mails. Subscribers should receive their copies by the first post on Friday morning.*

*"THE ELECTRICIAN" is on sale at the railway bookstalls throughout the Kingdom on Friday morning, and can be obtained of all Booksellers and Newsvendors; or direct from the Publishing Offices as above.*

*New Volumes of "THE ELECTRICIAN" commence in May and November.*

## SUBSCRIPTION RATES.

The rates for Subscriptions to "THE ELECTRICIAN" are as follows:—

| | 3 months | 6 months. | 12 months. |
|---|---|---|---|
| | s. d | s. d. | s. d. |
| For the United Kingdom | 5 0 | 10 0 | 19 6 |
| For Foreign Parts and Colonies:— Within Postal Union | 6 6 | 12 6 | 24 0 |
| For Aden, Borneo, Ceylon, China, India, Japan, Java, Labuan, Mozambique, New Caledonia, Persia, Philippine Islands, Siam, Transvaal, and Zanzibar | 7 6 | 14 6 | 28 0 |

## TO ADVERTISERS.

*"THE ELECTRICIAN" offers exceptional advantages to Advertisers.* **It has by far the largest circulation of any English Electrical paper, and circulates all over the World.**

*Particulars relating to Advertisements will be promptly forwarded on application to the Offices as above.*

TRADE ADVERTISEMENTS *intended for the current issue must reach the Offices not later than First Post on Thursday morning. Renewals of expiring advertisement orders and alterations to standing advertisements should be in the Publisher's hands by Wednesday at latest. No alteration can be made in Wrapper advertisements after Wednesday evening.*

SMALL PREPAID ADVERTISEMENTS *(for Rates see page xvii.) are accepted up to 4 p.m. on Thursday.*

## TECHNICAL PRINTING.

"THE ELECTRICIAN" PRINTING AND PUBLISHING COMPANY (LIMITED) *inform Electricians, Electric Light Engineers, &c., that they make a specialty of Technical Printing, and have a large Staff thoroughly acquainted with Electro-Technology. They can, therefore, promise Accuracy and Despatch in the Printing of Electro-Technical Literature, &c.*

## "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. (Royal 8vo.)

*Early in each year is issued* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. *The* DIRECTORY *was established in 1883, and the 1891 Edition, published on the 23rd February, 1891, consists of 900 pages of printed matter. The names and addresses of all persons engaged in the Electrical Industries at home and abroad may be relied upon as accurate. Useful Tables and Electrical Formulæ, and information specially compiled for this work are given, together with popularly-written Biographical Notices of the leading Electricians, Electrical Engineers, &c., accompanied in many cases by Portraits.*

*The issue for 1891 is ready, and should be ordered at once. Price 5s., post free 5s. 9d. Abroad postage extra. Full particulars on application.*

## ELECTRICAL BOOKS AND PUBLICATIONS

*All Books, Newspapers, and other publications, dealing with Electrical and kindred subjects, can be ordered direct of "*THE ELECTRICIAN*" Printing and Publishing Company, who are proprietors of the well-known "*ELECTRICIAN*" Series of Standard Electrical Works, and are agents for all the leading publishing houses at home and abroad.*

## CONTENTS OF THE CURRENT NUMBER.

NOTES ... 657
The Magnetic Circuit of Transformers: Closed versus Open. By S. Evershed. Continued. Illustrated ... 662
Photometers. Illustrated ... 664
A Method of Simultaneously Registering the Wave of Electrical Excitation and the Resultant Muscular Contraction. By A. D'Arsonval. Illustrated ... 666
Books Received ... 667
Meetings of Scientific Societies 667
ENGINEERING AT CAMBRIDGE ... 668
Reviews ... 670
The Electric Current and its Laws.—V. By John T. Sprague. Illus. Continued. 670
On Hysteresis in Presence of Alternating Currents. By Dr. George Finzi. Illustrated 672
Meters—Gas and Electric ... 673
Variations of Current in the Primary Conductor of Open Circuit Transformers. By Robert Shand. Illustrated .. 674
The University Training of Engineers. By J. A. Ewing, B.Sc., F.R.S. ... 676
The Guernsey Electric Railway 677
A Grand Trunk Telegraph Line 678
Physical Society.—The Theory of Dissociation into Ions, and its Consequences ... 678
Some Points in Electrolysis ... 678
Magnetic Proof Pieces and Proof Planes ... 679
The London-Paris Telephone Line ... 679
On the Variation of Volume in Liquid Dielectrics under the Action of the Electric Forces acting between the Plates of a Condenser. By Emilio Oddone ... 679
American Notes ... 680
CORRESPONDENCE—
Voltage and Electromotive Force—W. E. Sumpner ... 680
Control Magnets for Galvanometers—Eug. Obach ... 680
An Experiment with the Electric Arc—J. D. F. Andrews. Illustrated ... 681
Trade Notes and Notices ... 681
PATENT RECORD ... 681
COMPANIES' MEETINGS, &c.—
Elmore's Foreign and Colonial Patent Copper Depositing Company (Limited) ... 682
The British Tanning Company (Limited) ... 683
New Companies registered ... 683

## ENGINEERING AT CAMBRIDGE.

A report has been recently communicated to the Senate of the University of Cambridge by the Mechanical Workshops Enquiry Syndicate, on the proposed Engineering Laboratory. To those who are not familiar with University doings, the word "senate" is uncommon, but easily understood, while to business men the word "syndicate" is well known, but conveys a very erroneous meaning. A Cambridge syndicate has this in common with a City syndicate, that it is not unfrequently the precursor of an important undertaking; but in ordinary language it is a committee. The foundation of a school of engineering at a technical college or minor University is happily not an unusual matter, but there are several reasons why the development of such a school within the University of Cambridge presents considerable interest both to the educational world and to the profession, the principles of which it is intended to teach. Engineering at Cambridge may be said briefly to have been first taught by Prof. R. WILLIS. It was he who, having been appointed Professor of Natural Experimental Philosophy in 1837, first formulated and rationalised mechanical knowledge; and teachers are greatly indebted to him for putting lecture experiments and laboratory demonstrations on a solid and practical scale; while every intelligent patternmaker is familiar with the simple implement by means of which he is enabled to set out the teeth of gear wheels. The scope of Prof. WILLIS's teaching cannot be compared with the courses of to-day; but it was a great step to introduce experimental lectures among those who were wont to busy themselves with inextensible cords on frictionless pullies.

The next step was made by Prof. J. STUART, who was appointed Professor of Mechanism and Applied Mechanics in 1875, and under his auspices the workshops were started some 18 years ago. In a little shed, hard by the Cavendish Laboratory, undergraduates used to make scribing blocks after a given pat-

Digitized by Google

tern, and this scribing block differed from the ordinary tool, in that it was designed on a principle which required the student to use every tool in the workshop in order to construct it. This principle had its merits educationally, perhaps, to the disadvantage of the scribing block as a useful tool, when made. The workshop struggled on under peculiar circumstances into which it is not necessary to enter. One or two very clever workmen were employed, and their duties were divided between teaching the students and making scientific apparatus. The latter portion of the work was of a potboiling description, for it was intended to assist in defraying the expenses of the educational portion. At first some very good work was turned out, but the system was an impossible one, and it is well that it has been abandoned. The workshops were gradually extended, some good tools were provided and several were presented, and the teaching formed a valuable supplement to the courses of lectures which were given in one of the Botany lecture rooms. But for some time past it has been acknowledged that the place which the subject of engineering holds at Cambridge, cannot be compared with that which is given to it in many other places. It might well have been expected that this University would treat engineering as a mere practical and professional application of that which is taught there *as* science, and it might have met with the indifference with which practical science was regarded until quite recently at Oxford.

So far, however, does the progress of the outside world affect that donnish circle which sometimes seems so narrow, that not only do the authorities feel that they must advance with the age, but they show in their report that they do so in no grudging spirit, and with the best possible motives. It is indeed a sign of the times to find the following sentence with the *imprimatur* of a Cambridge syndicate: "The study of mechanics gains much in utility and loses nothing in educational value by being approached from the standpoint of the engineer." Admitting this, there is but one objection that can be raised, and, unfortunately, there is some reason in it. It has been common among a few establishments, where instruction has been given in engineering, to endeavour to turn out ready-made engineers. Sometimes this is done openly, and if we may say so, with audacity; and sometimes a particularly proficient pupil or two passes straight from the lecture-room to a good berth in some engineering firm, and it is consequently suggested to intending students, and more particularly to anxious parents, that the system of training in the works and in the office is out of date. The old term of seven years of apprenticeship gave place to that of three years, and this again to two years, preceded by a year at a technical college; and now, the fact that some students are found capable of earning a living at once is put forward as a proof that they are engineers, and that to follow them is the cheapest and quickest course. Cambridge has at no time encouraged this, and is not likely to do so. "Without attempting to supersede the practical training which a pupil must receive in the office of an engineer, or in engineering works," says the report, "several English Colleges have striven, with much success, to supplement this professional training by offering a course of scientific study, chosen so that it may have as direct a bearing as possible on professional requirements. The need on the part of engineers of such a scientific basis in their training is now generally admitted." The lecture-room naturally came first, the workshop followed, and the laboratory on a small scale will be begun at once. Its objects are well set forth in the report:—"The uses of such an engineering laboratory are four-fold. It makes the student's knowledge of mechanical principles more real by bringing him into contact with material examples. It gives him practice in those kinds of experimental work which he may afterwards have to perform in professional life. It teaches him how investigations are to be conducted, and gives him some experience in this higher work. And, lastly, it endeavours to contribute to the common store of knowledge by affording opportunities and appliances for original research." The first of these, dealing with knowledge of principles and with material examples, places them in the proper order. In the old way, the pupil was confronted in the workshop with the examples, and he had to consult his books in the evening, after his work, in the hope of discovering some principle which would account for them. The second item contains a careful reservation, and is, perhaps, a little too modest, offering, as it does, practice only in experimental work, while many a technical college promises practice in real professional work, encouraging the idea that the training can be thus completed. Such a system is as absurd as would be that of an art school which should undertake to teach the painting of Academy pictures, or a school of medicine which should attempt to qualify its students as physicians without walking the hospitals. The two latter uses of the higher order would, in themselves, justify the foundation of such a laboratory, although they are placed after the primary ones connected with teaching. The fascinations of original research are accompanied by an enthusiasm which is felt by others who are not directly engaged in it. The laboratory, says the report in conclusion, "will probably draw not a few men of mathematical ability into a profession they would otherwise not enter."

All that is wanting now is the money to carry out the complete scheme. An excellent site has been acquired near the Physical and Chemical laboratories, and the other scientific departments. The University has made an annual grant for demonstrators and current expenses. It is proposed to include a laboratory of practical or applied electricity. The resources of the University cannot do more for some time to come, the colleges being already laid under heavy contributions, and the funds not admitting of any considerable augmentation from increased fees of students. As our educational establishments are wholly free from any connection with the State, help must be sought from private individuals. Some £20,000 for buildings and plant are needed. Owen's College has been well provided for; £28,000 has recently been spent on the department of engineering at University College, Liverpool. What the Duke of Devonshire did for the Cavendish Laboratory may well be repeated by some generous benefactor, and with more certainty of success than, perhaps, in any of the similar undertakings that have done so much for technical education in this country.

---

**Superimposed Magnetisations.**—Experiments by M. Jamin have shown that two longitudinal magnetisations of inverse polarity may be imposed on a piece of steel without mutual neutralisation. The same has been shown by M. Decharme to be true for transverse magnetisation; and in a recent communication to the Académie des Sciences, M. Decharme describes the result of magnetising the same piece of steel successively, longitudinally and transversely. The specimen of steel was 100mm. long, 28mm. broad, and 3mm. thick. If the conditions were favourable and care was taken, it was found possible to obtain an iron-filing sketch, showing two simultaneously existing magnetisations. In most instances, however, the two magnetisations were merely superimposed, and by making the proper passes the longitudinal and the transverse magnetisations could be made to predominate in succession, and with increasing strength, until saturation point was reached. A bar magnetised first longitudinally and then transversely, would thus appear to be in a state of magnetic instability.

Digitized by Google

## REVIEWS.

**Decorative Electricity.** By Mrs. J. E. H. Gordon. With a Chapter on "Fire Risks" by J. E. H. Gordon, B.A., M.I.C.E. [London: Sampson Low and Co.]

A book dealing with the decorative treatment of electrical fittings is much needed, and the present work, handsomely got up and well illustrated, goes some way towards meeting the want. The subject has not yet become a branch of decorative art, and the authoress has not attempted to treat it as such. The other extreme has been reached, for the book simply describes existing fittings, and these not from various sources, but from one house.

An article recently appeared in our columns in which the beauty and comfort of ordinary electric light fittings were criticised, and the criticism was warmly resented by a correspondent. Mrs. Gordon, however, goes much further than the writer then ventured, and says, "modern *bright* brass-work should be avoided. I have seen a great deal of it used with electric light, but never with success." "There is a lamentable want of good and simple designs for hall and staircase electric lighting; those to be found at present are ungraceful and too heavy for the light lamps that they support." "Most of the electric light found at present in dining-rooms is very glaring and disagreeable, and fully justifies the remark I so often hear made by ladies, 'I never will have the electric light in my house, as it gives me a headache whenever I dine by it.' . . . There was a round table seating ten guests, and ten lamps with lemon-yellow shades were hung just above their eyes, so that the light was focussed into the eyes and face of everyone sitting at table. . . . showing up every wrinkle and line in the face. No one over the age of eighteen should be asked to sit beneath such a light." "I went to see some friends this winter, who were staying in an electrically-lighted hotel. They had switched off the electric light altogether, and they were reading with a shaded paraffin lamp, which they had asked the proprietor to procure for them. I inquired the reason, and they told me that they found it impossible to read by the bright, glaring, unshaded light of the central electrolier." Knowing that electric light lends itself with the utmost readiness to every possible artistic treatment, we give the utmost publicity to these quotations, in the hope that some efforts may be made to prevent such abuse, and to bring about more gracefulness and simplicity in fittings.

The subject is both worthy and capable of careful and systematic treatment; but the owner of a very beautiful old house is now having a private plant put down to save the trouble and nuisance of oil lamps, and he does not propose to introduce the light into the finest rooms, which are hung with old tapestry, because he has not found any fittings which will harmonise with the decorations.

The present book recommends carved cupids and tall bronze storks, while most lamps are shrouded in silk or lace handkerchiefs. The writer is a little too exacting in deciding which tints are permissible and which are to be avoided, and, in spite of her protestations, errs in over-elaboration. One or two unfortunate ideas are put forward, *e.g.*, sham candles "coated with *real* wax." Taste cannot be taught, and though its principles may be formulated, decorations must be carried out by artistic feeling, and not by rule. Some of the suggestions are excellent, and several practical hints contained in this book will be found very useful.

**Die Elektrischen Verbrauchsmesser.** By Etienne de Fodor. (A. Hartleben, Vienna, Pesth, Leipzig. 1891.)

The author of this little book, particularly in dealing with electrical and other units in his introduction, is perfectly sublime in his disregard of the element of time. This may, perhaps, be partly due to a looseness akin to that which is responsible for the term "wattmeter" as a name for an instrument performing the operation indicated by $\int V.A.\,dt$; but it is not on that account any the more excusable. Of the errors into which he is consequently led, some, such as the statements that a watt is energy, and that the work done by a *current* is equivalent to a certain number of kilogram metres per second, are so frequently met with, that they do not excite surprise, but one cannot help being startled by reading that a 16 c.p. lamp at 110 volts consumes ·5 ampere *per hour*, and in another place that half an ampere is equivalent as regards cost and light to a fifth of a cubic metre of gas. Instances of similar mistakes occur continually throughout the book.

To the 15 points enumerated by Prof. Forbes as desiderata in electric meters, the author adds three, based upon his practical experience at the Athens Central Station. These relate to the desirability of measuring the whole current, and not a fraction only, of eliminating the effects of residual magnetism, and double registration. The first two of these seem to be included in the first of Prof. Forbes', viz., "accuracy," though, as practical hints, they are certainly valuable. The descriptions which the author has compiled of the various types of apparatus are brought well up to date, and these, as well as the regulations with regard to meters that are adopted in various central stations will make the book useful to those who are not liable to get confused in their ideas as to what an electric meter is intended to measure.

**L'Annee Electrique.** By Ph. Delahaye, Septième Année. (Paris: Baudry et Cie.)

The aim of this publication is to give within the compass of some four hundred pages, a resumé of the principal electrical discoveries, inventions and applications chronicled by the technical press during the past year. The book is divided into ten chapters dealing respectively with electric lighting, batteries, telegraphy, telephony, atmospheric electricity, medical electricity, electro-metallurgy, electricity applied to railways, electric transmission of power, measuring instruments. Care and discrimination in the choice of subjects for notice and in the space allotted to them, would render M. Delahaye's annual volume a more useful and reliable authority than it can at present claim to be. Thus, in the section devoted to dynamos, the Polechko, and the Reignier and Bary machines are mentioned, but nothing is said about the Westinghouse constant-current alternator. Again, a quarter of the chapter on Medical Electricity is devoted to "La Première Electrocution," while the chapters dealing with electrical railway devices and the electric transmission of power are respectively almost entirely taken up with MM. Sartiaux and Weissenbruch's voluminous report to the Congrès International des Chemins de Fer and Mr. Reckenzaun's O.S.A. Paper. The remaining chapters, on the other hand, exhibit more sense of proportion. The idea of the work is excellent, but its execution cannot be recommended for imitation.

**Annuaire pour l'An 1891.** [Paris: Gauthiers, Villars et Fils.]

This is an official publication emanating from the Bureau des Longitudes, and is replete with tables intended for use by the physicist and astronomer. Some twenty pages are devoted to Terrestrial Magnetism, and seven only to Electricity, out of a total of nearly 800.

## THE ELECTRIC CURRENT AND ITS LAWS.—V.

BY JOHN T. SPRAGUE.

(*Continued from p. 609.*)

§ 42. We may now consider the actions which take place in an electric "source," and follow them into the "circuit," in order to see how electric energy and electric current are related to each other. I should first lay down a general principle, which, probably, no one will dispute, though they will practically set it aside. It is this. If we wish to get a clear comprehension of phenomena, we should trace them in their simplest forms, if possible, where they alone are operative, leaving the more obscure cases, in which disturbing or distinct agencies are at work, until we can clearly see the fundamental principles.

The galvanic battery is clearly the simplest form of source, because it is complete in itself. The dynamo and thermopile are both complicated with supplies of energy external to them. They are like the steam engine, not real sources of energy;

Digitized by Google

they only transform the energy supplied to them. But the galvanic battery not only supplies its own energy, it also makes clear the mode of transformation into "electric energy" and its relation to current. Once we get a clear insight into this we can more readily see our way to understanding how the same principles are working, in the same general manner, in cases where the operation is not itself apparent, and where the inventive genius might devise other explanations.

§ 43. The contact and chemical theories long disputed the explanation of battery phenomena; but the contact theory is now utterly dead. The thing which is occasionally mentioned now-a-days as the contact theory, contact potential, or E.M.F. of contact, is purely the chemical theory. The contact theory, as a real mental existence, died when the notion of "contact of heterogeneous substances" generally, was substituted for the definite doctrine that the mere contact of different metals set up a transfer of electricity, and was the cause of chemical action in the battery. The make-believe contact theory of to-day is only a mathematical ghost; the reality is that the bringing into contact, or close neighbourhood, of heterogeneous substance, brings their chemical forces into operation.

All this has been fully cleared up by the study of thermo-chemistry, the science of the relations of energy to material structures. Let us consider this a little.

Every one who has given even a casual attention to chemistry knows that the actions of change take place in "equivalent proportions;" the modern chemical notation, with its atoms containing more than one equivalent of matter, rather obscures this fundamental fact, but when we bring electricity into connection with chemistry, it brings the old fact into prominence; we have to recognise that, whether the modern "atom" has or has not an actual existence, the equivalent, which used to be called the atom, cannot be ignored.

Those who have gone a little deeper, know that energy plays its part concurrently with matter; that, when any equivalent of chemical action occurs, it either sets free a definite measureable quantity of energy, or that quantity of energy must be supplied to it, and stored up in the product ready to be released at a future time. This is, in fact, the real work of vegetable life, the breaking up of the fully oxidized water and carbonic acid, unburning them in fact, and storing the sun's energy in the new vegetable substances, which give it up again when burnt, and in a myriad other ways.

This, also, is what is done in a metal reducing furnace: we take oxides, carbonates, sulphides of zinc, and unburn them into the metal zinc, which contains a large quantity of "energy" which it will release in the act of oxidation. We can release it direct as heat, for zinc will burn, or we can release it, still under bondage, as electric "energy," and this is the function of the battery.

§ 44. I trust it will not greatly disturb Mr. Evershed if I say that I cannot well dispense with a few new terms, because the development of ideas is often checked when conveyed in words which have other uses, and many of our familiar electric terms imply a theory or physical basis which is really a nuisance. *Current* is one of these; the electric conductor has many important analogies with true currents of water, &c., but we do not know that any analogous thing exists in them; it introduces confusion as to the meaning of velocity, while we have no real evidence that there is any proper transmission, or any true velocity. I shall have to return to this, but at present I am going to suggest that, as "voltage" has found definite acceptance, "amperage" may prove a good substitute for current; indeed, it is occasionally used. We need only substitute "ohmage" for what is now absurdly called resistance, to have a complete formula freed altogether from theory.

$$\frac{\text{voltage}}{\text{ohmage}} = \text{amperage}, \qquad \text{and } \frac{V}{O} = A.$$

We all know that so-called ohmic resistance is not a resistance in any true sense; how can that be a *resistance* which accepts indifferently large and small currents? The term simply misleads the partially informed, and obscures the fact that the real resistance is as the square of current, and corresponds to what is known as resistance in mechanics. Ohmage is simply the reciprocal of "conductance," expressible in sizes and lengths of wire of given physical properties.

§ 45. *What is Amperage?*—It may be said to be merely an arbitrary measure of a hypothetical current. I am going to show that it is something very much more important; that it is the expression of the physical fact of nature, which is, or underlies the current itself; most unfortunately it is arbitrary and accidental, related to the facts by a troublesome fraction, instead of an integral figure, and that figure unity.

On p. 451 the new definition of the ampere value is given as a deposit of silver 0·001118 gramme per second. I may as well note an important omission—the *density* should be fixed—that is, the surface area on which the unit deposit is to be formed. Now, practically, silver is the best agent for actual determination; its equivalent is high (108), which minimises errors; its salts are easily obtained pure, and there is not much liability to subordinate actions. But theoretically speaking of silver simply hides the real fact. We must divide by 108 to get the real relation of the ampere to nature, and to the structural actions of matter. This gives us the value of the ampere in hydrogen, the unit and basis of all equivalent actions; and this, multiplied by the proper equivalent values, will give the relation of the electric current to all substances which take part in its transmission.

This value H = ·0000103518 is the *equivalency of the ampere*, or let us call it the "amperage equivalence." Had fate so arranged our energy system of units that this figure had been simply ·00001, what a clearance there would be of mathematical abstractions and metaphysical cobwebs! No one would have needed to poke about eolotropic and isotropic media for imaginary explanations of a fact which would be self obvious,—that electric current is purely a function of the structure of matter, and that amperage is purely the expression of the relation of what we call electricity, to the same equivalency of matter which governs all chemical actions whatever. But we have now to clear up the relation of energy to this equivalent.

§ 46. Chemical workers commonly represent the intrinsic or specific energy of reactions (§ 43) in terms of "calories per gramme equivalent;" it may be as truly expressed in foot-pounds per grain equivalent, as I did years ago, when very few electricians had even a glimpse of this side of nature. I then devised a unit of energy, and called it the "equivolt," which defined the relation of electromotive force to the equivalency of matter, and to the intrinsic energy specific to each kind of matter. The term has not caught on; I fear it indicated too absolute a barrier to the extension of abstract and visionary ideas. But the thing itself is now generally recognised, viz., a constant, which, used as a divisor on the calories per gramme equivalent, *gives us the voltage* which the chemical reaction sets up.

The unit or constant may be arrived at in various ways; the simplest is to take the time of an ampere current doing one equivalent of chemical action, which is the reciprocal of the amperage equivalence, or 96,601 seconds; multiplied by the energy $C^2R$, expended in that time under unit conditions, that is, in one ohm, we have the energy expended by the source in setting up unit voltage, and maintaining unit current. That is the constant (equi-volt) which, when applied to the chemical energy of the reaction in the source, gives the voltage of the source.

§ 47. It will be seen now, why I propose to give a name to this vague and general "specific energy." I propose to call it the "voltance" of the chemical reaction. As it sets up an opposing or "counter E.M.F." in any decomposition cell, any one who pleases may express this $-e$ as the re-voltance. We have now in view the two distinctive features of all sources, the "amperage equivalence," § 45, related to the structure of matter, and the "voltance" which is the density of the energy associated with that structure.

I may say that all that precedes this was written at intervals while recovering from a sharp illness, and was in the editor's hands before the issue of the number of March 27th, which I have just read with some surprise at finding Mr. O. Heaviside dealing, § 40, p. 633, with the very points I have been working out. I need scarcely say that I entirely differ from his opinion as to the superior value of abstract theory. I

Digitized by Google

take it that our only mode of attaining truth, is to find out what Nature does, not to invent mere imaginary schemes about her works. As to our relative knowledge of matter and ether, I have already spoken my mind, and will simply quote myself, p. 434. "I repudiate all ideas about what is called the essence of matter, or any interest in the question of what it really is. All this is of no concern to us. It belongs not to science, but to metaphysics." Mr. Heaviside says: "No one knows what matter is any more than ether, and we should rather explain matter in terms of ether than go the other way to work." I deny it in *toto*. We do know what we mean by matter; no one knows what they mean by ether. I may as well quote a reply of mine from elsewhere to this same erroneous statement: "We are often told that we do not know what matter is, and that we have no right to object to the ether notions on the ground that we do not know what ether is. Now this is pure cant; it is mere juggling with words. We know a great deal about the properties of the thing we mean by the word matter, and we can examine and test those properties. Nothing of this is to be said of the ether. The word 'matter' connotes a mass of natural obvious records of our cognition. The word 'ether' connotes nothing but our difficulties of defining some of those facts. What an infinite difference this is." Ether is one of these spirits called from the vasty deep, and, like Hotspur, I want proof that they will "come when you do call."

§ **48.** I fear the writer of the article, "Electromotive Force," p. 606, thinks there is some difference in our views. I agree with nearly everything he says. "Why should not a cell be said to liberate energy." That is what I do say. I use E.M.F. only as a phrase in common use, which is known to mean energy. Now, let us see what goes on in the source.

Zinc is consumed, an equivalent of zinc in each cell; that is, at each cross-section of the circuit, for each amperage equivalent. The equivalent of zinc being 32·6, we have gramme ·00033746 as the zinc representing one coulomb, *i e.*, one ampere second equivalent. We have now this fact to consider. This quantity of zinc is all that affects the question; it is of no consequence what is the nature of the cell, or what the energy of the reaction. That zinc generates its current equivalent, and cannot be made to generate more. It is a purely material relation.

§ **49.** Now turn to the energy. Energy of chemical action is within a material limit of the active substances. When released freely as heat, it becomes radiant, and distributes itself as conditions permit. To convert it into electric energy, which is linear, we must provide a line of force within and along which that transformed energy operates.

*What is a line of force?* Is it an abstraction or "concept," or is it a physical reality? That "thin red line" which has carried the might of England through so many "fields," is a veritable line of force, and whether it is an eolotropic medium or not, it distributes its energy at right angles to its linear formation. But it is built up of physical units—British men—each doing his own work in his own place, but standing "shoulder to shoulder" to form the line, which organisation converts into a unity pervaded by one living will.

It is the same with the "lines of force," magnetic and electric; these are built up of units—equivalents of matter; it is by the natural forces of these material units, not merely by an externally impressed force, that the lines are constituted; the lines are the organisation which combines the individual forces into one agent.

Every particle of matter possesses many forces; gravitation, chemical attraction, capacity for heat, and the two polar forces, which we know as electricity and magnetism; each of these—atomic functions of matter itself—is manifested by the capacity to assume a "polar" order; the electric polar order + −, + −, corresponding to the column or marching formation of troops, + and − being, as it were, the front and back of each unit of which the column is built.

Magnetic polarity N S, N S, corresponds to the linear formation of the same troops ranged "shoulder to shoulder;" it is the force manifested radially from an electric current, which becomes parallel lines in opposite directions on the two faces of a row of parallel currents, and this at once gives us the explanation of the functions of "ampere-turns" in magnetisation. Just as the insertion of sources into the electric polar order accumulates their energies within the electric circuit, so the accumulation of the lateral magnetic forces of that circuit in turns around a magnetic substance, adds to the stress on the magnetic lines of force set up in that substance, at right angles to the linear direction of the electric circuit.

The two sets of polar lines and forces are each capable of their own development, and employ and distribute energy each in its own way; but none the less they originate in the atomic forces of matter itself; they are both based upon the equivalence of matter, both propagated by physical lines of material equivalents, and excepting in those lines, so related to the "structure of matter," no man has ever witnessed electrical or magnetic phenomena.

*(To be continued.)*

## ON HYSTERESIS IN PRESENCE OF ALTERNATING CURRENTS.

BY DR. GEORGE FINZI.

As "we are to-day in the midst of a conflict which touches the very root of the matter," I shall be perhaps allowed to enter this conflict, as the bringer of some facts, not as the supporter of any theory; I hope far abler hands will prosecute and discuss the consequences of my experiments.

I cannot help thinking that the simple fact of the magnetisation of a piece of iron is still far from being thoroughly investigated or well understood; and, though these uncertainties and misunderstandings do not prevent us from magnetising tons of iron, or from covering the world with lines of force, they certainly hinder us from many important improvements in the magnetic circuits of dynamos and tranformers. From the first researches of Lenz and Jacobi (1839), to the latest of Ewing, the doctrine of magnetic induction has grown more and more complicated; the time has perhaps come to look for simpler phenomena. I need not recall how epoch-making Ewing's discovery of hysteresis has been; but to study hysteresis independently from any actual magnetisation, or magnetisation from any actual hysteresis, is a double method not yet adopted. The first of these two problems seems to me to be much easier than the second; it is the second, however, which has been first attacked by Prof. G. Gerosa and myself, in a Paper, now before the "Istituto Lombard di Scienze e Lettere," the conclusions of which I will now briefly explain.

To announce that a simple Faraday iron disc may transform alternating currents into mechanical power or into continuous currents, would be a striking but not a convenient starting-point. It is preferable to begin with the magnetisation curve, which has been a faithful looking-glass for all the successive phases of the question. There was, firstly, a straight line. Joule then obliged it to bend, and said, *Ne plus ultra*. Next came Wiedemann, who, laying down his arguments on the first part of the curve, impressed upon it an incurable distortion. At last, under Ewing's conduct, the curve has untwined itself, and an infinity of other curves have at once appeared. Moreover, every physical force acting upon the iron mass, influences the curve in the most strange and disappointing way. But let us consider Fig. 1: two curves of first magnetisation are drawn there, both belonging to the same sample of charcoal iron wire. The curve marked X is the usual well-known curve; the curve marked Y is regularly obtained when an alternating current of a sufficient strength passes through the wire. The corresponding X and Y curves of Fig. 2 relate to a cyclic variation of the magnetising force. (The current-density through the iron was, roughly, three amp. per square mm.) It is scarcely needful to translate the curves into ordinary language; everyone sees that the alternate current destroys the hysteresis, and the shape of the magnetisation curve is at the same time wholly changed. On the signification of the word "destroys" I shall return later. I must say now that the results of our experiments could perhaps be foretold; since Ewing's researches, we

Digitized by Google

know that hysteresis is much affected by mechanical vibrations; and we know besides, that alternate currents through an iron wire produce such vibrations, *ergo* . . . . The fact, however, had never been proclaimed, and besides, I think it is more likely that what we have observed is a direct consequence of the alternate current (which produces an alternating transverse magnetisation), no sensible vibration having been ever heard or felt.

Mathematical clothes have vainly, though perseveringly, been tried on the usual magnetisation curve. May we exclaim to-day, *Si scopron le tombe* . . . ? Even mathematical functions have their luck; Lamont's, Müller's, Sohncke's formulæ did not indeed shine a long time; but what a brilliant career has Frölich's (Robinson's) formula! After Frölich and Clausius, Prof. S. P. Thompson brought it before the world. And now it is the only one which agrees very well with our curves Y, equally well for iron, steel, and for every portion of the curves; no better agreement could be anticipated. This is, I think, very fortunate both for the physical meaning and the simple shape of Frölich's formula. In fact, let us remember Ewing's admirable theory of induced magnetisation; let us now consider the particular condition of a piece of iron when hysteresis has disappeared, as a *free state*, then every magnetisation will be represented by the single general formula:

$$k = k_m\left(1 - \frac{I}{I_m}\right),$$

where $k$ is the co-efficient of susceptibility, $I$ the intensity of

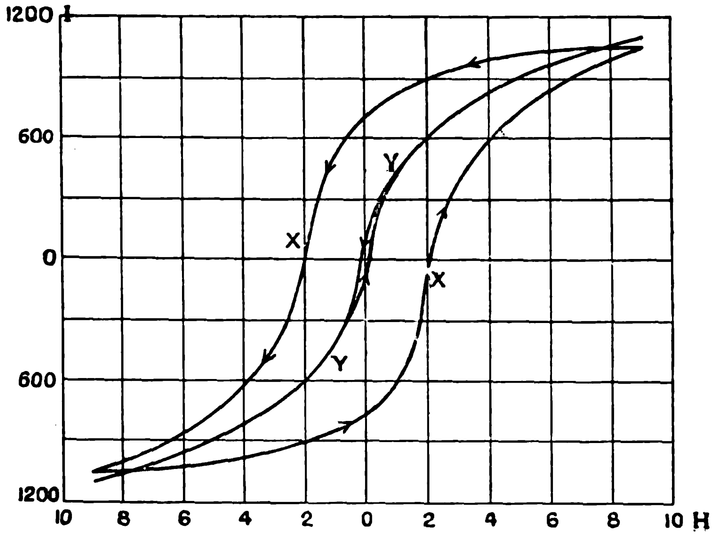



Fig. 1.

magnetisation, $k_m$ and $I_m$ the maximum of $k$ and $I$. Moreover, $I_m = 1750$ both for iron and steel. The well-known relations between $k$, $I$, magnetic resistance, and induction make the formula immediately useful in every problem of induced magnetisation (in the free state).

The iron cores of dynamos are sometimes, and those of transformers are generally, on account of the eddy currents, much more in the free than in the normal state; this consideration, I think, makes the theory of these systems a little different from the actual one, but I cannot enter into this now. I may say, however, that the core of a working transformer is in a peculiar condition; its permeance is greater than if no currents passed through the coils, load or no load, this or that frequency will also make considerable changes. I have spoken of "destroyed hysteresis." Of course, I do not think that hysteresis is no longer there. I only assert that if two cyclic magnetisations of very different frequency take place at the same time, the slow one does not show any hysteresis. As for the hysteresis loss, this is more likely to be transferred than abolished; but experiments are wanting on this point, as on many others, of this interesting question.

The extraordinary value of the initial permeance, which is one of the characteristics of the free state, may lead to the construction of a very curious machine. Once more the Sturgeon-Barlow-Faraday disc comes, and proves to be, if not a successful industrial machine (though the day may still arrive for it), at least a suitable system for electrical transformations of all kinds. Let us imagine an iron disc split radially into a multitude of narrow strips or filaments, all welded to the axis, but insulated from each other for the remainder of their length. A permanent horse-shoe magnet embraces a section of the disc. Then let us suppose that an alternate current passes through the filaments of a sector unsymmetrically placed in with respect to the magnet; this sector will increase its permeance and will accordingly be attracted by the magnet; but then another sector will take the place of the first, and so on; and thus the disc will set up a continuous movement of rotation. That is not all; if, whilst from an arc of the circumference to the axis, an alternate current is passing, and the disc is revolving, and the remaining arc or a portion of it is put into communication with the axis, a continuous constant current will flow through this circuit. Thus, our disc is performing a double transformation of energy, quite different from all those that take place in our ordinary dynamos and transformers. As to the efficiency of such a machine, nobody could, perhaps, attempt to foretell it; at least, to grasp at a molecular question of this kind is far above my power; but I hope to soon be able to submit it to experimental proof.

The few things I have said will, perhaps, be of no use in their actual state to electrical engineers; but this portion of electrical science is so interesting, and our experiments are so

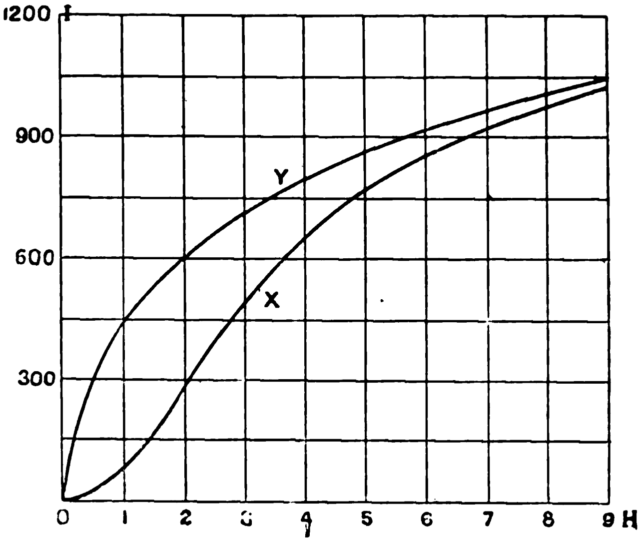



Fig. 2.

easy, that I hope they will soon be repeated and varied; and then many things may arise that we cannot even perceive now.

## METERS—GAS AND ELECTRIC.

A Paper, which was recently read before the Eastern Counties Gas Managers' Association by Mr. W. Barratt, and the discussion which followed it, contains several statements which are of interest in connection with the supply and measurement of electrical energy. Quoting from his own remarks at a discussion in 1875, on the testing of meters, the author said that he had never found one dry meter that would register the same under all circumstances. Take a two or three-light meter, and test it under $\frac{5}{10}$ths pressure, and it might be found to register within five per cent. of the quantity it was marked to pass. But pass through that meter from 12 to 18 cubic feet of gas and it would vary. If 18 cubic feet were passed, it would be from five to six per cent slow; if the same quantity of gas was passed through at a slower rate, it would be found to be what it was alleged to be when sent out from the manufactory. On

Digitized by Google

one occasion he wrote to Mr. Joseph Adamson, one of the first Presidents of the British Association of Gas Managers, stating there was not a dry meter that had come under his observation through which he could not get as much gas, without any registration, as that meter was sent out to pass. A dry-meter maker undertook to make a 10-light test-meter that should be absolutely correct under all circumstances. The meter came and was put through several tests; but, before the the testing was over, there was a variation of registration, as against the gas company, of no less than 7½ per cent. When he first went to Grantham, he tried to ascertain the leakage in the place, and, to his astonishment, found it to be 25 per cent. He was certain that this 25 per cent. could not go through the mains in the streets, and he therefore proceeded to discover the proportion of dry meters to wet throughout the town, and found a large proportion of dry meters. The inspector's book showed that out of 1,400 meters, there had been stopped, in six or nine months, no less than 30. On the other hand, during the whole of the time, very few wet meters had come under his notice which were not within two or three per cent. of being correct.

Since making the foregoing statement, he had seen no reason to alter his opinion, except that a more extended experience had caused him to have less faith than ever in dry meters.

In the discussion, it was stated that the gas unaccounted for at Yarmouth had been reduced from 30 per cent. to 7 per cent., no wet meters being used except the station meter, and this had to be wrapped up in winter and kept warm with a gas stove. A speaker who alluded to the delicacy of construction of dry meters, thought that wet meters should be attended to at intervals of six weeks, or at least once a quarter; and in the case of dry meters, after the first five years, they should be taken out and tested periodically—at least once in two years. The gas unaccounted for at Dereham was four per cent.

At Chesterfield the meters were visited eight times a year, and if, the manager said, he could afford it, he should visit them every month. The larger meters, in fact, were inspected every month, and very large and wet ones each week. Watches are not expected to keep perfect time without attention, and no one could expect a meter, which had to pass through all the vicissitudes which were alluded to during the discussion, to go on for ever without inspection. At Carlisle the meters were inspected once in two months, and once a week in the case of large meters. In the opinion of the manager, it was also desirable that wet meters should be inspected each week.

Mr. J. Barton (Peterborough) said that in discussing this question they had three things to consider: First, the capital charge for meters; secondly, their durability; and, thirdly, their correctness as to the measurement of the gas passed through them. Mr. Barratt had not given them any statistics as to the working of the wet meters in Grantham; and he should have liked to know how it worked out per 1,000 cubic feet of gas sold, for renewals, repairs, and inspection. He had a few figures with him relating to Peterborough, where dry meters were almost entirely used—in fact, he did not think there were a dozen wet meters in the town. During the past fifteen years the highest charge, per 1,000 cubic feet of gas sold, for renewals, repairs, cost of fixing and changing meters, and inspectors' wages, was 0·63d., in 1888, and the lowest 0·38d., in 1886—the average of the fifteen years being 0·46d. During that time the unaccounted-for gas had been reduced from 12·14 to 6·45 per cent. The consumption of gas fifteen years ago was 38½ million cubic feet, and it was now rather more than 67 millions. Thus the gas consumption had nearly doubled, while the cost of maintaining the meters had been reduced, as well as the unaccounted-for gas. Besides this, the price of gas had been reduced from 4s. 6d. and 5s. to 3s. 2d. and 3s. 4d. He thought that dry meters, with proper attention, were thoroughly reliable instruments. In his case they tested at the works one-fifth of the meters every year; so that all of them were tried for accuracy every five years—any meter which was found outside the range being sent to the makers for repair.

The discussion from which we have taken these extracts is interesting because it relates to the present state of gas meters, which were invented immediately after the introduction of gas, and have received very little alteration since. A few details have been modified, but there are only two classes, and all the essential features of these are to be found in the earliest meters that were made.

The figures as to gas unaccounted for show a considerably smaller leakage in the mains than might be expected from the smell which attends the opening up of the streets in which they are laid, and gas managers cannot tell how much is due to leakage and how much to erroneous meters. The leakage to earth from electrical mains can be read at once on an ammeter, and the discrepancy between the readings of the station meter and of the consumers' meters shows at once the mean error of the latter. This error is made up of two factors, want of accuracy in the record, and leakage, or passage of unrecorded current. The want of accuracy, again, may be due to an error in the original determination of the constant, or may have arisen by some mechanical disturbance of the mechanism in carriage or erection, or it may be due to an inherent defect in the principle of the meter, owing to want of proportionality throughout the range. A Board of Trade certificate for a meter, which is liable to alteration by mere handling and carriage, will be valueless. Such instruments must be checked after they are in place, either by a portable meter or by a time-reading. Meters which have not a "straight line curve" will probably fail to receive any certificate.

With regard to the importance of the unrecorded current, Messrs. Ferranti and Co. send us the following statement:—Distributing companies supplying current to 40,000 lamps of eight C.P., or rather their equivalent in various sizes, are now numerous. If these lamps are divided among 800 consumers, and taking only so small a quantity as one ampere for one hour each day, as that which passes unrecorded in each case, the loss to the Company would be £973. 6s. 8d. per annum, the current being supplied at 100 volts, and charged at 8d. per unit. A single one, or perhaps two lamps, are kept alight nearly all day, and sometimes all night, either by design or accident, by a very large number of consumers, consequently, unless their meters record accurately at low readings, the loss to the distributing Company will most probably be greater than that estimated above. Mr. Ferranti has from the first appreciated these considerations, and the success which he has attained in his meters is shown by the fact that the 10 ampere size starts with ·2 amperes, the 40 ampere with ·3, and the 100 ampere with ·5. In the direct current form of the Ferranti meter the magnets are of a special steel, the residual magnetism of which provides the initial field which enables them to start at such exceedingly low readings. In the alternating form this is not possible, but the same effect is attained by the use of a fine wire coil, through which a minute shunt current passes round the iron core, and produces a strong magnetic field relatively to the small current passing through the meter at low readings. The resistance of this shunt is 8,000 ohms, consequently the current passing through it at 100 volts costs the distributing company, at 8d. an unit, under 7s. 6d. per annum, but the great saving which it effects is a two-fold compensation for this.

## VARIATIONS OF CURRENT IN THE PRIMARY CONDUCTOR OF OPEN CIRCUIT TRANSFORMERS.*

BY ROBERT SHAND.

Despite the years during which the subject has received attention from those interested in electrical developments, few subjects are to-day more discussed or receive greater attention than that of the distribution of electrical energy by means of alternating currents and transformers.

Of late interest has been revived to some extent in transformers of the open magnetic circuit type, a revival which is undoubtedly due in great measure to the work done by Mr. James Swinburne in the development of his special "Hedgehog" form of open circuit transformer.

The results of a few experiments made upon an open-circuit transformer, the main object of which was to observe the variations of primary current under different conditions of secondary output, &c., may, therefore, be of general interest and incidentally serve to shed a little light on a statement of Mr. William Stanley, jun.,

* From the *Electrical World* of New York.

Digitized by Google

which appeared in one of his recent contributions on this subject. Mr. Stanley states: "In these transformers (open magnetic circuit) the value of the primary current varies comparatively little with the load derived from the secondary circuit, and when such a transformer is gradually loaded the primary current will remain, roughly speaking, constant, possibly varying 10 to 20 per cent."

This statement is misleading, inasmuch as that, though it may be true when considered in reference to some particular case or cases, it is not so in all. Indeed, it would appear purely a question of design in the construction of open circuit transformers, whether it be true or not; yet upon the unqualified assertion above quoted arguments are based calculated to bias the mind of the reader.

The experiments above referred to were made with the object, primarily, of observing the values of the primary inducing current under various conditions of the magnetic circuit, and the changes produced in such values by changes in the secondary output. While a claim for anything approaching rigid accuracy is not made for these observations, yet it is believed they approximate the truth with reasonable closeness.

The transformer on which the observations were made had approximately the same number of turns and volume of copper on primary and secondary conductors. The resistances also were about the same. Though such a construction would hardly be suitable in the case of a commercial transformer, in this case it suited the means at hand for making the measurements.

The transformer coils T (see Figure) formed a cylinder having an opening through its centre 2in. in diameter, into which the core was introduced, the outside diameter of the coils being 6in., the length 7in., and the weight about 30lb.

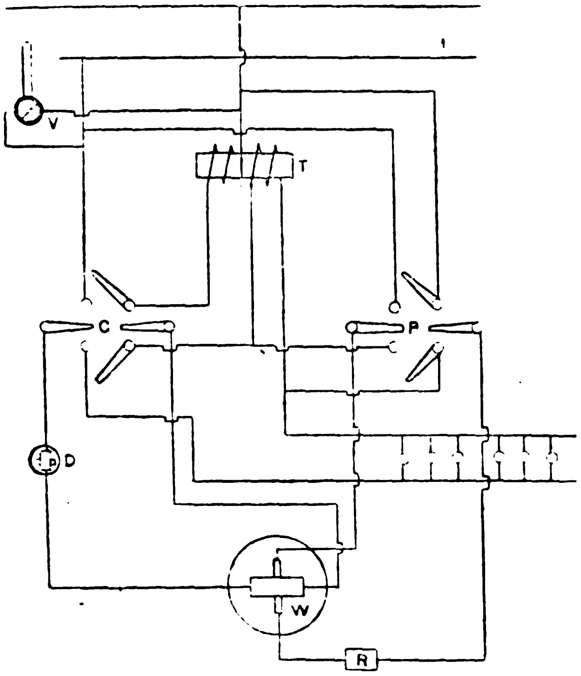



Diagram of Arrangements.

For observing the primary potential a Cardew volt-meter V was employed, for power measurements a watt-meter W having a large additional resistance R in series with the suspended pressure coil, and for current measurements a Siemens electro-dynamometer D. These instruments were disposed as shown in the figure, the commutating or switching devices C and P rendering it easy to connect them in either circuit, and to transfer them rapidly from one to the other. The primary potential varied from 100 volts in some cases to 104 in others. It was, however, kept fairly constant during each set of observations.

The drop given is, in each case, that observed when the secondary output was approximately 1,000 watts. Results given in Table I. were obtained from the copper coils alone, no iron whatever being employed.

In Table II. it will be observed that the energy taken up by the transformer when cold is very near 2 per cent. greater than that taken up after it had been run for some time and thus become heated. This effect was probably due to a decrease in the volume of parasitic currents in the core when the latter became heated.

When the core ends instead of being flattened down on the ends of copper coils were bristled up, and made to project out divergingly, the magnetising current fell to 3·1 amperes. The watts taken up, however (as indicated by wattmeter), remained practically the same.

The iron wire used in the construction of the cores was of poor quality, and was not annealed previous to use, consequently the energy taken up by the cores was, without doubt, excessive.

The quantity $C^2R$ with the secondary circuit open was in Table V. about two watts. If this quantity be accepted as representing the energy consumed over copper resistance, then the consumption of energy by the core comes out about 8,900 ergs. per cubic centimeter per cycle.

At induction taken in Table V., and with iron of the quality employed by Ewing in making his determinations, the energy taken up by hysteresis ought to be about 3,5000 ergs. per cubic centimeter per cycle. Consequently, if the consumption of energy be calculated on the basis of copper resistance and Prof. Ewin's curves, it would come out at about 18 watts, and if a quantity equal to one-third of this be allowed for parasitic currents in the core, &c., the total power with open secondary would still only be about 24 watts. Such a power consumption under the condition named would be quite moderate, even in the case of a transformer having so small an output as 1,000 watts.

Again, referring to Mr. Stanley's statement, it may be stated that on theoretical grounds alone it is difficult to understand how he could expect his statement to be substantiated in practice. The results shown in the test tables certainly do not do so. It would, therefore, appear that the objections which he raises to the employment of transformers of the open-circuit type are in reality non-existent as such. So far is it, indeed, from being the fact that the primary current will not vary more than 10 or 20 per cent. from light to heavy load on the secondary, Table V. shows it to vary nearly 500 per cent.

**Table I.**—(No iron used; drop = 3·4 volts.)

| Primary potential. | Primary current. | Primary watts. | Secondary current. | Secondary watts. | Efficiency per cent. |
|---|---|---|---|---|---|
| 100 | 52 | 657 | ... | ... | .. |
| 100 | 53 | 1,630 | 11·30 | 960 | ·59 |
| 100 | 54 | ... | 19· | 1,564 | ·68 (?) |

When secondary load was 1,564 watts the primary power was beyond the capacity of wattmeter.

**Table II.**—(Small iron wire core same length as coils; induction per centimeter of core, 23,000; drop = 3·5 volts.)

| Primary potential. | Primary current. | Primary watts. | Secondary current. | Secondary watts. | Efficiency per cent. |
|---|---|---|---|---|---|
| 104 | 16·5 | { 110 (cold) / 108 (hot) } | ... | ... | ... |
| 104 | 16·7 | 339 | 2·2 | 220 | ·65 |
| 104 | 17·2 | 531 | 4·14 | 410 | ·77 |
| 104 | 19·4 | 1,115 | 10·1 | 972 | ·87 |

**Table III.**—(Core of iron wire 7in. long; induction, 14,000; drop = 3·5 volts.)

| Primary potential. | Primary current. | Primary watts. | Secondary current. | Secondary watts. | Efficiency per cent. |
|---|---|---|---|---|---|
| 104 | 14 | 86 | ... | ... | ... |
| 104 | 14·4 | 300 | 2·1 | 210 | ·70 |
| 104 | 14·7 | 504 | 4·15 | 410 | ·81 |
| 104 | 19·1 | 1,334 | 12·2 | 1,185 | ·88 |

**Table IV.**—(Iron wire core 13in. long, projecting at each end 3in. beyond the copper coils; induction, 6,300; drop = 3·4 volts.)

| Primary potential. | Primary current. | Primary watts. | Secondary current. | Secondary watts. | Efficiency per cent. |
|---|---|---|---|---|---|
| 100 | 7·3 | 45 | ... | ... | ... |
| 100 | 8 | 330 | 2·9 | 280 | ·848 |
| 100 | 13·8 | 1,147 | 11·2 | 1,057 | ·92 |
| 100 | 19·1 | 1,699 | 17 | 1,558 | ·918 |

**Table V.**—(Same iron wire core used as in Table IV. The ends, however, instead of projecting straight out from the centre of the coil, were bent over flat and arranged radially over the ends of the copper coils. Induction, 6,300; drop = 3·5 volts).

| Primary potential. | Primary current. | Primary watts. | Secondary current. | Secondary watts. | Efficiency per cent. |
|---|---|---|---|---|---|
| 100 | 3·27 | 43 | — | — | — |
| 100 | 3·9 | 142 | — | 97 | .68 |
| 100 | 4·4 | 268 | 2·24 | 221 | .825 |
| 100 | 6·7 | 574 | 5·3 | 518 | .902 |
| 100 | 11·2 | 1,078 | 10·3 | 994 | .922 |
| 100 | 16·3 | 1,550 | 15·3 | 1,419 | .915 |

Digitized by Google

## THE UNIVERSITY TRAINING OF ENGINEERS.*

BY J. A. EWING, B.SC., F.R.S.

The education of engineers is no new subject; it has been so well and so widely discussed that one can scarcely hope to say anything about it that has not been better said before. But the matter has perhaps enough of present interest for us to excuse the repetition of a twice-told tale, for I have to plead for nothing less than the inclusion of a complete school of engineering in that new Cambridge which is fast springing up within the old. Experts have declared, with one voice, not indeed that the system of apprenticeship should be abandoned, but that it should be modified and supplemented. And the universities and provincial colleges are bestirring themselves, often with very remarkable energy, to supply what has been lacking. But the youth who aspires to the profession is still frequently sent directly from school into the office of a civil engineer, or into a great mechanical workshop. His powers of observing and reasoning are little developed; he has no grasp of mechanical principles; his stock of mathematics is scanty at the best, and he is absolutely ignorant of how it may be applied to material affairs. The theory of engineering is a sealed book to him, and in the office or the workshop he finds no one who will break the seal. Even as to matters of practical detail he is left pretty much to pick up what he can; it is the business of nobody to teach him. In time, of course, if he is a man of the right sort, he does learn a good deal, and some of the lessons are lessons that could be learnt in no other school. Before his five years or so of apprenticeship have expired he has seen actual work in all its stages. He has learnt something of the commercial conditions under which it is done. He has been in touch with men; he has learnt their habits and how they are to be managed. He has become acquainted with matters of organisation and business routine. He has come to know what good work is, and what it costs, and what is the time that should be taken for one and another kind of job. These lessons are invaluable; but I submit they are not the whole of engineering. If the pupil, on quitting his apprenticeship, carries away the faintest idea of how scientific principles bear upon engineering practice, he is exceptionally fortunate. The apprenticeship makes no provision whatever for teaching him that. Lest you suspect me of painting too black a picture, listen to a criticism passed on the system of engineering pupilage by an eminent practical engineer. In the evidence laid before the Royal Commission on Technical Education, whose Report was issued in 1884, Dr. Anderson, now director of the Woolwich Ordnance Factories, speaking then as a partner in the Erith Ironworks, said: "I have from 12 to 20 pupils who come chiefly from the great public schools. . . The minds of most of these young men who come to serve their apprenticeship with us are a complete blank as regards any of the sciences. . . Their mathematical knowledge is generally of a useless kind; it is all pure mathematics and they do not know how to apply it. They might just as well know no mathematics at all. They do not seem able to apply their knowledge to the simplest practical questions. . . I have an uneasy feeling that the pupils who leave our establishment know little or nothing except the use of their hands." That is the verdict of a practical man who has studied the system under his own eye, in his own works. It is perhaps severer than anything a professor of engineering could well venture to say. Dr. Anderson's evidence is so representative of what I conceive to be the drift of the best modern opinion on this subject, that I will quote a few sentences more. Dr. Anderson is not merely a destructive critic, he is prepared to point out a remedy, and the remedy he advocates is exactly that which I wish to press upon your notice. Asked what was his ideal of the training of the higher class of mechanical engineers (viz., employers and managers) in the future, he replied: "They ought to have a training such as the scientific colleges can give, and then come and carry out a shorter apprenticeship in the works. Instead of remaining five years at the works, as they do now in a great many cases, it would be better for them to spend three years at college and then come for two years to a practical training. . . I am convinced that that would be better." These, I take it, are beyond question the lines along which we should proceed: not to supplant the apprenticeship but to supplement and shorten it. The chief aim of a University School of Engineering is to give such a training in pure and applied science that when the pupil follows it up by spending two or three years in contact with actual constructive work he is well fitted to begin his professional career.

Before speaking of the work of the English schools in any detail, however, let us glance at what has been done abroad. There is much that is admirable in the foreign technical schools, and it will be admitted that they have fostered industrial development in France and Germany and Switzerland as perhaps nothing else could have done. But when we examine the constructive work that is carried out in those countries, or when we read the expressed opinions of men who have had experience of the system, we find evidence that the highly finished product of the foreign technical school lacks something that is often present in his rough-hewn English competitor. The Report of the Technical Educational Commission contains emphatic testimony on this point. Even those witnesses who are most alive to the inadequacy of our English apprenticeship as the sole means of training engineers give no encouragement to the idea that we should seek a remedy by copying the foreign polytechnic school. Take, for instance, the evidence of the late Sir William Siemens. Asked whether he would recommend us to copy the German Polytechnic School, he replied: "Certainly not. . . . . . I would rather employ a person who had been brought up in practice and who had supplemented his knowledge by study for himself than I would take a young man who had been entirely educated at an establishment like one of the polytechnic schools. . . . . . I think those schools are apt to teach the student details which he mistakes afterwards for principles." In America we find a number of highly organised and admirably conducted engineering schools, forming in some cases an integral part of universities; in others standing alone. In some respects they follow the Continental pattern, but with a difference. If I were to select one for special reference it would be the Massachusetts Institute of Technology. Workshop instruction is given "as an adjunct to the theoretical treatment of professional subjects;" and there is a superbly equipped engineering laboratory for which new rooms covering 15,000 square feet were provided less than a year ago. The work of this school is spoken of in the highest terms, and the fact that it has now 900 students bears witness to the estimation in which it is held in the United States. The Massachusetts Institute carries the college training of engineers to a degree of elaboration which we are perhaps disposed to deprecate; but it seems to me to avoid the most serious fault in the Continental schools.

I turn now to our own country. The University training of engineers as we understand it—the training which it should be our effort to give here—may be said to have had its foundation laid when Rankine was appointed to the professorship of Civil Engineering and Mechanics in the University of Glasgow. His introductory address—a noble vindication of the harmony of theory and practice in mechanics—was delivered just 35 years ago. It will be found printed as an introduction to his text-book of Applied Mechanics, the first of that great series of treatises in which he formulated the theory of engineering with so much of comprehensiveness, of precision, and of philosophic grasp that they hold their place to this day as the most indispensable volumes in the library of the educated engineer. Edinburgh followed 12 years later with the institution of its University Chair of Engineering, of which Fleeming Jenkin was the first occupant. It was my privilege to receive my first lessons in applied mechanics from that most inspiring and sagacious teacher, who succeeded in bringing his subject into close touch with the co-related sciences in the University curriculum, and in securing academic recognition of the course by means of the degree of Bachelor of Science in the Department of Engineering. The work so well begun in Glasgow and in Edinburgh goes on, but for the moment the development of these engineering schools has been outstripped—in respect of material equipment—by some of the younger colleges, which have had the advantage of a greater command of resources. If we wish to see the modern British ideal of a University school of engineering most fully realised, we must rather turn to Manchester, where the genius of Osborne Reynolds, aided as it has been by the wise liberality of the Whitworth trustees, in spending £10,000 upon an engineering laboratory, has achieved results of which Owen's College is justly proud. The Victoria University is indeed peculiarly rich in engineering schools; for besides Owen's it includes the Yorkshire College in Leeds and University College in Liverpool, each admirably furnished for the teaching of engineering. At Leeds the engineers of the district have given unequivocal evidence of their faith in the professional value of a college training by subscribing £10,000 to provide buildings and plant for the department of engineering; and at Liverpool the Walker Engineering Laboratories, recently completed at a cost of £23,000, form the most lavish provision of which any English college can boast. Time would fail me to speak of the many other institutions in this country at which similar teaching is given, with the aid of more or less perfect laboratory appliances—of the colleges at Birmingham, Bristol, Sheffield, Nottingham, and Cardiff; of the comparatively venerable school of engineering at King's College, London; of such special colleges as that at Cooper's Hill; of the laboratory I have just left at University College, Dundee—in the furnishing of which, again, the local engineers gave substantial help; of the great work the City guilds have done in London by founding the central institution in the west, with Prof. Unwin's splendid laboratory, and the Finsbury College in the east, where the suggestive ideas of a most original teacher—Prof. Perry—have taken practical shape. Amongst the London schools there is still one that calls for very special mention — I mean University College, for it was there

* Abstract of an Introductory Lecture delivered at Cambridge January 20, 1891.

Digitized by Google

that Prof. Kennedy created the first of those laboratories which now fill so large a place in the University training of engineers. To the great regret of all friends of that training, Prof. Kennedy has relinquished professorial work, but not until he has had the satisfaction of receiving, in the laboratories which have sprung up in all parts of the country, the most flattering tribute to his educational methods, the tribute of imitation. It is scarcely too much to say that the engineering laboratory has done for the scientific teaching of engineering what the physical laboratory has done for the teaching of physics, or the chemical laboratory for the teaching of chemistry. Fifteen years ago there was no such thing as an engineering laboratory in any of the English or Scottish colleges. What teaching was given was that of the lecture-room, supplemented only by practice in drawing, and in some cases by field-work in surveying and levelling. To-day, no university or college which professes to teach engineering considers itself complete without a costly laboratory. In promoting this change Prof. Kennedy has done a service to the cause of professional education which, it is safe to say, will not soon be forgotten. He found the engineering laboratory no more than a means of private research. He left it an instrument of education.

I conceive that one of our first aims in furthering the advancement of the School of Engineering in Cambridge, should be to secure the establishment of an engineering laboratory. The work which is done in it is essentially measurement. To carry it out with anything like fulness requires the provision of costly plant; some of it may, however, de done with rough and inexpensive appliances. We may at least make a beginning with them at once, and it is my hope to do so; but in doing that I trust I shall be acquitted of any intention to rest content until a laboratory is provided that will be worthy of the University of Cambridge. In the existing workshops we have a nucleus about which a laboratory may very naturally grow. Whether a University school of engineering ought or ought not to give its students any systematic instruction in the manual processes of the workshop is a question in regard to which experts are by no means agreed. On one hand it is urged that the college workshop is necessarily small, that practice in it cannot (and this all will admit) entirely take the place of pupilage in a manufacturing establishment; that time for it can be ill spared from the more necessary parts of the curriculum, and that the pupil will have a better opportunity of learning the same things in his subsequent experience at the works. On the other hand, it may fairly be pleaded that if the subsequent apprenticeship is to be shortened—as we contend it may—the pupil will do well to learn what he can of the use of tools during his college course; that much that is useful *can* be effectively taught, even in a small way; that the workshops gratify a healthy instinct, and that the time spent in them is an agreeable recreation in the midst of severer studies; that some acquaintance with the ordinary mechanical operations is of service even in the earliest stages of college training; that the workshops are of benefit to students who do not mean to be engineers—a consideration of special weight in Cambridge; and above all that a workshop forms a most important adjunct to an engineering laboratory. In our own case the question, so far as there is any question, is decided by the fact that the workshops exist; one's plain duty is to make the best possible use of them. As to exactly what that use should be I speak with the hesitation natural to one who has not yet had experience in directing this kind of training; but I conceive the workshops will be best turned to account if the pupil is put through a series of systematic exercises in woodwork and metal-work, in chipping and filing, in turning, drilling, planing, forging and the like. It is perhaps instructive in this connection to remark that at the Imperial Technical School of Moscow, where, as I have already said, there are large workshops, these are divided into two parts—practising shops and manufacturing shops. In the practising shops the student gains his first knowledge of the processes of wood and metal-working. The function of the practising shops is probably that which our University workshops may best attempt to fulfil. In any case, it seems to me that the question of the workshops is no more than a detail, and perhaps not even a very important detail, in a much larger question. The larger question is, how are we to secure anything like a fully-organised school of engineering?

The engineering school must be accepted as an integral part of the University system. We must have a department working in the closest association with collegiate tuition and other spheres of University activity, amply furnished in respect of buildings and plant, secure of University favour, and forming an accepted avenue to University distinction. The student who comes here with the serious intention to study engineering must be prepared to follow, and we must be prepared to find for him, a connected course carefully planned to be at once educative and professionally useful, which will engage his full attention during the usual period of academic residence. Without an organised engineering school, Cambridge must lose many good men who intend to be engineers who forego the benefits of University residence and the unrivalled advantages which this University offers to mathematical students, in order to seek elsewhere the special training their profession demands. The schools of mathematics, physics and chemistry will profit by association with a school of engineering. And again, among the men of mathematical bent who in any case would come to Cambridge there must be a few whom an engineering school would draw into a congenial profession which they otherwise would miss. There is still another aspect of the matter, too important to be passed without brief mention. Apart from its service to professional students, an engineering school has work to do in the training of those whose business in life will be to teach applied mechanics. This is a career that now gives occupation t a very great number of men in the colleges, in the technica schools, in the numerous classes that are conducted in all industrial centres under the auspices of the Department of Science and Art. The training of these teachers is a work of national importance in which the University of Cambridge may surely take a share. Is the School of Engineering at Cambridge to be as complete, as well furnished as any existing school? Where are we to look for the £10,000, the £20,000, which has supplied the wants of Manchester, of Leeds, of Liverpool? I was cheered to read in the address of the Vice-Chancellor to the Senate his expression of belief that should the establishment of an engineering laboratory be held to be in itself desirable, pecuniary help from non-resident as well as resident friends of the University was not likely to be refused. I appeal for that help earnestly and confidently, convinced that a laboratory is, not simply desirable, but indispensable.

## THE GUERNSEY ELECTRIC RAILWAY.

As we announced in a recent issue, the contract for the electrical equipment of the line owned by The Guernsey Railway Company has been obtained by Messrs. Siemens Bros. and Co. As this line will be the first in the United Kingdom to be run on the overhead trolley system, the following information, for which we are indebted to the railway company's manager, may be of interest:—

The length of the line is 2 miles 1,430 yards, composed as follows:—1 mile 680 yards of street, with single track, and 1 mile 750 yards single track outside the street. The track is single with 5 turnouts, aggregating 600 yards in length, and there are 28 single track curves, which are mostly very slight. The overhead wires are to be at a height of not more than 25ft., nor less than 20ft. The maximum grade is 2½ per cent., and runs for a distance of 500ft., and there are other grades of 2 per cent. The maximum grade on curve is 2 per cent., and is on a curve of 75ft. radius. It is situated about 1½ miles from the power station.

The line was built in 1879, and is in fair condition. The gauge is 4ft. 8½in., 250 yards of track being paved with granite setts and 1¼ miles macadamised. Nearly 1½ miles is laid with 40lb. steel and iron rails (ordinary railway section), and the remainder with 40lb. rails of tram section. The ground on which the line is laid is chiefly made ground and sea shingle.

The contractors will supply two four-wheeled 50 passenger cars, completely equipped with motor trucks, and the following cars now in use will be converted into motor cars, viz.:—1 double-decked bogie 5 ton 68 passenger car; 1 single storey composite bogie 6¼ ton 42 passenger car. All the motor cars will be lighted by electricity, and will have to run on the level at a speed of 12 miles per hour, fully loaded, under all conditions of weather and track, and with four cars running. The poles are to be of iron in the streets, though outside the town they may be of wood. The power station is situated close to the track, at a point about 2¼ miles from the remote end of the line. The generating plant will comprise a 25 H.P. Marshall compound undertype engine, and a dynamo giving 100 amperes at 500 volts.

The Legislative Assembly of the island having appointed a committee to supervise the work, it will have to be carried out and completed to their satisfaction, and that of their engineer, as well as that of the Directors of the Company and their engineer. The formal sanction of the Royal Court of the island will also be required on completion, before the work is taken over, and passengers allowed to be carried. The electric cars will commence running at the beginning of July.

**The Chicago Exhibition.**—It is stated that Her Majesty's Government have notified to Mr. Blaine, Secretary of State, their acceptance of President Harrison's invitation to take part in the Exhibition, to be held at Chicago in 1893, and that Lord Salisbury has also informed the President that a Royal Commission will be appointed to further British interests in connection with the Exhibition.

Digitized by Google

## A GRAND TRUNK TELEGRAPH LINE.

The Bengal Chamber of Commerce, says the *Pioneer* of Allahabad, in the course of their annual report, state that they supported a suggestion of the Bombay Chamber that "an early inquiry should be instituted by Government as to the practicability of a land line of telegraphs from Chaman *viâ* Kandahar and Herat to Teheran on the one side and to the Russian system of telegraphs on the other, as affording a cheaper route of telegraphic communication with Europe and the United Kingdom than those now existing." Now, while there can be no doubt that it would be most desirable in the interests of civilisation and commerce to link Chaman with the Russian system of telegraphs in the Trans-Caspian Province by way of Mashad, which is now in communication with Teheran, there are serious difficulties in the way of laying and maintaining the wire through Eastern Afghanistan. The project is not a new one; it was put forward tentatively in our columns some seven or eight years ago, and was freely discussed at the time. Our view then was that the consent of the Amir of Kabul to the scheme might possibly be obtained by the grant of liberal annual payments; that His Highness might undertake to guard the line from attack by the tribesmen; and that trained Mahomedan signallers and line-men might be sent from India to Kandahar, Farrah, Herat, and other points selected for stations. A correspondent, whose opinion commanded the highest respect, at once pointed out that, given the consent of Amir to the scheme, it would still be impossible to maintain the line, as the tribes along the route would to a certainty never allow it to remain intact. The Afghan officials would be lukewarm in carrying out orders which the Amir himself would probably issue in a half-hearted way, for the constant punishment of offending tribes would serve to make his rule unpopular among the turbulent sections of his subjects. There is, we fear, only too much reason to believe that this view is the correct one. Since the time when the project was discussed Abdur Rahman has not shown any desire to open out his dominions. On the contrary, he has almost destroyed trade with India by the imposition of prohibitive duties; and though he has in his own capital availed himself of some of the scientific appliances of civilisation, he is still firm in his determination not to have railways and telegraphs in his dominions. It is but 160 miles from Jamrud to Kabul, and the telegraph line could be laid that distance in a few weeks, but His Highness prefers trusting to the old system of mounted messengers, though during the dangerous phases of Ishak Khan's rebellion in Afghan Turkistan he would doubtless have been glad of a more rapid means of communication with the Punjab. We must, therefore, come reluctantly to the conclusion that he would not support a project for a telegraph line to Herat, and that if his consent was exacted under political pressure there would be but a small chance of the line being maintained in working order.

But if the Bombay and Calcutta Chambers of Commerce desire an overland telegraph line to Europe, they might turn their attention to the Seistan route. Taking Quetta as the starting-point on the side of India a line could be laid through Nushki to Nasirabad, and thence across the Lut Desert to Yezd and Kashan, in the neighbourhood of which town it would join the Indo-European line. The distance by this route to Teheran would be actually less than by way of Kandahar, Herat and Mashad, but against this must be set the fact that the wire already links Mashad with Teheran. On the other hand the line would only be liable to such interruptions as occur on the present Indo-European system in Persia. The nomadic tribes are given to committing wilful damage by using the insulators as targets for rifle practice, but every year offences of this kind become fewer and fewer, and the Persian officials are less obstructive than they were when there is a question of securing the punishment of offenders. The Quetta Kashan line would not pass through any portion of Afghanistan. The safety of the wire could be assured through the Nushki district by the Chief Commissioner of Baluchistan, while the Teheran Government would look after it through Eastern and Central Persia. At present the heaviest expenditure on the Indo-European system is in connection with the cables from Karachi to the Persian Gulf. These have to be repaired from time to time, and even now a large sum has been sanctioned to lay a new cable altogether. A land line is of course immensely cheaper both to lay and maintain than a cable, and with this alternative route from Quetta rates to and from Europe would be considerably lowered. Were Teheran connected direct with the Indian telegraph, traffic would at once be attracted to this overland route; and looking still further ahead to the time when Bhamo is linked with the Chinese Telegraph now laid to Momein, 100 miles from the Burman frontier, it may be prophesied that the bulk of the messages to and from the Further East would pass over what might be called the Indo-Persian line. They now find their way along the Madras-Penang cable, one of the most expensive to maintain in the world and one also which is not uncommonly interrupted. This project of a Grand Trunk telegraph line may seem to be a-head of the times, but the maps will show that Quetta lies almost half between Calcutta and Teheran, and the telegraph wire, unlike the railway, seeks the most direct route when there is a question of through communication between adjoining countries. When the Central Asian question has been laid at rest it may become possible to connect Chaman with Mashed and the Russian line east of the Caspian; but so long as Afghanistan retains its independence it will not be feasible to lay the telegraph to Kandahar and Herat.

## PHYSICAL SOCIETY.

At a meeting of this Society on March 20, 1891, Prof. S. U. Pickering, F.R.S., read a Paper on

### "The Theory of Dissociation into Ions and its Consequences."

According to this theory electrolytes are entirely dissociated into their ions in weak solutions. This dissociation was held by Arrhenius to absorb heat, and although heat is evolved by the dissolution of hydrochloric acid, &c., it is not maintained that dissolution evolves heat, but that the heat absorbed by the decomposition of the molecule into its atoms, is more than counter-balanced by the heat supposed to be evolved by the combination of the atoms with their electric charges. These actions the author considered improbable, and thought that, before being accepted, the theory must give satisfactory answers to the following questions:—How can matter combine with an affection of matter to produce heat? Whence do the electric charges originate? Why does not the opposite electrification of the different atoms make them cling more firmly together instead of dissolving the union between them? And why should an atom which possesses a strong attraction for a negative charge (such as chlorine) go to the positive electrode during electrolysis?

When a dilute solution, which is supposed to contain some gaseous molecules, is further diluted, then, according to the theory, some of the molecules are dissociated, and, if heat is absorbed, it follows that the dissociation, and therefore dissolution, of the gas, must absorb heat; yet, he said, it can be shown that in some of these cases the dissolution of a gas evolves a large amount of heat.

The antagonism between the present and the old electro-chemical theory, according to which the atomic charges are identical with the free energy of an atom, and are the cause of combination, not decomposition, was commented on, as well as the disagreement between the present theory and Clausius' view that there are a few ions or atoms present in a liquid owing to accidental superheating of some of the molecules. Reasons, however, were adduced for believing that the presence of even a few atoms in a solution to be improbable.

A communication on

### "Some Points in Electrolysis,"

was made by Mr. J. Swinburne. Considering a reversible single fluid cell, the author, by a process of reasoning, based on Carnot's principle, and the conservation of energy, arrives at Helmholtz's equation, $E = E_c + \theta \frac{dE}{d\theta}$, where E is the electromotive force, $E_c$ the part due to chemical action, and $\theta$ the absolute temperature. Writing the equation in full, using suffixes *n* and *p* to denote the negative and positive plates, it becomes

$$E_n + E = E_{nc} + E_{pc} + \theta \frac{dE_{ny}}{d\theta} + \theta \frac{dE_p}{d\theta}.$$

He then shows that by having the two plates in different vessels and heating them to different temperatures, the Peltier effects represented by $\theta \frac{dE_n}{d\theta}$ and $\theta \frac{dE_p}{d\theta}$, can be determined separately. Similarly those of a two-fluid battery might be found by arranging the junction of the fluids in a third vessel.

After pointing out the desirability that the conditions under which all thermo-chemical data have been obtained should be clearly stated, he proceeded to show that any cell in which secondary actions occur (as, for example, if zinc oxide, primarily formed by electrolysis, were to dissolve in sulphuric acid) must necessarily be non-reversible. He also contended that in a secondary battery the formation of lead sulphate on both plates is the essence of the cell action, and that there is no intermediate formation of PbO.

On the subject of so-called "nascent" hydrogen or oxygen, he said that, reasoning from the conservation of energy, showed that neither could exist. Taking the case of persulphate of iron in dilute sulphuric acid, which is said to be reduced to protosulphate by the "nascent hydrogen," liberated on putting a piece of metal (say magnesium) into the liquid, he said, a better explanation of the phenomena would be that the metal dissolves, if it either reduces the metal or evolves hydrogen; and, as the former requires less energy, the reduction takes place, and when no reducible salt is

Digitized by Google

available, hydrogen is evolved. Evolution of hydrogen and reduction of the per-salt are thus *alternative* and *not consecutive* actions.

Examining Dr. Lodge's views on the contact E.M.F. between metals, he remarked that, if the tendency of a metal (such as zinc) to oxidise can produce an electric stress or difference of potential which prevents further combination, actual combination must charge the metal if it be insulated. A piece of sodium, however, oxidises continuously, and, therefore, should become charged to such an enormous potential that it would emit sparks. As this effect is not known to occur, the author suggested that the volta effect may be due to films of water; and in support of this view, adduced the fact that metals, when perfectly dry, do not combine with chlorine, and that even sodium is not attacked by dry chlorine.

DISCUSSION.

In the discussion on the two Papers, Prof. PICKERING said the idea of nascent elements had, to a large extent, been given up by chemists, and pointed out that the fact of one reaction taking place rather than another was not merely a question of heat energy, but that a kind of chemical selection was involved.

Prof. S. P. THOMPSON recalled attention to the fact that the products of electrolysis depend on the E.M.F. employed in producing it, and thought the E.M.F. required to produce the various products might be taken as a measure of their affinities. He did not agree with Mr. Swinburne's method of finding the E.M.F. of a secondary battery from thermochemical data, for he failed to see how two similar actions going on at the two plates of a cell could add anything whatever to the E.M.F. of the cell.

The PRESIDENT (Prof. Ayrton) said the question whether the potential difference between two dissimilar substances was due to oxidation or to mere contact, could only be decided by direct experiments made in a vacuum from which all traces of moisture and oxygen had been removed. Without agreeing with Dr. Lodge's view on the subject, he pointed out that the continuous oxidation of a piece of insulated sodium need not necessarily produce a great potential difference, for the combination might produce heat.

After Prof. PICKERING and Mr. SWINBURNE had replied to the points raised, Mr. Walter Bailey took the chair, and Prof. PERRY read a note "On the Variation of Surface-Tension with Temperature," by Prof. A. T. Selby, M.A. Considering unit mass of liquid at constant volume, but variable surface (S), and temperature ($t$), the author expresses the gain of intrinsic energy due to changes of the variables by $dH + dW = k\,dt + (l + T)\,dS$ where $dH$ is the heat absorbed, $dW$ the work done on the film, $k$ the specific heat at constant volume, $l$ the latent heat of extension, and T the surface-tension. This being a perfect differential, it is shown that $T = c - bt$, and $l = bt$, $c$ and $b$ being constants. Supposing $c$ and $b$ to be independent of the specific volume of the liquid, it is shown that at the critical temperature $t = \frac{c}{b}$. Hence this temperature may be determined by finding the surface-tension at two very different temperatures. Since, also, $l = bt$, the latent heat of extension is proportional to the absolute temperature. Reasons for supposing $b$ to be independent of the specific volume are given in the Paper.

Mr. BLAKESLEY described an effect of temperature on surface-tension, which he had observed in sensitive spirit levels. By warming one end of the tube, even by the hand, the bubble immediately moves towards that end. This effect, which might produce considerable error in engineering operations, was, so far as he was aware, not mentioned in the text-books.

Prof. PERRY remarked that, although the volume, temperature, and surface of the liquid had been referred to in the Paper, pressure was not mentioned, and on this point he inquired whether the results arrived at were true, quite independent of the pressure.

Prof. S. P. THOMPSON, D.Sc., then read a Paper on

**"Magnetic Proof Pieces and Proof Planes."**

The distribution of magnetism over magnets has been examined in various ways by different observers, but mostly by observing the force of detachment of either rods, ellipsoids, or spheres used as proof pieces. In all these cases, it was, the author said, difficult to see exactly what was measured, for the presence of proof pieces altered the thing to be tested. The pull exerted must also depend on the permeability of the piece used as well as on its shape and disposition with respect to the magnetic circuit; he had, therefore, investigated the subject by finding the actual distributions by means of a flat exploring coil and ballistic galvanometer, both with and without the presence of proof pieces of various shapes and sizes. The results show that the perturbations produced by the proof pieces are always large, in some cases the perturbed field about a point being four to six times the unperturbed field. In most cases, however, the ratio of the perturbed to the unperturbed field was constant, so long as the former did not exceed 6,000 C.G.S. units. The amount of perturbation was also found to depend on the saturation of the magnet, and on whether it was a permanent or an electromagnet. The numbers obtained in various experiments, and curves plotted from such results, were shown. In conclusion, the author said, that in using proof pieces, much depended on the accuracy of the contact, but in any case, the results obtained were not very reliable. The flat exploring coil, or magnetic proof plane, however, furnished a satisfactory method of examining magnetic distributions.

## THE LONDON-PARIS TELEPHONE LINE.

The London-Paris telephone line, after having been placed for one day gratuitously at the service of the public, came into regular operation on Wednesday, April 1st. The following notice has been issued by the Post Office:—

*Telephonic Communication between London and Paris.*

On and after Wednesday, April 1st, telephonic communication between London and Paris will be open to the public.

Call offices have been established at the General Post Office, West (Bath-street), open always, and the Threadneedle-street branch Post Office (Stock Exchange), open on week days from 8 a.m. to 8 p.m. As soon as possible a call office will be established at the West Strand telegraph office (Charing-cross), open always.

The charge will be 8s. for a conversation of three minutes. Not more than two consecutive conversations can be allowed, except when no other applicant is waiting at any of the offices to use the telephone.

In making appointments for conversations correspondents should bear in mind that Paris time is about ten minutes in advance of London time.

Persons desirous of speaking to Paris direct from their own houses or offices in London can be provided with the necessary wires and apparatus, on terms to be ascertained on application to the Secretary, General Post Office, E.C.

These wires can be used not merely for the purpose of communicating by telephone with Paris, but also for the purpose of sending telegrams for transmission within the United Kingdom or abroad. They can also be used to call a messenger for the express delivery of a letter or parcel.

The speaking cabinet at the General Post Office is situated on the ground floor, near the main entrance, turning out of Newgate-street. It is large enough to contain the speaker, and the walls are padded so as to be sound proof. Numbers of applications for private lines from large firms have been received, and the commercial success of the enterprise is said to be already assured. We may mention that the Roulez transmitter, which is favoured by M. Amiot and the French electricians, is formed by little holes in a carbon block, which are filled with small pieces of carbon filament. The mouths of these holes are covered by the diaphragm, which is a thin disc of charred wood.

## ON THE VARIATION OF VOLUME IN LIQUID DIELECTRICS UNDER THE ACTION OF THE ELECTRIC FORCES ACTING BETWEEN THE PLATES OF A CONDENSER.*

BY EMILIO ODDONE.

Kerr, as we know, has shown that a liquid dielectric submitted to the electric forces acting between the two plates of a condenser has a bi-refractory action on light, and may be compared to a uniaxial crystal, the axis of which is parallel to the lines of electric force. The liquids investigated were ranged under two headings. The *positive* liquids, such as bi-sulphide of carbon, glycerine, &c., behaved like glass stretched in the direction of the lines of force. The *negative* liquids, such as ether, the oils, &c., behaved like glass compressed in the same direction. Quincke endeavoured to show that the action on light arose from a change of volume due to the influence of the electric forces; the positive liquids undergoing an increase, and the negative liquids a diminution, both changes being proportional to the square of the charge of the condenser and inversely as its surface. Others, and even Quincke himself, subsequently recognised that certain experiments were in complete disagreement with this hypothesis, and to settle all doubts the author reinvestigated the whole question of change of volume, employing minute precautions for the elimination of causes of error.

The apparatus used was a kind of glass thermometer with large bulb. In the bulb were two platinum laminae placed face to face and forming the plates of the condenser. The bulb and a portion of the tube was filled with the liquid to be tested.

When the liquid had not been very carefully purified it was a very obvious conductor of electricity. Owing to its conductivity, a current of electricity passed between the two plates of the charged condenser. This resulted in a very sensible heating. The question therefore arises, were not the dilatations observed by Quincke simply due to this heating? If care be taken to keep the whole apparatus at a constant temperature, if the liquids under examination are thoroughly purified, these dilatations always diminish, and become at times almost imperceptible. The author was only able to discover contractions in a few particular cases, with sweet almond oil for instance, and these contractions were accompanied by strong vortical movements, which seemed to point to a mechanical action, completely masking the supposed electrical action.

The author concludes that within the limits of his experiments there is no change of volume of liquid dielectrics under the action of electric forces; the expansion observed being due to heating caused either by the polarisation of the dielectric, or by the passage of a current through the imperfectly insulating liquid.

* The *Rendiconti della R. Accademia dei Lincei*, May, 1890. From an abstract by M. Lucien Poincarré, in the *Journal de Physique*, March, 1891

Digitized by Google

## AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *March* 20, 1891.

**Gas and Electric Light Statistics.**—As a rule American public documents are anything except interesting, but a striking exception is to be found in the report of the Board of Gas and Electric Light Commissioners of the Commonwealth of Massachusetts for 1890. It contains a very large amount of important and instructive information, and a very full statistical account of the operation of the gas and electrical companies within that State. During that year there were in that State three fatal accidents from the electric current. All three men met their death from thousand-volt alternating currents; two of them by a leak from line along the guy wire, the other in attempting to take a joint. Gas was responsible for eight fatal casualties in the State of Massachusetts, and nearly 200 in the United States. Eleven electric light companies were incorporated during the past year, operating about 150,000 incandescent lamps and 15,000 arc lamps. In addition there is a motor service of both arc and incandescent circuits aggregating a little over 2,600 H.P., most of it in small machines. As might be expected the prices charged for electric light vary very widely from place to place, the arc lamps furnished for public lighting ranging in price from $60 to $180 per year. Commercial lights are furnished at about the same price. Incandescent lighting ranges from 1 cent. per ampere hour by meter, upward, a common contract price for 16-c.p. lights in commercial service being $10 per year. The dividends reported by 22 companies show that the business pays fairly well, the amounts ranging from 1½ to 10 per cent., and averaging nearly five per cent. The aggregate receipts for electric lighting and power during the year were very nearly $2,000,000.

**Primary Batteries.**—Perhaps the most obnoxiously active of all so-called electrical enterprises are the primary battery companies. There is a large and flourishing crop of them just at the present time, a few engaged in legitimate business, more in promiscuous swindling. One delightful example of the latter class was recently unearthed where the alleged batteries simply acted as a high-resistance shunt across the incandescent lighting mains used to supply the lamps for the edification of prospective investors. This game has been worked more than once, and will probably serve many a time again to extract the hard-earned dollars from the pockets of those who are more greedy than wise. No amount of exposure and abuse seems to have the slightest effect on the vitality of the thorough-going primary battery fraud. I do not know whether they are active with you in England, but here, at times, the number of primary battery swindlers engaged in vigorous work is something almost beyond belief. This state of things makes it very difficult for an honest battery for ordinary purposes to make any headway.

**Lighting of Railway Tunnels.**—The recent disastrous collision in the tunnel that affords entrance for the railroads into New York City has stirred up public opinion to the point of demanding that tunnels shall be properly lighted, especially the tunnel in question. In spite of the fact that for several years the great Hoosac tunnel had been brilliantly illuminated, the railway officials here in New York solemnly aver that it is impossible to light a tunnel so as to be of the least service. This allegation is made for two reasons: In the first place, they seriously object to any expenses that are not forced upon them; and, second, they hope, by frightening the public by keeping constantly before it both the danger of collision and the impossibility of averting it in the present tunnel, to obtain permission to seize bodily upon Fourth-avenue and make an open cutting clear down to the Grand Central Station in 42nd-street. Fortunately their game is a little too obvious, and it will probably lead to no resutls; but meanwhile several railway companies near the city, especially those doing suburban service, are seriously looking into the question of the electric lighting of their tunnels, and it is most likely that the present season will see one or more plants installed for that purpose.

## CORRESPONDENCE.

### VOLTAGE AND ELECTROMOTIVE FORCE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The article on Electromotive Force, published in your last issue, raises a question of some interest. The words "voltage" and "electromotive force" are, unfortunately, often used indiscriminately, one for another, as if their meanings were precisely the same, and it thus seems at first sight that the former word, which is shorter and more expressive, could always with advantage displace the latter. It is, moreover, often asserted that the word "electromotive force," besides being a lengthy and round-about term, implies a false idea by leading one to imagine that it is of the nature of a mechanical force. But however this may be, there is still an advantage in having a separate word, like electromotive force, to use exclusively in connection with the electric power *generated* in a circuit, while reserving the word "voltage" to refer to the power used up or *spent* in various ways in the circuit. Both electromotive force and voltage, when multiplied by the current, represent power, but, whereas the former denotes the total power of the current, the latter only refers to a part of it. Thus, a dynamo whose electromotive force is 100 volts, driving a motor which absorbs a voltage of 80, by means of a conductor, whose resistance absorbs 20 volts, gives out power, represented by the number 100, which is divided into two parts—80 and 20—according to the voltages. The E.M.F. of a dynamo, or battery, corresponds with its total electrical output, whereas the terminal voltage corresponds with its useful output. The E.M.F. should be reserved for the energy supplied, while the distribution of energy can be denoted by the voltages. The ideas represented are those of income and expenditure, and though both are measured in the same units, it is desirable to keep the two sides of the balance-sheet as distinct as possible. This can best be accomplished by using different words to describe the items on the two sides. The words "debtor" and "creditor" have been adopted in one case, and the words "electromotive force" and "voltage" should be used in the other.

Voltage can always be measured by a voltmeter, but E.M.F. cannot always be so determined. Voltage must be caused by E.M.F., but E.M.F. may exist without voltage, as when a magnet is pushed symmetrically through a circular ring. E.M.F. is generally local, while voltage is necessarily distributed. One is generally referred to a particular portion of the circuit where the energy is being supplied, while the other is always described with reference to two points. E.M.F. represents a condition of supply which is generally fairly constant, however much power is supplied. Thus, the E.M.F. of a dynamo or battery does not as a rule vary very much as the current is altered. This, however, is not true of voltages, as, for instance, the voltage at the terminals of a battery.

The other question raised in your article about the seat of electromotive force in a battery, rests on an entirely different basis. All that is clear about this matter is, that the energy is obtained from the chemical actions going on within the cell, just as the source of energy in a steam boiler is the heat of combustion of the coal. The "seat" of electromotive force in a cell, or of motive force in a boiler, may, like the source of a man's income, be a very questionable thing, but as long as the condition of supply is fixed and regular, the power of expenditure is perfectly definite.—Yours, &c.,

W. E. SUMPNER.

### CONTROL MAGNETS FOR GALVANOMETERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR,—In your issue of March 20th, on page 610, a description of Messrs. Nalder Brothers' ballistic galvanometer is given, in which you credit Dr. Mullineux Walmsley, of Edinburgh, with the special form of control magnet applied thereto, and which allows the intensity of the magnetic field, in which the needle moves, to be altered without interfering with its direction.

On July 9, 1883, I read a Paper before the Physical Society, in which I described various improvements applied to my tangent

Digitized by Google

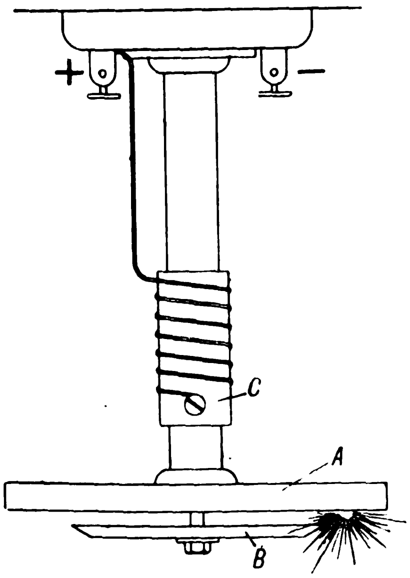
galvanometer with movable coil, and amongst these, the special kind of control magnet you now attribute to Dr. Walmsley. This Paper was afterwards published in the *Philosophical Magazine* for August, and also in the *Proceedings* of the Physical Society, and, with your permission, I will quote the following passages therefrom:—" For that purpose (*i.e.*, to adjust the constant of the galvanometer to a certain value), an auxiliary magnet is placed east or west of the needle in a plane, parallel to the meridian, which can turn round a horizontal axis passing through its neutral point and the centre of the needle, and being at right angles to the diameter on which the coil (of the tangent galvanometer) is turned. This magnet *does not affect the zero position*, and, moreover, if placed exactly vertical with its magnetic axis, it does not alter the original constant, which then only depends upon the horizontal terrestrial component, more or less modified by the surroundings, but if it is dipped, *the horizontal force acting on the needle is either augmented or diminished*, according to the direction in which the magnet is turned, and to the amount of dip given." All the tangent galvanometers with movable coils manufactured by Messrs. Siemens Brothers, since 1883, are provided with these control magnets, which you term "tail magnets," as may be seen from the illustrations of the instruments in various publications, of which I will mention only the following, viz., *Engineering*, August 3, 1883, p. 104; Kemp's "Handbook of Electrical Testing," 4th edition, p. 37; "Kittler's Handbuch der Elektrotechnik," Vol. I., p. 242. Some five or six years ago I made numerous experiments with the new kind of controlling magnet, and completely worked out its theory, but I have hitherto refrained from publishing the results; however, I hope soon to be able to do so.—Yours, &c.,

Woolwich, March 28, 1891. EUG. OBACH.

## AN EXPERIMENT WITH THE ELECTRIC ARC.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: The interesting article which you reproduced in your issue of 27th inst. headed "An Experiment with the Electric Arc," recalls to my mind a practical application of the phenomena described which I made in 1879, and patented 11th June, of that year. One form of the lamp and the one which best illustrates the design is as follows:




A, Carbon disc for positive pole. B, Carbon disc for negative pole. C, Iron tube, carrying a coil of wire through which the current to the lamp passes and induces the arc to travel round the periphery of the negative disc.

This lamp and several modifiations of it are described in three patents taken out in 1879 and 1881.—Yours, &c.

J. D. F. ANDREWS.

41 and 42, Parliament-street, London, S.W.
March 28th, 1890.

## TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

TENDERS WANTED.—Our advertisement columns contain particulars of plant and machinery for sale by private treaty, including a vertical boiler 6ft. by 3ft. 6in. disc, three Rigg's patent 3-cylinder engines, a new horizontal steam engine, sliding and screw cutting lathes, slotting, milling, radial and hand drilling machines, shafting, pulleys, &c. Orders to view at 4, Station-buildings, Acton-street, Haggerston, London, N.E., may be obtained on application to Messrs. Wheatley Kirk, Price and Goulty, 52, Queen Victoria-street, E.C., to whom tenders are to be sent.

RESULT OF TENDER.—The following tenders were received for lighting Ballymena with gas or electricity from August 16, 1891, to May 16, 1892:—Ballymena and Harryville Gas Light Company, Limited (gas), £336. 3s.; Messrs. J. E. H. Gordon and Co., Limited, 11, Pall Mall, London, S.W. (electricity), £365. The former tender was accepted.

THE ELECTRICAL ACCESSORIES COMPANY (LIMITED).—Owing to increase in business, it has become necessary to modify the arrangement of the staff, and Mr. C. L. Schwind, son of Mr. Charles Schwind, chairman of Messrs. Handysides, of Derby, has been appointed manager.

THE ELECTRICAL ENGINEERING CORPORATION.—We are informed that Mr. W. Pixley has been appointed by the Court of Chancery receiver and manager of this Corporation, on behalf of the debenture holders.

"THE IRONMONGER."—We have received the Spring issue of *The Ironmonger*, consisting of not less than 500 pages of matter, much of which is of interest to many of our readers.

UNITED ASBESTOS COMPANY (LIMITED).—We are in receipt of a new catalogue issued by this Company, giving full particulars of their various well-known manufactures. The catalogue is neatly printed and fully illustrated, and the particulars given will interest many of our readers A list of the goods manufactured by the Company specially adapted for electrical purposes, are described in page 28. Among the illustrations will be found two excellent photographs of the destruction of the Queen's Theatre, Manchester, by fire in August of last year, on which occasion the drop curtain made of the United Asbestos Company's patent Victor metallic cloth, was the means of saving the whole of the stage scenery and effects. There is also a view of Messrs. Davey, Paxman and Co.'s installation of boilers at the Paris Exhibition, covered with the Company's boiler composition. The Company notify that they have recently opened two additional branches—at 135, Bute-street, Cardiff, and at Provident-buildings, Bristol.

GANDY BELT MANUFACTURING COMPANY (LIMITED).—We have received a copy of the new price list and particulars of the various manufactures of cotton and camel hair belting of this Company.

## PATENT RECORD.

### APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

March 2, 1891.

3,694. F. W. WEBB and A. M. THOMPSON. Crewe. Improvements in electrical switches.

3,738. J. MARX. London. Improvements in and apparatus for electrolysing and bleaching.

3,740. M. KOECHLIN. London. Improvements in electric meters.

3,748. A. MCLEAN. London. Improvements in the production of slabs and blocks for electrical insulators and other purposes, and apparatus to be used in the manufacture thereof.

3,755. B. DUKES. London. Improvements in automatic switches for electric currents (A. Heil, Germany).

March 3, 1891.

3,765. L. H. BUCHANAN. Manchester. Improvements in and connected with electric arc lamps.

3,789. B. J. B. MILLS. London. Improvements in the depolarisation of electric batteries (A. Bellemain, France).

3,799. A. CLARK. A new or improved solution or composition for charging electric batteries.

3,823. S. LEVY. London. Improvements in electric signalling and lighting for the prevention of railway accidents, and for lighting railway and other carriages.

March 4, 1891.

3,867. R. KENNEDY. Glasgow. Improvements in electricity meters.

3,868. F. T. HOLLINS. Leytonstone. Improvements in arrangements and apparatus electrically communicating with engine-drivers of railway trains and others, for signalling purposes and otherwise.

3,893. W. J. GLOVER and G. E. PREECE. Salford. Improvements in electrical cables.

3,895. F. G. CORNING. London. Improvements in apparatus for transferring electric car batteries. [Date applied for, under Patents Act, 1883, Section 103, August 5, 1890, being date of application in United States.]

3,904. J. P. RICHARDS. Penge. Electrical switches.

March 5, 1891.

3,939. W. H. ELLIOTT. Tipperary. Improvements in interlocking of points, signals and electric signals.

3,957. L. B. MILLER and M. W. WOODS. London. Improvements in instruments for measuring electricity.

3,967. J. COAD. London. Improvements in portable electric safety lamps.

3,984. O. PATIN. London. Improvements in and relating to electric arc lamps.

March 6, 1891.

4,005. F. BRYAN. London. Improvements in dynamo electric machines.

4,044. R. H. SIMPSON. London. Improvements in electrical storage batteries or accumulators.

4,064. G. HOOKHAM. London. Improvements in electricity meters.

March 7, 1891.

4,099. W. P. AKESTER. London. Improvements in electric arc lamps.

4,120. W. J. FRYER. London. An improved imitation candle for use with electric incandescent lamps.

March 1891.

4,170. W. H. WILLATT. Hull. An improved method for the distribution of electricity.

4,188. J. A. MAYS. London. Improvements in electrolysis.

## SPECIFICATIONS PUBLISHED.

1890.

3,096. DE FERRANTI. Electric meters. (Price 11d.)
3,193. SWINBURNE. Electric transformers. (Price 8d.)
3,272. FLETCHER. Electric switches. (Price 6d.)
3,937. RAWSON and SNELL. Electric flash signalling lanterns. (Price 8d.)
4,086. BARLEY and STEVENSON. Dynamo machines. (Price 6d.)
4,235. REES. Filaments for electric lamps. (Price 6d.)
4,260. THOMPSON (Young). Electric distribution. (Price 8d.)
4,984. ROBINSON. Electric telegraph apparatus. (Price 8d.)
5,008. FURTADO. Electro telephonic apparatus. (Price 6d.)
5,016. BARY. Electric reversible machines. (Price 8d.)
5,678. KALB. Electric tension regulators. (Price 8d.)
5,750. CROMPTON (Fritsche). Dynamo electric machines, &c. (Price 8d.)
5,938. BOETTCHER. Secondary element. (Price 8d.)
6,005. SAYER. Electric lamp adjuster. (Price 6d.)
6,267. MARX. Electrical conductors. (Price 8d.)
6,392. BLÁTHY. Safety fuses for electric currents. (Price 6d.)
6,475. LOWRIE and HALL. Electric safety device. (Price 8d.)
6,495. CLARK (Schuckert and Co.). Electric telegraphs. (Price 8d.)
7,335. MACAULAY-CRUIKSHANK (Ressig and others). Incandescent lighting. (Price 8d.)
13,799. LAKE (Electric Secret Service Co.). Electric signalling. (Price 8d.)
18,266. DAVIES and DUTSON. Conduits for electric tramways. (Price 6d.)
19,496. MUNSIE. Insulators. (Price 8d.)
20,126. DUTTON. Galvanic batteries. (Price 8d.)
20,510. LAKE (Wood). Electrically welding metal articles. (Price 8d.)
20,540. THOMPSON (Coffin). Welding metals electrically. (Price 6d.)
21,143. RHODES. Electric batteries. (Price 6d.)
21,183. MILLS (Ongley). Electric protective and signal systems. (Price £2 2s.)

1891.

536. ATKINSON, C. W. and L. B. Dynamo-electric generators, &c. (Price 6d.)
667. THOMPSON THOMPSON (The Hess Electric Storage Battery Co.). Voltaic accumulators. (Price 8d.)
669. PULUJ. Electric cut-outs. (Price 8d.)
659. LEIGH (Gardiner). Therapeutic magneto-electric machines. (Price 8d.)
1,114. CHURCHWARD (Robertson). Electric railways, &c. (Price 8d.)

## COMPANIES' MEETINGS.

### Elmore's Foreign and Colonial Patent Copper Depositing Company (Limited).

Notice is given that a general meeting of the holders of Priority Shares in this Company will be held at the registered office of the Company, 64, Cannon-street, E.C., on the 6th inst., at two o'clock, for the purpose of sanctioning by extraordinary resolution the alteration or modification of their rights and privileges involved in the proposed alterations in the Articles of the Company set out below. Resolved :—

*"That this meeting of holders of Priority Shares in Elmore's Foreign and Colonial Patent Copper Depositing Company (Limited), hereby sanctions and approves of the following proposed alterations in the Articles of Association of the Company, namely—"*

(a) *That Article 109 shall be cancelled.*

(b) *In place thereof the following Article shall be substituted, namely—"(109).—All dividends shall be payable out of profits only ; but such dividends may be declared and paid either in cash or by the distribution of specific assets taken at their par value, and in particular of shares, debentures, or other securities of any other company, or partly in one way and partly in the other."*

(c) *Article 110 shall be altered by inserting after the words "until they have received a return" the words following, namely, "(either in cash or in shares, debentures, or other securities taken at their par value.)"*

Notice is also given that a general meeting of the holders of Founders' Shares in the Company will be held at the office as above on the same date, at half-past two o'clock, for the purpose of sanctioning by extraordinary resolution an alteration in the Articles of the Company, similar to that set out above.

Notice is further given that an extraordinary general meeting of the Company will be held at the office as above, on the 6th inst., at three o'clock in the afternoon, when a similar resolution to that set out above

PATENT
SILICIUM BRONZE AND SILICIUM COPPER WIRE.
The best for overhead Telephone and Telegraph Lines,
AND ALL ELECTRICAL PURPOSES.
Hard Drawn High Conductivity Copper Wire.
ROLLED AND DRAWN
PHOSPHOR BRONZE.
PHOSPHOR BRONZE
BEARINGS, BUSHES,
AND OTHER PARTS OF
ELECTRICAL MACHINERY
SOLE PROPRIETORS of the British, Indian and Colonial Patents,
THE PHOSPHOR BRONZE COMPANY (Limited),
87, Sumner Street, Southwark, London, S.E.
WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

Digitized by Google

will be proposed. Should the resolution be passed by the requisite majority, it will be submitted for confirmation as a special resolution to a second extraordinary meeting, which will be subsequently held.

---

In reference to the matters referred to in the above notices, the Directors of the Company have issued the following circulars —

"March 19, 1891.

"Sir,—In enclosing you formal notices for extraordinary general meetings of the separate classes and the whole body of shareholders, I beg to inform you that the Directors, in compliance with the wish unanimously expressed at the annual general meeting held on January 29th last, have taken Counsel's opinion as to the measures to be adopted in order to enable them to distribute amongst the shareholders the large amount of assets held by the Company, and represented by shares and debentures of the French and Austrian Companies.

"Counsel has at length advised that it will be necessary to modify Clause 109 of the Articles of Association, which in its present shape precludes the payment of dividends except out of profits actually realised and converted into cash.

"It will also be necessary to modify Clause 110, which, as it at present stands, taken in conjunction with Clause 109, would render the proposed distribution of assets impossible until the Priority shareholders should have received a premium of £10 per share in cash.

"If these clauses are altered so as to enable the Directors to distribute the above securities, as though they were dividend in specie, they will immediately propose a distribution equivalent to £6 per Priority Share and £5 per Founders' Share, reckoning the securities to be divided at their par value. The effect of this and of the previous distributions will be that the Priority shareholders will have received back in cash the whole of the original capital invested, and, in addition, in securities a premium of 120 per cent., while the founders will receive securities equivalent at their par value to the original value of their shares. All the remaining foreign patents owned by the Company remain intact, and should prove a source of considerable value to both classes of shareholders, one-fourth going to the Priority Shares and three-fourths to the Founders' Shares.

"The Directors take this opportunity of informing you that satisfactory reports have been received of the progress of the French and Austro-Hungarian Companies. The French Company is progressing rapidly with the erection of its large works at Dives, near Havre, and M. Secretan, the General Manger, confirms his previous statement that he will commence working on a large scale in July next. As to the Austro-Hungarian Company, a factory with suitable buildings and spare land, together with turbines and free water power to the extent of 540 horse power, has been selected, thus avoiding the delay attendant upon the erection of special buildings. The preliminary agreement has been signed, and the property, which is in the neighbourhood of Cologne, will be conveyed to the Company as soon as the consent of the Prussian Government has been received.

"By order of the Board,

"J. SHURMER, Secretary."

---

"Referring to the circular issued on the 19th inst., relative to the proposed distribution of the Company's securities, as dividend in specie, to the holders of the Priority and Founders' Shares, I am directed to state that in consequence of the large number of shareholders who are expected to attend, the meetings will be held at the same hour, at the Cannon-street Hotel, in the City of London (Pillar Hall, on the second floor), instead of at the offices of the Company.

"Some alternative proposals have been brought before the Board, and the Directors deem it well to point out that they do not by any means pledge themselves to carry out the distribution as proposed in the circular, but are anxious in this respect to act only in accordance with the expressed wishes of the shareholders, who, at the general meeting, held on the 29th of January last, unanimously called upon the Board to take steps to effect a distribution of the Company's securities. The Directors confine their recommendation to the Company taking the power to make a distribution of shares or other securities; and they strongly urge upon the respective shareholders to attend the meetings called for April 6th next.

"By order of the Board,

"J. SHURMER, Secretary."

## The British Tanning Company.

An extraordinary general meeting of the British Tanning Company (Limited) was held at Winchester House, Old Broad-street, E.C., on Wednesday, March 25th, when the subjoined resolution, which was passed at the extraordinary general meeting of the Company, held on March 10, 1891, was submitted for confirmation as a special resolution, viz.:—

"*That the Bill now read, entitled 'An Act for rendering valid certain letters patent to Eugene Worms, of Paris, in the Republic of France, and Jean Balé, of the same place, for improved process and apparatus for tanning by aid of electricity,' be, and the same is hereby approved subject to such additions and variations as Parliament may think fit to make therein.*"

Mr. H. MOXON, who presided, explained that the resolution was necessary, inasmuch as a patent for electrical tanning in a similar way had been used by other people, and it was, therefore, needful to get the validity of this Company's process settled by the somewhat unusual course of application to Parliament.

The resolution was confirmed.

## NEW COMPANIES REGISTERED.

**DERMATINE COMPANY (LIMITED).**—Registered by Crosley and Burn, 2, Moorgate-street, E.C., with a capital of 55,000 in £5 shares. Object: To carry on in the United Kingdom, or elsewhere, the business of the manufacture of dermatine, in accordance with an agreement made between the Dermatine Company (Limited) (thereinafter called the Old Company) of the first part, John Cooper, liquidator of the Old Company, of the second part, and Edward Green, as trustee for this Company, of third part.

**EDINBURGH AND LEITH SAFE DEPOSIT COMPANY (LIMITED).**—Registered in Scotland, with a capital of £20,000 in £5 shares. In addition to the usual safe deposit business, the Company propose to carry on the business of gas, electrical and mechanical engineers, and all other businesses relating to lighting and heating.

**LANGNESS COPPER COMPANY (LIMITED).**—Registered with a capital of £35,000 in £1 shares, to acquire certain mining rights in the Isle of Man, and to carry on generally the business of miners.

**LONDON RUBBER AND PACKING COMPANY (LIMITED).**—Capital, £3,000 in £5 shares. Object: To acquire the business carried on by the London Rubber and Packing Company, dealing in india-rubber, gutta percha, leather, and electrical goods, &c., at 47, High Bridge, Newcastle-upon-Tyne; and to manufacture, construct and deal in all kinds of electrical articles, appliances and fittings, and leather, india-rubber and gutta percha goods of every description.

## CITY NOTES, &c.

**BRAZILIAN SUBMARINE TELEGRAPH COMPANY.**—The receipts of this Company for the week ended March 27th amounted to £5,427.

**CITY AND SOUTH LONDON RAILWAY COMPANY.**—The receipts of this Company for the week ended March 28th amounted to £702.

**CUBA SUBMARINE TELEGRAPH COMPANY.**—The estimated traffic receipts of this Company for the month of February were £4,000, as compared with £4,018 in the corresponding month of last year.

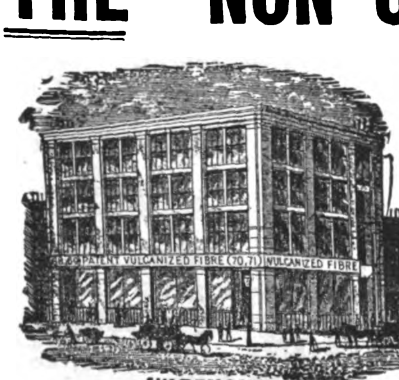
**WESTERN AND BRAZILIAN TELEGRAPH COMPANY.**—The traffic receipts of this Company for the week ended March 27, 1891, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £4,431.

**SUBMARINE CABLES TRUST.**—It is notified that on and after the 15th inst. the coupon due in October last will be paid in full by Messrs. Glyn, Mills and Co., of Lombard-street, between the hours of 10 a.m. and 2 p.m. Certificate-holders are requested to present the coupons for October, 1890, only, and not those payable on April 15, 1891.


# THE NON-CONDUCTOR OF ELECTRICITY.

**VULCANISED FIBRE,**

PATENTED.




WAREHOUSE.

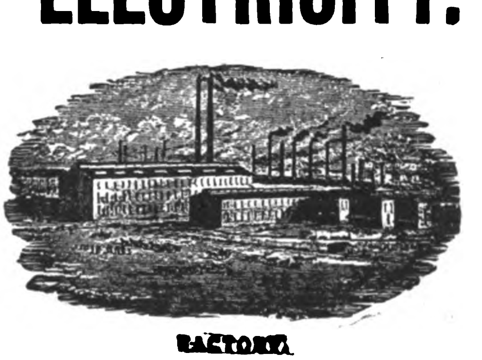
This new material is supplied in two qualities, Flexible and Hard.

The FLEXIBLE is a substitute for Leather, Rubber, Gutta Percha, &c., and is extensively used by Brass Founders, Axle Makers, Hydraulic, Sanitary, and other Engineers, Pump Makers, Carriage Builders, &c.

It makes the best Hot and Cold Water Packings, and for Axle Washers of all kinds it is unequalled.

The HARD is a substitute for Metals, Hard Wood, Ivory, Vulcanite, Ebonite, &c., and is a good Insulator.

Sold in sheets, 5ft. 6in. by 3ft. 6in., varying in thickness from 1-50in. to 1in.



FACTORY.

FLEXIBLE, 2/- per lb.; HARD, 2/8 per lb.

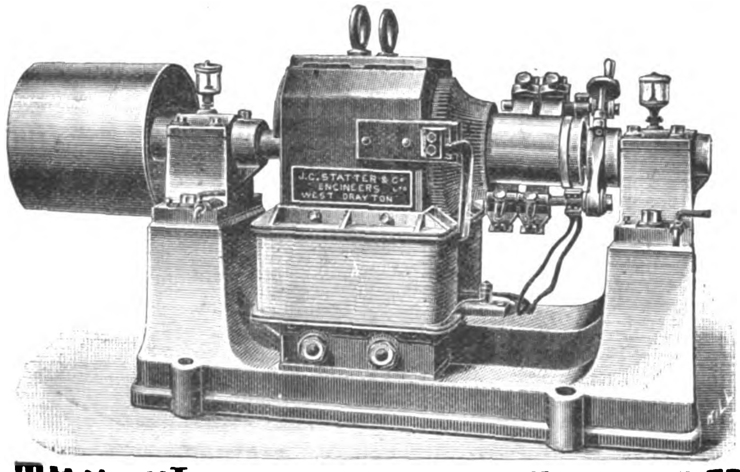
**MOSSES & MITCHELL, 70, Chiswell-st., London, E.C.**


Digitized by Google

# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name. | Previous Week's Price, March 25. | | Price Wednesday, April 1. | | Rate per Cent. Yielded. | Dividend Due. | Business Done During Week Ending April 1. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **TELEGRAPHS.** | | | | | £ s. d. | | | |
| £1,381,380 | Stock | 15/0 | Anglo-American | 47 | 48 | 47 | 48 | 6 0 0 | Jan., Apr., July, Oct. | .. | .. |
| £2,809,310 | Stock | 30/0 | Do. Preferred | 84 | 85 | 84½ | 85½ | 6 14 6 | " " | 85½ | 84¾ |
| £2,809,310 | Stock | .. | Do. Deferred | 11 | 11½ | 11 | 11½ | .. | .. .. | 11⅝ | — |
| £250,000 | 100 | 4% | African Direct, Telegraph 4% Debentures | 99 | 102 | 99 | 102 | 3 18 5 | January and July .. | .. | .. |
| 130,000 | £10 | 3/0 | Brazilian Submarine xd | 11¾ | 12¼ | 11¾ | 12 | 6 5 0 | Mar., June, Oct., Dec. | 12 | 11¾ |
| £84,000 | £100 | 5% | Do. 5 per Cent. Bonds | 100 | 103 | 100 | 103 | 4 17 1 | January and July .. | .. | .. |
| £75,000 | £100 | 5% | Do. 5 per Cent. Bonds (2nd Series, 1906) | 103 | 107 | 103 | 107 | 4 13 6 | June and December | .. | .. |
| $7,216,000 | $100 | 7% | Commercial Cable Capital Stock xd | 108 | 110 | 107 | 109 | 6 2 4 | April and October .. | .. | .. |
| 10,000 | 10 | 8/0 | Cuba Submarine | 10½ | 11½ | 10½ | 11½ | 6 19 2 | February and August | .. | .. |
| 6,000 | 10 | 10% | Do. Preference 10% | 16½ | 17½ | 16½ | 17½ | 5 14 3 | " " | .. | .. |
| 12,931 | 5 | 2/4½ | Direct Spanish (£4 paid) xd | 3¾ | 4¼ | 3¾ | 4¼ | 6 11 9 | April and October .. | .. | .. |
| 6,000 | 5 | 10% | Do. Preference 10% xd | 9½ | 10½ | 9 | 10 | 5 0 0 | " " | .. | .. |
| 60,710 | 20 | 3/6 | Direct United States | 10½ | 10⅞ | 10½ | 10⅞ | 6 15 0 | Jan., Apr., July, Oct | 10⅝ | .. |
| 400,000 | 10 | 2/6 | Eastern | 14½ | 14⅞ | 14½ | 14⅞ | 4 10 5 | " " | 14⅝ | 14½ |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference | 15¼ | 15¾ | 15¼ | 15¾ | 3 16 2 | " " | 15½ | 15 9/16 |
| £1,200,000 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock | 107 | 110 | 107 | 110 | 3 12 9 | May and November | .. | .. |
| £200,000 | 100 | 5% | Do. 5 per Cent. Debentures, 1899 | 107 | 110 | 107 | 110 | 4 10 11 | February & August | 107¾ | .. |
| 250,000 | 10 | 2/6 | Eastern Extension | 14¾ | 15¼ | 14¾ | 15¼ | 4 13 4 | Jan., Apr., July, Oct. | 15⅛ | 15 |
| £320,000 | £100 | 4% | Do. 4 per Cent. Debenture Stock | 104 | 107 | 105 | 108 | 3 14 1 | .. | 106½ | .. |
| £91,800 | 100 | 5% | Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900 | 103 | 106 | 103 | 106 | 4 14 4 | January and July .. | .. | .. |
| £145,300 | 100 | 5% | Eastern & S. African 5 per Cent. Mor. Deb., 1900 | 103 | 106 | 103 | 106 | 4 14 4 | " " | .. | .. |
| 180,227 | 10 | 1/9 | Globe Telegraph and Trust | 9⅜ | 9⅝ | 9⅜ | 9⅝ | 5 4 0 | Jan., Apr., July, Oct. | 9 5/16 | 9½ |
| 180,042 | 10 | 6% | Do. 6 per Cent. Preference | 15 | 15½ | 15 | 15½ | 3 18 8 | " " | 15 1/16 | — |
| 150,000 | 10 | 5/0 | Great Northern | 17 | 17½ | 17¼ | 17¾ | 4 5 9 | Jan., April, and July | 17¼ | .. |
| £15,000 | 100 | 5% | Do. 5 per Cent. Debentures, 1881 | .. | | .. | | .. | January and July .. | .. | .. |
| £230,000 | 100 | 5% | Do. 5 per Cent. Debentures, 1883 | 103 | 106 | 103 | 106 | 5 13 2 | March & September | .. | .. |
| 17,000 | 25 | .. | Indo-European | 38 | 40 | 39 | 41 | 6 1 11 | May and November | 40½ | 40 |
| 33,348 | 10 | 2/6 | London Platino-Brazilian | 6½ | 7½ | 6½ | 7½ | 5 14 4 | " " | .. | — |
| £100,000 | 100 | 6% | Do. 6 per Cent. Debentures | 105 | 108 | 105 | 108 | 5 11 1 | March & September | .. | .. |
| 9,000 | 8 | 4/0 | Reuter's | 8¾ | 9¼ | 9 | 9½ | 5 6 10 | April and October .. | 9⅜ | — |
| 3,381 | £100 Cert. | 6% | Submarine Cables Trust 6% | 115 | 120 | 115 | 120 | 5 0 0 | " " | .. | — |
| 15,609 | 10 | 4/0 | West African Telegraph | 8 | 9 | 8 | 9 | 5 11 1 | January and July .. | .. | — |
| £290,900 | 100 | 5% | Do. 5 per Cent. Debentures | 97 | 100 | 97 | 100 | 5 0 0 | March & September | .. | — |
| 30,000 | 10 | 3/0 | West Coast of America | 2 | 3 | 2½ | 3½ | | January and July .. | .. | .. |
| £150,000 | 100 | 8% | Do. Debentures 8% 1902 | 92 | 97 | 92 | 97 | .. | June and December | 95 | 93 |
| 88,321 | 10 | .. | West India and Panama | 2¼ | 3 | 2⅞ | 3⅜ | .. | .. | .. | .. |
| 34,563 | 10 | 6/0 | Do. 1st Preference 6% | 11½ | 12 | 11½ | 12 | 5 0 0 | May and November | .. | .. |
| 4,669 | 10 | £3 | Do. 6 p. c. 2nd Pref. | 11½ | 12½ | 11½ | 12½ | 4 16 0 | " " | .. | .. |
| 64,174 | 15 | 6/0 | Western and Brazilian | 12 | 12½ | 12 | 12½ | 4 16 1 | " " | 12⅜ | 12⅛ |
| 27,873 | 7½ | 6/0 | Do. 5 per Cent. Cumulative Preferred | 6¾ | 7¼ | 6¾ | 7¼ | .. | — | 7 | 6⅞ |
| 27,873 | 7½ | 4/6 | Do. 5 per Cent. Deferred | 5¼ | 5¾ | 5¼ | 5¾ | .. | .. | 5½ | — |
| £200,000 | 100 | 6% | Do. 6 per Cent. Debs., Series "A" 1910 | 103 | 106 | 103 | 106 | 5 13 2 | February & August | .. | .. |
| £250,000 | 100 | 6% | Do. 6 per Cent. Mort. Debs., Series "B" 1910 | 103 | 106 | 103 | 106 | 5 13 2 | " " | 103½ | — |
| $1,336,000 | $1,000 | 7% | Western Union 7 per Cent. 1st Mortgage | 120 | 125 | 120 | 125 | 5 12 0 | May and November | .. | — |
| £175,100 | £100 | 6% | Do. 6 per Cent. Sterling Bonds | 100 | 104 | 100 | 104 | 5 15 5 | March & September | .. | — |
| | | | **TELEPHONES.** | | | | | | | | |
| 224,850 | 14/0 | 0/4⅘ | Consolidated Telephone Const. & Maintenance. | 7/16 | 9/16 | 7/16 | 9/16 | .. | May and November | .. | — |
| 220,000 | £1 | 3% | Oriental (11s. paid) | 5/16 | 7/16 | 5/16 | 7/16 | 4 8 7 | Yearly | .. | .. |
| 488,984 | 5 | 2/6 | National | 4⅜ | 4⅝ | 4⅜ | 4⅝ | .. | June and December | 4⅝ | 4 7/16 |
| 15,000 | 10 | 6/0 | Do. 6 per Cent. Cumulative 1st Pref. | 12¾ | 13½ | 13 | 13½ | 4 8 11 | " " | 13⅜ | 13½ |
| 10,000 | 10 | 4/9⅗ | Do. 6 per Cent. Cumulative 2nd Pref. (£8 pd) | 10 | 10½ | 10 | 10½ | 4 11 7 | " " | .. | — |
| 209,750 | 1 | ½% | South of England, Ordinary | ⅛ | ¼ | ⅛ | ¼ | .. | — | .. | — |
| 20,000 | 5 | 2/1 | Do. 6 per Cent. Cumulative Pf. (£3 10s. pd) | 2¾ | 3¼ | 3 | 3½ | .. | .. | .. | — |
| 58,000 | 5 | 1/0 | United River Plate | 3 | 4 | 2½ | 3½ | .. | January and July .. | .. | |
| £146,128 | Stock | 5% | Do. 5 per Cent. Debenture Stock | 85 | 95 | 85 | 95 | 5 5 3 | .. | .. | — |
| £3,200 | 100 | 7% | Do. 7 per Cent. Debentures | .. | | .. | | .. | — | .. | — |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | | | |
| 19,900 | £5 | .. | Electricity Supply Co. of Spain | 4½ | 5 | 4½ | 5 | .. | .. | .. | — |
| 111,000 | 5 | .. | London Electric Supply | 2¼ | 2½ | 2⅜ | 2⅝ | .. | .. | .. | .. |
| 43,900 | 10 | .. | Metropolitan Electric Supply (£9 paid) | 8¾ | 9¼ | 8¾ | 9¼ | .. | — | 8⅞ | .. |
| 7,730 | £5 | .. | St. James' and Pall Mall | 6½ | 6½ | 6½ | 6½ | — | — | .. | — |
| 42,853 | 5 | .. | Westminster Electric Supply (£4 paid) | 3⅞ | 4⅛ | 3⅞ | 4⅛ | .. | — | 4 | — |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | | | |
| 63,416 | 3 | .. | Brush Electrical Engineering | 2¼ | 2½ | 2⅜ | 2⅝ | .. | .. | 2⅝ | 2½ |
| 63,416 | 2 | 1/1 | Do. 6 per Cent. Preference | 1½ | 2 | 1¼ | 2 | 6 0 0 | June and December | 1 | — |
| 20,000 | 5 | 3/6 | Crompton and Co., 7 per Cent. Pref. Shares | 5 | 5½ | 5 | 5½ | 6 7 3 | January and July .. | .. | .. |
| 17,139 | 5 | .. | Edison and Swan United | .. | | .. | | .. | — | .. | .. |
| 45,000 | 10 | 6% | Electric Construction | 5 | 6 | 5½ | 6½ | .. | — | .. | .. |
| 70,000 | 2 | 10/0 | Elmore's Patent Copper Depositing | 3 | 3½ | 3 | 3½ | .. | — | .. | .. |
| 20,000 | 5 | .. | Fowler-Waring Cables (£4 paid) | 2½ | 3½ | 2½ | 3½ | .. | .. | .. | .. |
| 41,600 | 10 | 10/0 | India Rubber, Gutta Percha & Telegraph Works | 19 | 20 | 18½ | 19½ | 5 2 7 | February & August | .. | .. |
| £200,000 | 100 | 4½% | Do. 4½ per Cent. Debentures, 1896 xd | 104 | 106 | 102 | 104 | 4 6 7 | March & September | .. | .. |
| 11,334 | £10 | 6/1 | International Okonite Limited Ordinary | 7 | 8 | 7½ | 8½ | .. | .. | 7¾ | 7¾ |
| 11,334 | £10 | 5/0 | Do. Preference | 9¼ | 9¾ | 9¼ | 9¾ | 8 4 1 | .. | .. | .. |
| 78,949 | 5 | 4/10⅘ | Swan United (£3. 10s. paid) | 4½ | 5 | 4½ | 5 | 6 19 10 | May and November | .. | .. |
| 37,350 | 12 | 36/0 | Telegraph Construction and Maintenance | 45 | 47 | 45 | 47 | 5 0 0 | March and July | 46½ | 46½ |
| £150,000 | 100 | 5% | Do. 5 per Cent. Bonds, red. 1894 | 102 | 105 | 102 | 105 | 4 15 3 | January and July .. | .. | .. |
| | | | **RAILWAYS.** | | | | | | | | |
| 50,000 | £10 | .. | City and South London Railway | 5½ | 6½ | 5½ | 6½ | .. | .. | .. | .. |


# IMPROVEMENTS IN DYNAMOS




## STATTER-BRUNTON DYNAMO.

**The latest design in the market, made with all the advantages of the latest scientific knowledge and the highest mechanical skill.**

The woodcut represents our B TYPE DYNAMO. A most efficient machine, working noiselessly, and without sparking or overheating; is highly finished and well proportioned. The output is so rated in our Catalogue that the machines may be worked very much in excess of their stated full output for short periods.

**STOCK SIZES UP TO 77 KILOWATTS.**
**MACHINES BUILT TO 500 KILOWATTS.**

**THE ELECTRICAL ENGINEERING CORPORATION, LIMITED,**
STATTER'S] [UNITED

68, Victoria Street, London, S.W.

WORKS:—ALLIANCE ENGINEERING WORKS, WEST DRAYTON, NEAR LONDON.


Digitized by Google

# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 673.—Vol. XXVI. FRIDAY, APRIL 10, 1891. Price Fourpence.

## NOTES.

With reference to our comments on the electric lighting of the British Museum in our last issue, we are glad to learn that there is ample power and plant to light the whole place, but only half is lighted on account of the expense of attendance. As it is, there are often more attendants and policemen than visitors. We were certainly under the impression that only sufficient plant had been provided for lighting half the galleries, and it was said, when the lighting was inaugurated, that there was no room for more. From the first evening there has been no attempt either to light the whole, or to enable the afternoon visitors to remain after dusk. If, instead of reopening the museum from eight till ten it were kept open continuously until two hours after dusk, we venture to think that a very considerable increase in the number of visitors would be found. It may be said that such a method would not meet the wants of a certain class, who can only get there between eight and ten in the evening. This may be so, but it has been proved that very unfortunately this class does not put in an appearance. The present arrangement is so very unusual that no argument can properly be drawn from the observed number of visitors.

Electrical engineers are justly proud of the modern dynamo as being one of the most efficient machines that has ever been produced, but they are none the less eager to introduce further improvements. Hitherto the electrical losses have been separated from the mechanical losses, and have been grouped into two classes, conductor losses and core losses. The former can be easily calculated from $C^2 R$, but the separation of the Foucault currents from hysteresis has been largely a matter of guess-work. In the present issue will be found two Papers, published simultaneously by request of the authors, and dealing with a very simple method of testing and analysing the core losses. We should be rather surprised if the curves turned out in practice to be straight lines, as assumed, and it is a pity that, after all, the mechanical friction enters so largely into the question. The method is so easy to carry out that we hope it will receive careful attention experimentally.

In a letter to the *Standard*, Mr. P. V. Luke, Director of the Construction Branch of the Indian Government Telegraph Department, suggests that as telegraphing without wires has been accomplished under certain circumstances, communication with our light-ships might be effected thus. He refers to the Paper by Mr. Melhuish (*Electrician*, Vol. XXIV., p. 597), and to Mr. Willoughby Smith's experiments at Eastbourne (*Electrician*, Vol. XXII., p. 56.) The idea certainly has some fascination about it, Mr. Preece succeeding in establishing communication across the Solent to the Isle of Wight, and telegraphed across the Severn without wires, merely using earthplates at a sufficient distance apart. But such methods are hardly practicable at present, and only serve to throw light on problems connected with cross-talk and the other disturbing influences.

The obvious way of communicating between a lightship or a lighthouse and the coast would be by flash signals, but a slight mist would effectually stop the beam of light, since mist is opaque to light. Why is it opaque? Partly because its particles are conductors of electricity, and partly because the frequency of the vibrations is high. The first reason cannot be avoided, and difficulties arise in attempting to get over the second. Hertz has shown how slower vibrations may be received and observed, but the wave length of such vibrations is at least a foot. Optical experiments with these radiations have to be carried out with huge prisms and reflectors, and even then the longest dimension of the apparatus being only a few wave lengths, all sorts of difficulties arise from diffraction and interference. These phenomena, though they puzzle microscopists, have not yet been investigated, for they only occur in ordinary optics when we use lenses and prisms of a few hundredths of a millimetre in diameter. But if we could reduce the frequency about 2,000 times, and produce vibrations of about two hundred thousand million per second, we should get waves about one millimetre long. These radiations would probably pierce not only a fog, but a brick wall. *When* we get such vibrations there will be many interesting uses for them. One, at all events, would be the possibility of communicating between lightships and the shore.

The inductive disturbances, which are so annoyingly common in telephony, are generally attributed to the electromotive forces induced in one circuit by the variation of current in the other; but it has been more than once suggested that the cross talk may be due to electrostatic and not electro-magnetic action. Mr. J. J. Carty has studied the phenomena from the latter point of view in a more thorough way than any other investigator. An account of his work will be found in *The Electrician* for December 6, 1889, and we print this week his further Paper read before the American Institute of Electrical Engineers. The experiments he describes are of great interest, and some of

Digitized by Google

them (notably that indicated in Fig. 9) are hard to explain, except on the theory he suggests. He seems, however, to have ignored the possibility of any disturbances being caused by electro-magnetic action. His wires are in general placed very close together—much closer than telephone wires are in practice—and though this no doubt increases the electrostatic action, it still more increases the mutual induction of the wires. His experiments, too, would have been more convincing if he had used metal sheets of suitable thickness, thus separating out the two effects, eliminating them in succession by screening.

THE subject of cross-talk is one of great importance and its explanation is still very obscure. If, Mr. CARTY's explanation is correct, it is remarkable that double metallic circuits yield such good results. The capacity of two wires is greatest when they are closely adjacent, as in a double circuit, and if cross talk is accounted for by the condenser action of wires placed at a considerable distance from each other, one would imagine that the condenser currents between the wires of a double metal circuit would be large enough to considerably distort the sounds transmitted, although, of course, no such injurious effect takes place. In connection with the electrostatic theory of cross-talk it is, however, worth noting that the capacity of two long thin wires is by no means negligible, even when their distance apart is very considerable. We calculate that the capacity of two parallel wires, whose distance apart is ten times their diameter, is 0·015 microfarads per mile. This may be increased to ten times this amount by bringing the wires near together till they are almost touching, but it cannot be very much diminished by separating them. In fact the capacity is more than one-quarter of this amount, even if the distance apart is 10,000 times the diameter; and as the alteration in distance makes such a small change in the capacity, it is probably unimportant that the wires should be straight and parallel, provided their distance from each other is considerable. These values seem too small to account for the disturbances except for sounds of very high frequency, but the fact that the capacity is not much diminished by increasing the distance of the wires is a point in favour of Mr. CARTY's experiments, and also tends to show that, if his explanation is correct, cross-talk may take place between telephonic circuits separated from each other by very great distances.

MR. PREECE, who has investigated this subject by numerous experiments carried out on a very large scale, has expressed a decided opinion that the origin of the disturbances is entirely electro-magnetic. His work, however, cannot be taken as deciding between the two theories. In fact, the possibility of detecting these disturbances at distances of several miles tends rather towards the conclusion that the electrostatic theory is the correct one; for, while electro-magnetic effects diminish inversely as the distance between the wires, the capacity effects are more nearly constant being inversely proportional to the logarithm of the distance. Mr. PREECE has calculated from some of his observations the smallest current which can be detected with the telephone, and in doing so has assumed that the disturbances are electro-magnetic. If this limiting current were calculated by some entirely different method, a comparison with Mr. PREECE's result would tend to show which of the theories is the correct one.

WE commented in a recent issue on some experiments by WIENER, who, by the skilful use of photography, succeeded in detecting the nodes and internodes in a wave of light rendered stationary by reflection from a metallic surface. These experiments have given rise to a very able controversy in the *Comptes Rendus* and the *Journal de Physique*. At first it was supposed that they completely confirmed FRESNEL's theory of light, according to which the direction of vibrations in a luminous ray is perpendicular to the plane of polarisation. It has, however, been pointed out by MM. POINCARÉ and POTIER that until something more is known as to the nature of photography, it is possible to interpret the experiments so as to conform either to FRESNEL's theory or to the rival theory of NEUMANN and MACCULLAGH, in which the luminous vibrations are supposed to occur in the plane of polarisation, and not perpendicular to it. In all kinds of waves, whether of sound, light, or electromagnetism, there are two kinds of disturbances taking place. In sound waves there are not only vibrational movements of the air, but also changes of pressure, and any undulatory disturbance is propagated in an elastic medium by means of both dilatations and rotational vibrations, the analogues of which in the electromagnetic theory are the displacement currents in the dielectric, and the magnetic changes. The energy of the wave is represented equally well by either kind of vibration, as the amplitudes are proportional; but the two disturbances do not increase and decrease together—in fact, one attains its greatest value when the other is least. The directions of these vibrations are perpendicular to each other, and it is impossible to determine the direction of either experimentally until it is known which kind of vibration affects the testing instrument. WIENER's experiments clearly demonstrate the interference effects caused by reflection, but do not afford a crucial test of the rival theories of FRESNEL and NEUMANN. They rather tend to show that these theories are complementary to one another. Each appears incomplete in itself, and the electro-magnetic theory reconciles them by binding them together.

A DECIDEDLY vigorous discussion sprang up in the House of Commons on Monday evening last, in connection with the vote of £1,900 for oil lamps used in the Houses of Parliament, the net result of which was a generally expressed opinion that if the annual oil bill could not be reduced it would be a good thing to extend the electric light throughout the building. Amongst the many instructive remarks made on this occasion was one by that champion of accuracy the senior member for Northampton, who was of opinion that the First Commissioner of Works would confer a public benefit if he would cause a record to be kept of the cost per hour of each electric lamp, many persons having found the present forms of the electric meter entirely incorrect. The indications of the average electric meter can certainly be relied upon to be true to within one or two per cent. Can as much be said for the statements of the average Member of Parliament?

Digitized by Google

**Aberdeen.**—The Town Council are about to advertise for a firm to undertake the electric lighting of the town.

**Royal Institution.**—The evening discourse on Friday next will be given by Prof. Rücker, and will be on "Magnetic Rocks."

**Basle.**—The canal for conveying the water required to drive the electrical plant for the Sissach Gelterkinden Electric Railway is now complete.

**Incandescent Lamp Litigation in France.**—The Société des Lampes Incandescentes Edison-Swan has commenced an action for infringement against the Société Khotinsky.

**African Cables.**—The Spanish Government is about to lay a cable from Bonny to Fernando Po. From the latter place a cable is to be laid by the German Government to Camerun.

**Institution of Civil Engineers.**—The annual dinner of this Institution was held on Wednesday evening in Merchant Taylors' Hall, Threadneedle-street. Upwards of 230 were present.

**Electric Lighting in Spain.**—The following towns in Spain have the electric light:—Valencia, 6,000 lamps; Gijon, 1,000; Albacete, 800; Cuenca, 700; Pampeluna, 550; Talavera, 400; Guadalajara, 70.

**St. Pancras Electrical Exhibition.**—This Exhibition, which has been open daily since March 14th, closed on April 1st. During the 14 days that the Exhibition was open over 14,000 people visited it.

**Brussels.**—It has been decided to construct a small circular electrical railway in the Bois de la Cambre. The scheme has been approved by Baron Jamblenne, who has worked out the technical details of the project.

**Physical Society.**—The Papers to be read before this Society next Friday are (1.) "On a Property of Magnetic Shunts," by Prof. Silvanus Thompson; (2.) "An Alternating Current Influence Machine," by Mr. Wimshurst.

**Recipe for a New Insulating Material.**—The *Revue Industrielle* gives the following:—Glove glue (*colle de gant*), 1,000 parts; resin oil, 100 parts; oxydised linseed oil, 500 parts; colophane, 150 parts; paraffin, 250 parts.

**Cannes.**—The water discharged from the Sianne Canal, at Cannes, France, is equivalent to 300 H.P. This power is about to be utilized for driving torbines, which will actuate dynamos for the supply of electric light and power in the town.

**National Telephone Electrical Society.** — On Wednesday, the 25th ult., Mr. C. A. Smith read a Paper before this Society on "Magneto and Dynamo Electric Generators." On Friday, the 3rd inst., Mr. W. A. Baxter, Chief Inspector, read a Paper on "The Bell Telephone."

**Electric Light for Coast Defence.**—Classes have been opened at the School of Military Engineering at Chatham for instructing officers and men of the Royal Artillery in the manipulation of the electric light and of electrical machinery. The first class has been taken from the Portsmouth garrison.

**The Ratio of the Centimetre to the Inch.**—The following very simple approximate ralation between centimetres and inches, viz., 33 to 13, was given in a recent letter to *Nature* by Dr. Oliver Lodge. This ratio should be useful for slide rule work. For ordinary arithmetical work we often use 4 to 1 + $1\frac{1}{2}$ per cent.

**Electric Launch Charging Stations on the Thames.**—We are informed that Messrs. Woodhouse and Rawson have arranged for the erection of a permanent charging station on the banks of the river at Chertsey, under the management of Mr. J. Taylor. The station is now in course of erection, and will be ready to undertake the charging of all sizes of electric launches by the beginning of the river season.

**Electric Funeral Trains.**—According to the *Western Electrician*, Pittsburg is soon to have electric funeral cars. The stockholders of the Suburban Rapid Transit Electric Railway Company decided at a recent meeting to place several cars at the disposal of funerals. There are seven cemeteries on the route traversed by the Company's system, and it is expected that the venture will be a great financial success.

**Gas and Electric Lighting in Rome.**—At the recent general meeting of the Società Anglo-Romana per l'Illuminazione di Roma col Gas e Altri Sistemi, it was declared that the total profits during 1890 amounted to £85,517. The electrical plant of this Company consists of four 600 H.P. dynamos and two 150 H.P. dynamos. The total number of lamps installed is equal to 33,000 eight c.p. lamps. There has been an increase equal to 12,000 eight c.p. lamps during the past year.

**The Naval Exhibition.**—A feature of this Exhibition will be a model of the Eddystone Lighthouse. The building will be in every way an exact reproduction of the new Eddystone Lighthouse itself. It is 167ft. 6in. in height; it is promised that the electric light on the top will be 5,000,000 c.p. This presumably refers to the illuminating power of a concentrated beam. But why not make the beam parallel? Then the candle-power would be infinitely great—on the photometer.

**Royal Society.**—The following Papers were read before the Royal Society yesterday: Sir William Thomson, P.R.S.: (1.) "On Electrostatic Screening by Gratings, Nets or Perforated Sheets of Conducting Material. (2.) "On Variational Electric and Magnetic Screening," Prof. Ayrton, F.R.S., and Dr. W. E. Sumpner, "The Measurement of the Power given by any Electric to any Circuit;" Prof. S. P. Thompson, "On Galvano-Hysteresis." Preliminary notice. Sir William Thomson's Papers will be found in another part of this issue.

**Brighton.**—At the meeting of the Town Council last week the Lighting Committee reported that they had received a letter from the Brighton and Hove Electric Lighting Company, proposing that the Corporation should treat for the purchase of the Company's undertaking. The committee recognised that the Company had some claim, and recommended a negotiation. This was deemed inexpedient by several members, and a negative amendment being submitted, a lengthened discussion ensued, but the report was ultimately adopted.

**Manchester.**—The Electric Lighting Sub-Committee of the Gas Committee of the Manchester Corporation have prepared a report with reference to electric lighting, to be presented at the next meeting of the Council. The Sub-Committee suggest that in the initial stages, with view to obviate mistakes as far as possible, the best professional and disinterested advice should be sought to draw up a complete scheme including the most efficient, modern, and economical appliances for the carrying out of the Corporation's Provisional Order.

**Rope Transmission.**—The two principal objections to the transmission of power by manilla rope have always been the inability of the rope to stand, for a long time, the effect of moisture, and the internal friction caused by passing over the sheaves. Both of these faults have, an American paper says, been greatly mitigated in the "Stevedore" transmission rope, which is laid up with tallow and plumbago with the twist of the rope, the tallow making it partially waterproof and the plumbago acting as a lubricant, and reducing the internal friction.

**The Copper Market.**—The deliveries of copper in England and France during March, although 1,500 tons less than in the corresponding month of 1890, exceeded the total supplies, the former being 9,962 tons and the latter 9,284. In the past twelve months the deliveries have exceeded the supplies by 33,585 tons. The stocks are now reduced to 58,353 tons, as compared with 91,938 tons a year ago, that amount being slightly under that of three years ago. The present price of copper at £53 per ton compares with £48. 15s. a year ago, and £39. 15s. two years ago.

**A Winter Thunderstorm.**—A somewhat remarkable storm occurred recently in the Cape Cod region. The area over which it was most severe comprised Cape Cod, the shores of Buzzard's Bay, Martha's Vineyard, and the eastern end of Long Island. A careful examination of the reported accidents by lightning in this district on the night of March 1st, shows that eight churches were struck, six houses, ten barns, one vessel at sea, one life-saving station, and one marine signal station. Strangely enough, there appears to have been no loss of human life, although five persons are reported to have been seriously injured. The storm occurred during a fall of snow.

Digitized by Google

**The Subway Question in Sheffield.**—The Works Sub-Committee of the Highways Committe of the Town Council recommend the early consideration of the subway question, in order that advantage may be taken of any opportunity offering for the construction of subways in the centre of the town. The Sub-committee believe that by accomodating the gas and water mains, together with telephone, telegraphic, and electric light wires, in connection with the sewers, great saving would result financially to the Corporation, whilst promoting the interests of all parties concerned.

**Electric Traction in Bremen.**—The Bremen Tramways Company has just decided to remove all its horse cars and to substitute electric cars. The Company has been induced to come to this decision on account of the good results obtained with the experimental line laid down last summer. It is intended to adopt the Thomson-Houston overhead wire system. The Imperial postal authorities objected to the use of the overhead conductor, owing to the interruption in the telephone service, but, notwithstanding this, the police authorities have already given their permission for the use of the system. The Senate is also prepared to give consent.

**Overhead Wires in Rochester, N.Y.**—The following statistics appeared in the report of the Brush Electric Light Company of Rochester, N.Y.:—

| | |
|---|---|
| Number of circuits | 29 |
| ,, miles overhead wires | 315 |
| ,, of arc lamps | 1,334 |
| ,, ,, motors | 549 |
| ,, ,, grounds during 1890 | 32 |
| ,, ,, times wires broken, 1890 | 3 |

It was only found necessary to shut down two circuits on account of grounds; the others were localised and repaired before the circuits were started.

**London-Paris Telephone Line.**—Experiments continue to be made in connection with this line. A few days ago London was placed in telephonic communication with Marseilles (a distance of more than 700 miles), and speaking was found to be possible, but far from good. The statement which has appeared in the daily papers to the effect that one can hear better at the London end than at the Paris end is, it is hardly necessary to say, without foundation. Any small disturbances to which the line is still liable are probably attributable to the method of running the wires on the French side, where a complete twist is effected every six posts instead of every four posts as with us, so that there is considerable want of symmetry.

**The Order of Railway Telegraphers.**—The Order of Railway Telegraphers is having a good deal of trouble of late, says the *Western Electrician*. The last difficulty promises to be serious. It is reported that the general manager of the Union Pacific has issued an order instructing the general superintendents to ask all the telegraph operators on their respective divisions to withdraw from the Order of Railway Telegraphers, and to discharge all who refuse. This order has been executed, and every operator on the entire system from the Missouri River to Portland, Ore., and from Denver to the Gulf, received a notice to withdraw from the Order or resign from the service of the Company. No reason was given for this demand, except that the Company did not wish the operators in its employment to belong to such an organisation.

**Cylinder Lubrication.**—It is well known that vegetable and animal oils are unsuitable for cylinder lubrication. In an article on the subject in the *Portfeuille Economique des Machines*, M. Recour states that when colza oil was used on the railway with which he was connected, it was necessary to burn out the deposit in the ports of the locomotive cylinders after the engine had run 18,000 miles. At the end of a year's service this deposit was from ·06in. to ·08in. thick on the piston faces, and from $\frac{1}{10}$in. to $\frac{1}{8}$in. thick on the covers and steam ports. In the exhaust ports the thickness of deposit was as much as ·27in. to ·35in. On analysis the deposits proved to consist of carbonaceous matter from the decomposition of the oil, and of the oxides of iron and copper due to the wear of the valve and cylinder surfaces. When tested in the laboratory at temperatures 212° Fahr. to 536° Fahr., it was found that colza oil first absorbed oxygen, then gave off hydrogen, and finally broke up into oleic and stearic acid with the separation of glycerine.

**Underground Telephone Wires in the City.**—At the last meeting of the City Commission of Sewers, a report was brought up from the Streets Committee on the application of the National Telephone Company to place a portion of their telephone cables beneath the public ways. The report recommended that permission should be given for the work, so far as the Company could arrange to do it, simultaneously with the electric lighting companies. A letter was read from the Brush Electrical Engineering Company pointing out the question of laying telephone cables in the same conduits with electric wires, was one which required the gravest consideration; and pending further investigations the Company hoped the Commission would defer a final decision on the subject. After some discussion, the matter was referred back to the Streets Committee to examine the report.

**Cable and Land Line Interruptions and Repairs.**—

| | Date of Interruption. | Date of repair. |
|---|---|---|
| | 1890. | 1891. |
| Jamaica Porto-Rico-St. Croix cable | Dec. 15 | March 2 |
| | 1891. | |
| Transandine Line | Jan. 8 | ,, 20 |
| Para-Maranham cable | Feb. 10 | ,, 6 |
| Trinidad-Demerara cable | ,, 11 | ,, 3 |
| Constantinople Dardanelles cable | ,, 16 | ,, 6 |
| Metelin-Aivali cable | ,, 20 | ,, 2 |
| Moulmein-Bangkok Line | ,, 25 | ,, 2 |
| Indo-European Line | ,, 27 | Feb. 28 |
| Ceara-Maranham cable | Mar. 3 | Mar. 4 |
| ,, ,, ,, | ,, 8 | ,, 9 |
| Mollendo-Arica-Iquique cables | ,, 5 | * |
| Ceara-Pernambuco cable | ,, 14 | * |

* Not yet re-established.

**Proposed Lighting of Antwerp by Electricity.**—At the general meeting yesterday of the Antwerp Waterworks Company, the chairman, Mr. Charles Crew, referred to the negoitations which are pending for lighting the City of Antwerp by means of electricity. He stated that the town had been anxious for some time to have the city lighted by the electric light, but the Gas Company and their own Company had monopolies. They had both been approached by the parties interested, with whom conditional contracts had been entered into. It was proposed to obtain from this Company the hydraulic power which was required at the small local stations, the establishment of which was contemplated. The Gas Company, in consideration of an extension of their concession, had agreed to give up their monopoly so far as regarded the lighting of the city by electricity, and they themselves had agreed—while incurring no money risk or other responsibility—to their water being used for the purposes required for the payment of a royalty. There was a general desire at Antwerp for the electric light.

**Sir John Pender, K.C.M.G.**—During his recent visit to Constantinople, Sir John Pender was honoured with a private audience by the Sultan, by whom he was received with great cordiality. The Sultan expressed regret that, owing to ill-health, he had not been able to entertain Sir John as the head of the Submarine Telegraph System, but invited him to again visit Constantinople, when he would give a dinner in his honour. The Sultan further charged Sir John with kindly messages to many high personages in this country. At Athens Sir John entertained the King and Queen of Greece at lunch on board the Eastern Telegraph Company's cable steamer "Mirror." On his return journey, he visited Paris, and was decorated by the President of the French Republic with the Legion of Honour. Sir John's colleagues on the Board of the Eastern Telegraph Company have passed a resolution congratulating him on the honour bestowed upon him by the French Government, and thanking him on behalf of the shareholders for the valuable services he has rendered the Company by his visit to Egypt, Turkey, Greece, and Paris.

**City and South London Railway.**—At Lambeth Police Court, on Monday, the City and South London Railway Company were summoned by the London County Council for having, on or about March 6th, erected a certain structure beyond the general line of buildings at Stockwell without

Digitized by Google

the consent in writing of the Council. Mr. Burton appeared on behalf of the London County Council, and pointed out that the summons had reference to a zinc and wooden projection beyond the walls of the station, and beyond the proper building line. Mr. Hopkins observed that a similar case had been before him some time back. Mr. Burton said that was with regard to the line of frontage of stations and offices, and had been decided against the Company. The solicitor who appeared for the Company observed that this was a case exactly similar to that already heard, upon which a case had been granted for a superior Court. Mr. Hopkins agreed to adjourn the summons pending the decision of the superior Court. On Sunday last a regular service of trains was commenced between Stockwell and the City. Hitherto traffic has been carried on only on week days.

**Magnetic Phenomena in Central Russia.**—In a recent communication to the Académie des Sciences, General Alexis de Tillo calls attention to some remarkable local magnetic disturbances which occurred between the towns of Kharkov and Kourk. The area of disturbance is only about 22 miles from north to south by 15½ miles from east to west, and the following are the magnetic data for the principal centres of disturbance :—

| Village. | Declination. | Dip. | H. | Total intensity. |
|---|---|---|---|---|
| Nepchaevo | +48° west | +81 | 0·11 | 0·84 |
| Visloje | −33° east | +52 | 0·40 | 0·65 |
| Kisselevo | −38° east | +63 | 0·33 | 0·72 |
| Sobinino | +30° west | +60 | 0·38 | 0·75 |
| Petropaoloko | −20° east | +76 | 0·19 | 0·80 |

The greatest distance between the above-mentioned localities is not more than eight miles, and yet the declination varies by 86deg. and the dip by 29deg. The normal values for this district are :—Declination, 1° east ; dip + 64° ; H 0·21 ; total intensity, 0·48. So far as the geological constitution of the soil is known, it gives no clue to the cause of the disturbance.

**The Tudor Accumulator.**—The Tudor accumulator has attained considerable vogue in Belgium, especially in connection with central station work, as the following figures will show. The commune of Dolhain (Limburg) possesses a central lighting station which supplies current to 1,300 lamps, and it is provided with three batteries of 240 ampere-hour Tudor cells. The Compagnie Franco-Belge pour l'Eclairage Public par l'Electricité has four central stations in operation, and employs Tudor accumulators in all of them. The station in the Rue Montagne (Brussels), which has some 1,000 8 c.p. lamps and several arcs connected, possesses a battery of Tudor cells of 750 ampere-hours' capacity, and the station in the Passage du Nord (Brussels) is provided with two batteries of 756 ampere-hour cells. The Gand station has a battery of 590 ampere-hours' capacity; and, finally, the Ninove station has a 756 ampere-hour battery. The battery at the Passage du Nord was recently exposed to very severe test. The boilers at this station are below the level of the roadway, and during the recent thaw the boiler-house was flooded, and for four and twenty hours no steam could be generated. The batteries consequently had to bear the full brunt of the load, and according to the registering ammeter curve 1,780 ampere-hours were taken out of them, or 17·6 per cent. more than their normal capacity.

**Telegraph Extension under Difficulties.** — The *Pekin Gazette* contains a memorial from the Viceroy of Yunnan, reporting that the line of telegraph communication in Yunnan has been extended to Momein, on the borders of Burmah. The task of making the preliminary surveys was entrusted to a Chinese official, aided by a foreign artisan. The task of surveying the route and procuring the supply of poles occupied from March, 1888, to February 23, 1889. The construction of the line was commenced on the latter date and was completed on May 30th following. The distance from Yunnan Fu to Momein is 530 miles, and the route lies through a mountainous and densely-wooded country, where frequently no trace of habitation occurs for over 30 miles. The Mekong, the Salween, and the Shweilei rivers had all to be crossed in fever-stricken localities. The passage of the Salween, in particular, is attended with horror. Its waters are muddy and turbulent, and so deadly that the feet of men and hoofs of horses are said to rot and drop off from contact with them. The officers and men of the expedition crossed the river on rafts, and only reached the opposite bank after a very hard struggle. The season being summer, the malaria was at its worst, and no fewer than ten members of the party succumbed to its effects during the three days occupied in carrying the telegraph line across the river. The difficulties connected with the construction of this extension line have been far greater than any experienced in first introducing the telegraph system into Yunnan, and it is asked that the officers engaged on the work may receive rewards on the same scale as is accorded for the safe transmission of urgent messages from the field of battle.

**An Alternate-Current Electric Mining Plant.**—About a year ago the Gold King Milling and Mining Company, which owns a group of mines at Telluride (Col.), decided to instal an electric plant to work its machinery. The Gold King Mill is at an elevation of 11,000 feet above the sea, and 3,000 feet above the San Miguel Valley. Close by a branch of the San Miguel River falls 500 feet in a distance of less than a mile, and even at the season of lowest supply can furnish about 2,000 H.P. A contract was entered into with the Westinghouse Company to supply the necessary plant. A dam was erected, and from the headgate the water is conducted through an iron pipe 4,000 feet long to the power station. Here the stream is divided, and the water is delivered to two six-foot Pelton water-wheels. The ultimate capacity of 800 H.P. in the generators is provided for. The motor-station is two and a-half miles from the generators. The generator employed is a Westinghouse self-exciting incandescent alternator, motor and generator being alike, except in some minor details. It was determined to use an E.M.F. of 3,000 volts. The conductor is a No. 3 B. and S., bare copper wire, erected on poles. The loss in transmission is barely 5 per cent. The starting device employed is a two-wire 10 H.P. Tesla alternating motor. This is used simply and solely for bringing the large motor up to synchronism, when it is cut out until again required. The large motor is self-exciting, and takes care of itself easily enough after it is once brought up to speed. It is altogether probable, says the *Electrical World*, that other mines in the vicinity will shortly receive a similar equipment, as the region is one where fuel is none too easily obtained, and water power can be had almost for the asking.

**Institution of Electrical Engineers' Benevolent Fund.**—The Council of the Institution of Electrical Engineers believe that, although happily the necessity does not now exist, a time will inevitably arrive when a benevolent fund in connection with the Institution will be found most desirable for the assistance of necessitous members and their families, or the families of deceased members ; and they consider that the formation of such a fund should be commenced at once, while the Institution is yet comparatively young. The fund will be called the "Benevolent Fund of the Institution of Electrical Engineers," and it is proposed that it be managed and administered on lines similar to those which govern the Benevolent Fund of the Institution of Civil Engineers, which has been the means of effecting a vast amount of good, and one of the chief features of which is that the names of the recipients of any grants from the fund are not published. The members of last year's and this year's Council have among themselves already subscribed an amount of £224. 5s., and they trust that all members will assist in the establishment of the fund, not only by personally subscribing, but by using their influence to obtain subscriptions and donations from such of their friends as take an interest in the institution or in the profession which it represents. It is hoped that even the youngest members will give their support to the fund by a contribution, however small in amount. It is requested that all subscriptions or donations to the fund may be forwarded to the secretary of the Institution, and, in order to avoid confusion, that the ordinary subscriptions to the Institution be *not* included in the same remittance. A member of the Council will subscribe £52. 10s. if, before the end of the year, nine other members will each give a like sum

Digitized by Google

## THE MAGNETIC CIRCUIT OF TRANSFORMERS: CLOSED VERSUS OPEN.

BY S. EVERSHED.

(*Continued from page 664.*)

§ 54. Compare two generating stations, one supplying through "closed," the other through "open" transformers. For each 10 H.P. converter on the circuits, the "closed" system will have to supply two amperes as load plus ·11 for exciting during the assumed six hours of heavy load, while during the daytime probably ·5 ampere for load plus the exciting current will be required, so that the ratio of heavy load to light load is about $\frac{\cdot 61}{2 \cdot 11} = \cdot 29$, and this is nearly enough the ratio of the plant in use. Under the same conditions the heaviest output of the "open transformer" station will be two amperes useful load plus ·9 ampere exciting current, and ·5 plus ·9 ampere on the light load, a ratio of $\frac{1 \cdot 4}{2 \cdot 9} = \cdot 48$, so that the closed system will run 29 per cent. of its plant during light load, as against 48 per cent. with open transformers. Recollect, that this does not mean 29 and 48 per cent. of the *power*—the open circuit transformers will be wasting less than half the power lost in the cores of their closed rivals. What it does mean is, that the current capacity of the alternators at light load must be 29 and 48 per cent. of heavy load for the closed and open systems respectively, so that the latter system will necessitate the running of large engines and dynamos during 16 or 20 hours a day at a fraction of their normal load, and therefore giving a very low all-round efficiency. In short, the coal wasted in running engines at a small load will cut down the saving effected in the open transformers, leaving only a balance, and that balance not by any means necessarily on the right side. This is a point on which there is really no evidence one way or another; no accurate analysis of alternate-current station running expenses having yet been published.

§ 55. It may be taken for granted that a station supplying through open transformers would be seriously hampered by the large idle current for exciting, just as many—perhaps all—closed transformer systems are now saddled with the inordinate waste of power in the cores. Station managers were once told that they need take no notice of the primary current on light load, it had a lag of ever so many degrees so it meant nothing at all practically as power; but at least one manager knew and had the courage to declare that the coal bill told a very different tale, that the product of volts and amperes hardly required multiplying by the cosine of the lag to make it tally with the coal consumption. We know definitely now what was only vaguely suspected a few years ago, we know what all the power went for: core hysteresis and eddy currents. We have learnt how to eliminate the latter by reducing the thickness of the core plates, their width is of insignificant importance. It would be rash to say that we can never hope to save the entire waste due to hysteresis, but it appears at present to be impossible to do so, except by throwing away the whole of the iron core. And when that is either wholly or partially done, a new difficulty and new loss arises in the shape of idle current. But, while it may be really impossible to produce changing induction in iron without hysteresis loss, it is certainly quite possible to produce large idle currents without using large alternators, so that there is still some hope of our ultimately being independent of hysteresis. The ground for that hope will be seen in a future article.

§ 56. By this time the sceptical reader is probably looking for some justification of the views of transformer phenomena advanced in these Papers. He wants to know what reasons can be given for preferring these vaunted practical notions to the old and complex analytical explanations of the phantom. Granted that the phantom has no relation to the real, have the transformers discussed here any resemblance to reality? Do those indicator diagrams represent facts? These are pertinent questions, and it is necessary to devote some space to their satisfaction. It should first of all be clearly understood that the analytical method must always fail to represent facts when iron forms the whole or any part of the magnetic medium in a transformer. Starting with the perfectly legitimate assumption of a sine E.M.F., analysis can only tell us what the value of the exciting current is when there is no hysteresis; for the attempt to find C necessitates the further assumption that B is expressible as a function of H, and therefore C, in order that terms involving rate of change of induction may be simplified into terms involving rate of change of current, by which means the necessary relation between E and C can be expressed. But It is known that the fundamental law of magnetisation of iron, nickel, and cobalt (the magnetic metals) is now, and is likely to remain for a long time to come, a dark mystery; thanks to Dr. Hopkinson and Prof. Ewing we are beginning to see a faint glimmer, but hardly more than enough to enable us to perceive the almost hopeless clumsiness of our modes of thought, when we are dealing with the ultimate construction of matter. For the present then it is mere waste of time—a darkening of counsel, to deal with an iron-cored transformer as though its coils had specifiable constant co-efficients of self and mutual induction.

§ 57. The diagram method involves no assumption as to the relation of B to C. Starting for example, with the assumption of a sine E.M.F. (an almost necessary assumption for analytical treatment, but not so for diagrams—only convenient), it is next assumed (but only for the moment) that the counter E, due to changing induction in the core, is also sinoidal; it follows that the induction itself must vary according to a sine law. The result of previous experiment on the magnetic properties of the iron core, enables the proper value for the existing current to be determined for each instant during the period. Now it is clear that if the primary coil had no resistance, the exciting current would require no electromotive force to maintain it, and the counter and impressed E.M.F.'s would be exactly equal and opposite at every instant. But the primary coil has a finite though small resistance, and this means that in addition to an impressed E.M.F. to balance the counter E.M.F., there must be just sufficient force to maintain the exciting current; an amount easily calculated by multiplying each instantaneous value of the current by the resistance of the primary coil. When all these values are added in their right order to the component E.M.F.'s balancing the counter E.M.F.'s, the result is a wave of total E.M.F., which, if applied at the primary terminals, would produce the exciting current and induction waves given by the diagram. This E.M.F. wave is not really a pure sine function; as has already been noticed, the C R part of the E is necessarily of the same shape as the current wave. Commercial transformers being made to carry the whole load current with a very small loss of volts over resistance, the value of C R for the exciting current, which in a closed transformer is a very small fraction of the full load current, becomes vanishingly small when compared with the counter E.M.F. wave. Consequently indicator diagrams represent very closely indeed the actual behaviour of real transformers.

§ 58. It must not be supposed for a moment that the construction of "no load" diagrams is impossible under some conditions—they may be useless, but they can be drawn for every condition. To take an extreme case, imagine No. 2 as a closed transformer had a primary coil of 2,240 turns as before, but instead of 1·4 per cent. drop at full load due to its resistance, let it have a drop of 20 per cent. This requires the resistance to be about 107 ohms, and since the maximum value of the exciting current is ·162 ampere, the maximum value of C R to maintain it is only 17·3 volts, so that even with an enormous full load drop, the shape of the impressed E.M.F. wave would hardly differ appreciably from that of the counter E.M.F. We do not assert that a given E.M.F. wave produces exactly specifiable current and induction waves, but given a counter E.M.F. wave (of any shape whatever) first the induction, then the exciting current, then C R, and finally the requisite E.M.F. wave may be found by drawing the diagram. It may be that the E.M.F. wave so found is one which no alternator produces, but it is absolutely certain that given a suitable alternator, the transformer would run according to the diagram. When the E.M.F. wave is very nearly the same shape as the counter

Digitized by Google

E.M.F. wave—a condition fulfilled with abundant accuracy by all commercial transformers—we may, if we please, begin by choosing a known wave form from some real alternator; then by drawing the counter E of the same form we can find the induction wave necessary to make such a counter wave. That is really the only difficult step in the progress from impressed **E** to exciting current. We have to find the integral of the counter E in order to plot **B**, and this is a tedious process unless E can be expressed by an integrable formula, for it is necessary to measure the area of the E curve from zero up to half a dozen or more equidistant epochs during a half period, and use the values of the areas as the ordinates of the induction wave. The writer hopes to deal with such non-analytical diagrams, as they may be called, in a future series of papers, where also the construction of diagrams for various loads on a transformer will be described. For the purpose of the present articles the "no load" diagrams give a sufficiently clear notion of the relation between exciting current induction and waste power.

§ **59.** We have now, we hope, dispelled any suspicion that the diagrams involve a fallacy. Just where analytical treatment breaks down, the method of diagrams gives us what is wanted; it appeals to experiment for the relation between **B** and **H**; and the only error introduced is vanishingly small in the case of all real transformers. But although the diagrams may bring us to a perfectly logical conclusion on the assumed basis of fact, how if some phenomena of vital importance

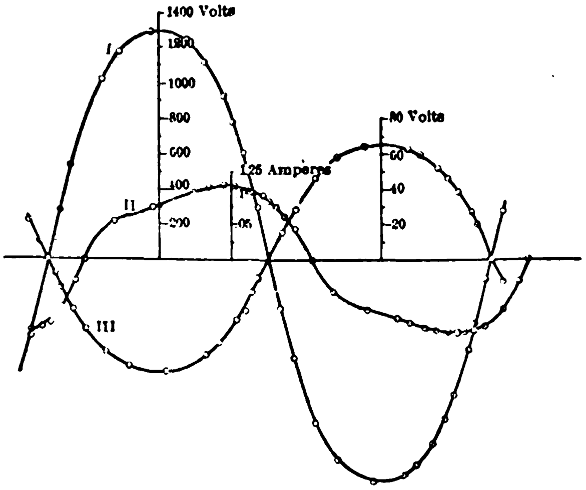



FIG. 17.—Humphrey and Powell's Curves of 40-light Transformer on Open Circuit. I., Primary volts. II., Primary current. III., Secondary volts.

have been neglected? What if the supposed viscous hysteresis is a fact? What if it is possible to carry iron through cyclic changes in induction without loss of energy; finally, suppose it is not necessary for the production of E.M.F. in the coils of a transformer that there should be any changing induction linked with them. These horrible suggestions are the result of certain recent experimental determinations of the losses in transformer cores made independently, and by different methods, by Mr. Mordey and Prof. Ayrton. It may as well be admitted at once, that if their results are confirmed, the diagram must be based on the new facts and those given in these Papers will require revision. The case for and against open magnetic circuits would not be materially affected if these new phenomena became recognised as substantial facts. Viscous hysteresis could only lead to a greater waste in the core than that assumed in these Papers, so that the arguments for the open circuit would be strengthened. The effect which seems to point to diminution of energy waste in the iron, only occurs as the load on the transformer is increased, so that there can be but little advantage here for a transformer running practically unloaded for 16 or 20 hours a day; what little gain there might be is only of slightly more importance to the closed than the open transformer.

§ **60.** Those who are inclined to accept the alleged phenomena alluded to in the last paragraph, will do well to remember that other experimenters besides those mentioned, have been working at the same problem and have arrived at totally different results. While we in England are trying to force L, M, $\frac{dc}{dt}$, and cos $\theta$ on an unwilling transformer, the American electricians are patiently and steadily adding to our knowledge of the real transformer by a direct appeal, not to Fourier's theorem, not to empirics, not to their imagination, but to Nature. The work done by Prof. Ryan and by various students at

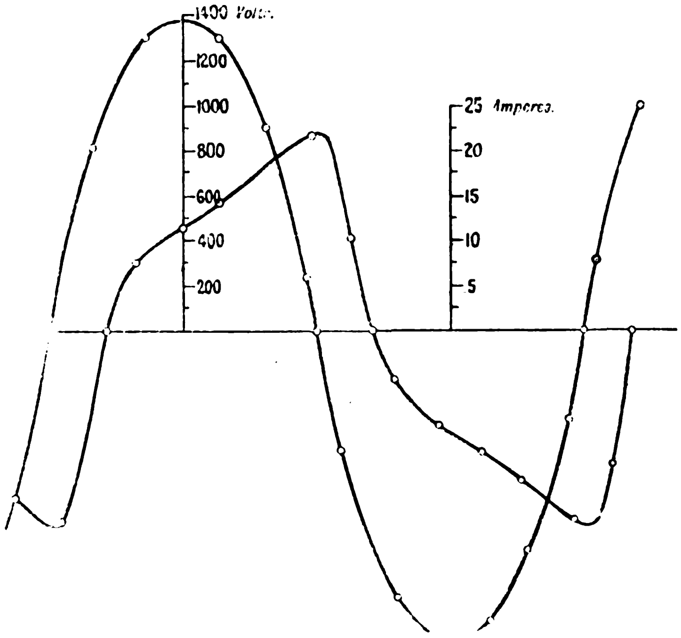



FIG. 18.—Humphrey and Powell's Curves of 10-light Transformer.

the Cornell University, answers in the clearest manner some of the vexed questions respecting hysteresis and eddy currents. Prof. Ryan's method consists, shortly, in running a real live transformer under all sorts of conditions, and ascertaining the shapes and relations of the primary and secondary E and C waves by means of a revolving contact, which enables him to obtain the simultaneous values of E and C at any desired epochs during a whole period. He thus obtains an indicator

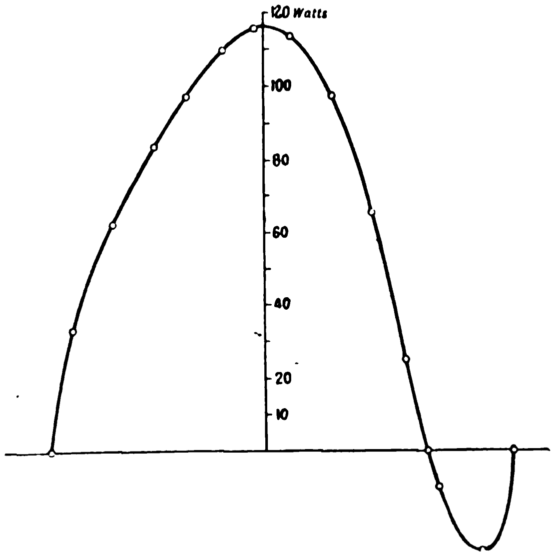



FIG. 19.—Humphrey and Powell's Curve of watts wasted on Open Circuit by 40-light Transformer.

diagram by observation, which stands in the same relation to the predicted diagrams given in these Papers, as an indicator card taken from an engine cylinder in actual work, does to a diagram which might be predicted from the laws of heat. Several diagrams taken by Ryan's method from closed transformers are given by Messrs. Humphrey and Powell, in a Paper read before the American Institution of Electrical Engineers, and published in the journal of that Institution, Vol. VII., No. 10. In Fig. 17 we reproduce the "no

Digitized by Google

load" diagram for a 40-light transformer. It will be noticed that the exciting current, although following roughly the course we have predicted, differs in having its sharper corners rounded off to a large extent, so much so that the maximum value does not occur at the epoch when $E = 0$, as of course it should do if eddy currents are small. Turning back to Fig. 10, it will be readily understood that any large increase in the Y component will tend to displace the maximum value of $X + Y$, and lead to a curve more closely resembling that found by Humphrey and Powell. Another diagram is given in Fig. 18, taken from a 10-light transformer in which the induction density was far too high. Notice the increased sharpness of the turning-points, and the sudden drop from maximum current to zero—precisely the results we should expect. The power wasted at no-load in the 40-lighter is shown in Fig. 19, which is taken from the same Paper. This curve includes $C^2R$ loss in addition to the core waste.

(*To be continued.*)

## ON ELECTROSTATIC SCREENING BY GRATINGS, NETS, OR PERFORATED SHEETS OF CONDUCTING MATERIAL.*

BY SIR WILLIAM THOMSON, D.C.L., P.R.S.

### 1. *Grating.*

§ 1. Maxwell, in his "Theory of a Grating of Parallel Wires" ('Electricity and Magnetism,' Arts. 203-205,† and Plate XIII.), gives a very valuable and interesting two-dimensional investigation of electrostatic screening, and a most instructive diagram of "Lines of Force near a Grating," which powerfully helps to understand and extend the theory, and to acquit it of an accusation wrongly made against it in the last two sentences of Art. 205. It is only on the supposition of the grate-bars being circular cylinders that the investigation is less than rigorous; and that supposition nowhere enters into the investigation; it merely appears in the word "radius," in the first line of the last sentence but one of Art. 204, and it is contradicted in lines 3 and 4, and by the rest of the sentence, and by the next sentence. (*See* § 6 below.)

§ 2. The conclusion, "$\alpha = -0{\cdot}11a$," in the last sentence of Art. 205, condemned as "evidently erroneous," is quite correct, and very interesting. It shows that a corrugated metal plate agreeing with the equipotential surface $c = \frac{1}{2}a$, exceeds in electrostatic capacity a plane metal surface through the poles of the diagram (Plate XIII.), with the surroundings described in Art. 204, and supplies the datum requisite for finding the exact amount of the excess. The reason for the greatness of the excess clearly is that the surface $c = \frac{1}{2}a$, which just touches the plane through the poles of the diagram midway between the poles, is everywhere nearer than this plane to the other plate of the condenser (*see* § 7 below).

§ 3. For $c = a/6$ we have, by (11) of Art. 205, $\alpha = 0$, and the corresponding equipotential, partially shown* in Maxwell's diagram, is a set of curves concave towards $z = -\infty$, and asymptotic to the lines $x = (i \pm \frac{1}{4})a$, $i$ denoting any integer. (See §§ 10 to 13 below.) For every value of $c$ less than $a/6$, the equipotential is a row of ovals; and the grating formed by constructing these ovals in metal has less electrostatic capacity in the circumstances described in Art. 205 than a plane through the poles or the ovals (this being no doubt what is meant by "a plane . . . in the same position" as the grating).

§ 4. For every value of $c$ exceeding $a/6$ the equipotential, instead of being the boundary of a grating, is a continuous corrugated surface, and its electrostatic capacity exceeds that of the plane through the poles.

§ 5. Begin now afresh, and let it be required to find the electric force in the air on either side of an infinite row of parallel bars at equal consecutive distances, $a$, each uniformly charged with electricity. Let $\rho a$ be the quantity per unit length on each bar, so that $\rho$ would be the surface density, if the same quantity were uniformly distributed over the plane of the bars. Taking O in one of the bars, O X perpendicular to the bars, and O Z perpendicular to their plane, we find (by Fourier's method) for the $z$-component of force at any point $(x, z)$ for which $z$ is positive,

$$Z = \frac{4\pi\rho}{a}\left(\tfrac{1}{2} + \epsilon^{-mz}\cos mz + \epsilon^{-mz}\cos 2mz + \&c.\right) \quad . \quad (1)$$

where

$$m = 2\pi/a \quad . \quad . \quad . \quad . \quad . \quad . \quad (2).$$

Summing this we find

$$Z = \frac{2\pi\rho}{a}\,\frac{\epsilon^{mz} - \epsilon^{-mz}}{\epsilon^{mz} - 2\cos mx + \epsilon^{-mz}} \quad . \quad . \quad . \quad (3).$$

This has equal positive and negative values for equal positive and negative values of $z$, and it therefore gives the value of the $z$-force, not only for positive, but also for negative, values of $z$. Taking now $-\int Z dz$, with constant assigned to make the integral zero for $z = \pm D$, we find

$$V = \rho a\left(\log\frac{1}{\epsilon^{mz} - 2\cos mx + \epsilon^{mz}} + mD\right) . \quad (4)$$

as the potential due to the grating, and two parallel planes at equal distances, D, on its two sides, each uniformly electrified with half the quantity of electricity of opposite sign to that on the grating.

§ 6. If we now construct in metal, C, any one complete equipotential surface, $V_0$, of this system, and electrify it with the same quantity of electricity as that which we gave originally to the infinite row of infinitely thin bars; and if we place metal planes, B, B', at the two places of zero-potential ($z = \pm D$), we have an insulated conductor, at potential $V_0$, between two planes, B, B', at zero potential, and at distance 2D asunder, on each of which the electric density is $\frac{1}{2}\rho$. For brevity I shall denote the insulated conductor by I.

Its electrostatic capacity per unit area of its medial plane (the plane of the original infinitely thin bars) is $\rho/V_0$.

§ 7. This conductor, I, is symmetrical on each side of its medial plane, and consists either of an infinite number of isolated parallel bars, each surrounding one of the original infinitely thin bars, or of a plate symmetrically corrugated on its two sides, with maximum and minimum thicknesses respectively at the places of the infinitely thin bars, and the lines midway between them. For the case of isolated bars, let $2c$ be the diameter of each, in the medial plane. Then, to find $V_0$, we must put $x = \pm c$ and $z = 0$, in (4). Thus we find

$$V_0 = 2\pi\rho\left(\frac{a}{2\pi}\log\frac{1}{4\sin^2\frac{\pi c}{a}} + D\right) \quad . \quad (5).$$

Hence the electrostatic capacity of I in the circumstances is

$$1\left\{2\pi\left(D + \frac{a}{2\pi}\log\frac{1}{4\sin^2\frac{\pi c}{a}}\right)\right\} . \quad . \quad . (6)$$

which is greater or less than $1 (2\pi D)$, the electrostatic capacity that it would have if reduced to its medial plane, according as $c >$ or $< \frac{1}{6}a$ (compare § 5 above). The conductor I, to be a grating, implies $\sin^2\frac{\pi c}{a} < 1$, and therefore requires that

$$V_0 > 2\pi\rho\left(\frac{a}{2\pi}\log 4\right) = 2\pi\rho\,(D - {\cdot}22a) \quad . \quad (7).$$

When $V_0$ exceeds this critical value, the conductor I is the continuous plate corrugated on each side, which was described in § 7. The critical value corresponds to an immediate case of a plate so deeply furrowed on each side as to be just cut through by its two surfaces crossing at right angles; and (7) shows that the electrostatic capacity of the conductor I so constituted is equal to that of a plane sheet of thickness,

$$2a\log[2^2]/(2\pi), \text{ or } {\cdot}44a \quad . \quad . \quad . \quad . \quad (8),$$

* Paper read before the Royal Society, April 9, 1891.

† In formula (7) of Art. 204, delete λ; in Art. 204, delete 2 in last line of p. 250 (Edition 1873); and delete 2 in lines 6 and 16 from foot of the page.

Digitized by Google

insulated midway between the two earth plates B, B′, at the same distance asunder as they had with I between them.

§ 8. By (4), (5), and (7), we have for the equation of the surface constituting the two sides of I in this critical case,

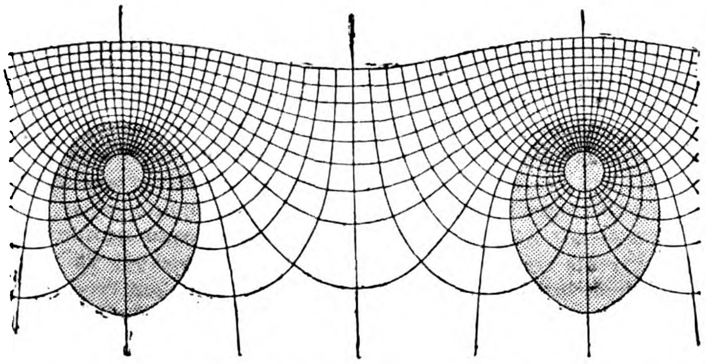
$$\epsilon^{-mz} - 2\cos mx + \epsilon^{-mz} = \log 4 \quad . \quad . \quad . \quad . \quad (9).$$

Taking double the positive value of $z$ which this gives when $x = 0$, we find

$$2a \log [(1+\surd 2)^2]/(2\pi), \text{ or } \cdot 562a \quad . \quad . \quad . \quad . \quad (10)$$

as the maximum thickness of I. This is $(1+\surd 2)/2$, or 1·28 times the amount shown in (8) for the thickness of plane-sided plate of equal electrostatic capacity; which is just such a relation as is expected before calculation!

§ 9. If $\phi(z, x)$ denote what V becomes when in place of $m$D we substitute $-mz$ in (4), we have the potential due to a uniform electrical force $\rho am$, or $2\pi\rho$, added to the $z$-component, of the force due to the grating with its given charge of $\rho a$ quantity per unit length of each bar; and it is the equipotentials and lines of force of this system that are represented in Maxwell's diagram of Plate XIII., reproduced here. In it the



resultant force for infinitely large positive values of $z$ is parallel to O Z, and of constant value $4\pi\rho$; and it is zero for infinitely large negative values of $z$. The approximation to these values is very close, at only so moderate a distance as $a$ on either side of the grating.

§ 10. Choosing, in the system of § 6, any one of the multiple-oval equipotentials around the infinitely thin bars, that indicated by the shading, for example, which I have added to Maxwell's diagram, let $c$ be the distance from the infinitely thin primary bar within it, at which it is cut by the plane of the primary bars. By putting in the expression for $\phi(z, x)$, $z = 0$, and $x = c$, we find

$$\phi(0, c) = \rho a \log \frac{1}{4\sin^2 \frac{\pi c}{a}} \quad . \quad . \quad . \quad (11)$$

as the potential at the surface of each of these chosen ovals. Construct now each of these ovals in metal, and let the supposed uniform force, $2\pi\rho$, be produced by uniform electrification of density $-\rho$, on a metal plane, B, at any great distance, $b$, on the positive side of the grating. We thus construct a grating of thick bars of oval-shaped cross section which, when electrified with the same quantity of electricity as that which we gave initially to the infinitely thin bars, and subjected to the influence of the equal quantity of negative electricity on B, has $\phi(z, x)$ for potential through external space from B ($z = b$), to infinite distance on the other side of the grating ($z = -\infty$), and has for potential through all the portions of space within the surfaces of the grate-bars the constant value expressed by (11). In this system the potential, for positive values of $z$ great in comparison with $a$, is, by (4) with $-mz$ instead of $-m$D,

$$\phi(z, x) \doteqdot -4\pi\rho z \quad . \quad . \quad . \quad . \quad (12).$$

The difference of potentials between B and the grating is, by (6) and (5),

$$\phi(0,c) - \phi(b,x) \doteqdot 4\pi\rho\left(b + \frac{a}{4\pi}\log\frac{1}{4\sin^2\frac{\pi c}{a}}\right) \quad . \quad . \quad (13).$$

Hence the electrostatic capacity of the mutually insulated system, B, and the grating of oval-shaped bars is equal to the capacity of a pair of parallel planes, B and a plane at a distance beyond the plane of the primitive infinitely thin bars equal to

$$\frac{a}{4\pi}\log\frac{1}{4\sin^2\frac{\pi c}{a}} \quad . \quad . \quad . \quad (14).$$

§ 11. If in (4) we put $-nz$ in place of $m$D, we have the potential of a system in which, besides the electricity of the primary bars there is distant electricity such as all in all to give at great enough distances on the two sides of the primitive bars uniform fields of $z$-force respectively equal to

$$\rho(m+n), \text{ for } z \doteqdot +\infty \text{ ; and } \rho(m-n), \text{ for } z \doteqdot -\infty \quad . \quad (15).$$

If, in (4) with $-nz$ instead of $+m$D, we put

$$\epsilon^{-V/\rho a} = C \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (16),$$

we find, as the equation of the equipotential surfaces,

$$-2\cos mx + \epsilon^{mz} + \epsilon^{-mz} = C\epsilon^{-nz} \quad . \quad . \quad . \quad (17).$$

By taking $n = 0$, or $n = m$, we fall back on the cases of §§ 5—8, and §§ 9, 10, respectively.

§ 12. To find an approximate equation for the equipotentials at distances around primitive bars small in comparison with $a$, the distance from bar to bar, let $x$ and $z$ be so small that we may neglect all powers of $mx$, $mz$, and $nz$, above the square, which implies that C is small of the same order as $(mx)^2$ and $(mz)^2$, (11) becomes

$$\left\{ \begin{array}{l} x^2 + \left(\dfrac{z + \frac{1}{2}nr^2}{1 + \frac{1}{4}n^2r^2}\right)^2 = r^2 \\ \text{where } r^2 \text{ denotes } m^{-2}\,C \end{array} \right\} \quad . \quad . \quad . \quad (18).$$

This shows that, to the degree of approximation in which we neglect cubes and higher powers of $mx$, $mz$, $nz$, the equipotential is a row of elliptic cylinders of eccentricity $\frac{1}{2}nr$, with the primitive bars for one set of their foci and their greater diametral planes perpendicular to the plane of the primitive bars. When $n = 0$, the equipotential is a row of circular cylinders having the primitive bars for their axes; and this is true to the higher approximation, in which we need only neglect powers above the cubes of $mx$ and $mz$, as we see by going back to equation (17), with $n = 0$.

§ 13. The conclusions of § 12 are useful for detailed investigation of the screening effect of plane gratings of circular or elliptic, straight parallel bars electrified with given quantities of electricity and placed with their planes perpendicular to the lines of force in a uniform field of force, and to corresponding problems in which potentials are given, as in Maxwell's §§ 203—205.

§ 14. Instead of a single row of parallel equidistant infinitely thin bars in one plane, let us take for primitives or foci, as we may call them, two or more such rows, parallel or not parallel, all in one plane or not in one plane. We may thus form an endless variety of force systems available for illustrating or helping to solve problems which may occur. Towards the several problems of electric screening we find important contributions by considering in two parallel planes rows of focal lines parallel to one another for one case and perpendicular to one another for another case. The consideration of three rows of focal lines in one plane, dividing it into equal and similar triangles alternately oriental in opposite directions, leads to a complete theory of electrostatic screening by a triangular lattice of metallic wire or ribbon. The fundamental potential formula for this system obtained by summation of expressions given each by an application of (4), to one of the three rows, is

$$V = \log \frac{1}{(\epsilon^{lz} - 2\cos lp + \epsilon^{-lz})^{\omega a}(\epsilon^{mz} - 2\cos mq + \epsilon^{-mz})^{\rho b}(\epsilon^{nz} - 2\cos nr + \epsilon^{-nz})^{\sigma c}} + 2\pi(\omega + \rho + \sigma)D \quad . \quad . \quad (19),$$

where $a$, $b$, $c$ denote the intervals between the successive lines of the three systems, $\omega a$, $\rho b$, $\sigma c$, the quantities of electricity per unit length of bar in the three systems; $p$, $q$, $r$, $z$, special

Digitized by Google

co-ordinates of the point for which (19) expresses the potential, viz., $z$, its distance from the plane of the focal bars, and $p$, $q$, $r$ its distances from three planes drawn perpendicular to this plane through a bar of each of the three systems; D the value of $z$ for a plane for which the potential is zero, and, lastly,

$$l = 2\pi/a,\ m = 2\pi/b,\ n = 2\pi/c \quad . \quad . \quad . \quad . \quad (20).$$

For the present, however, we may confine ourselves to the case of two rows of focal lines dividing a plane into squares and charged, both rows, with equal quantities, $\rho$, of electricity per unit length. The potential formula, a particular case of (19), is

$$V = \rho a \left[ \log \frac{1}{(\epsilon^{mz} - 2\cos m x + \epsilon^{-mz})(\epsilon^{mz} - 2\cos m y + \epsilon^{-mz})} + 2 m D \right] (21).$$

§ 15. The consideration of the equipotentials of this surface is very interesting. The equipotential lines in the plane of the focal bars given by the equation

$$16 \left( \sin \frac{\pi x}{a} \sin \frac{\pi y}{a} \right)^2 = \epsilon^{-V/\rho a} \quad . \quad . \quad . \quad (22)$$

are shown in the accompanying diagram of curves.

§ 16. Considerations quite analogous to those of §§ 6, 7, 8, and again the other considerations analogous to those of §§ 9—13, are, after the full explanations there given, easily completed, so as to formulate a full theory of electrostatic capacity and electrostatic screening for square nets of wire exposed to electric action giving uniform fields of force at distances on each or on one side of the plane of the net, considerable in comparison with $a$, the side of each square.

---

## ON VARIATIONAL ELECTRIC AND MAGNETIC SCREENING.*

BY SIR W. THOMSON, P.R.S.

§ 1. A screen of imperfectly conducting material is as thorough in its action, when time enough is allowed it, as is a similar screen of metal. But if it be tried against rapidly varying electrostatic force its action lags. On account of this lagging, it is easily seen that the screening effect against periodic variations of electrostatic force will be less and less the greater the frequency of the variation. This is readily illustrated by means of various forms of idiostatic electrometers. Thus, for example, a piece of paper supported on metal in metallic communication with the movable disc of an attracted disc electrometer, annuls the attraction (or renders it quite insensible) a few seconds of time after a difference of potential is established and kept constant between the attracted disc and the opposed metal plate, if the paper and the air surrounding it are in the ordinary hygrometric condition of our climates. But if the instrument is applied to measure a rapidly alternating difference of potential, with equal differences on the two sides of zero, it gives very little less than the same average force as that found when the paper is removed and all other circumstances kept the same. Probably, with ordinary clean white paper, in ordinary hygrometric conditions, a frequency of alternation of from 50 to 100 per second will more than suffice to render the screening influence of the paper insensible. And a much less frequency will suffice if the atmosphere surrounding the paper is artificially dried. Up to a frequency of millions per second, we may safely say that, the greater the frequency, the more perfect is the annulment of screening by the paper; and this statement holds also if the paper be thoroughly blackened on both sides with ink, although possibly in this condition a greater frequency than 50 to 100 per second might be required for practical annulment of the screening.

§ 2. Now, suppose, instead of attractive force between two bodies separated by the screen, as our test of electrification, that we have as test a faint spark, after the manner of Hertz. Let two well-insulated metal balls, A, B, be placed very nearly in contact, and two much larger balls, E, F, placed beside them, with the shortest distance between E, F, sufficient to prevent sparking, and with the lines joining the centres of the two pairs parallel. Let a rapidly alternating difference of potential be produced between E and F, varying, not abruptly, but according, we may suppose, to the simple harmonic law. Two sparks in every period will be observed between A and B. The interposition of a large paper screen between E, F, on one side, and A, B, on the other, in ordinary hygrometric conditions, will absolutely stop these sparks, if the frequency be less than, perhaps, four or five per second. With a frequency of 50 or more a clean white paper screen will make no perceptible difference. If the paper be thoroughly blackened with ink on both sides, a frequency of something more than 50 per second may be necessary, but some moderate frequency of a few hundreds per second will, no doubt, suffice to practically annul the effect of the interposition of the screen. With frequencies up to 1,000 million per second, as in some of Hertz's experiments, screens such as our blackened paper are still perfectly transparent; but if we raise the frequency to 500 million million, the influence to be transmitted is light, and the blackened paper becomes an almost perfect screen.

§ 3. Screening against a varying magnetic force follows an opposite law to screening against varying electrostatic force. For the present, I pass over the case of iron and other bodies possessing magnetic susceptibility, and consider only materials devoid of magnetic susceptibility, but possessing more or less of electric conductivity. However perfect the electric conductivity of the screen may be, it has no screening efficiency against a steady magnetic force. But if the magnetic force varies, currents are induced in the material of the screen which tend to diminish the magnetic force in the air on their remote side from the varying magnet. For simplicity, we shall suppose the variations to follow the simple harmonic law. The greater the electric conductivity of the material, the greater is the screening effect for the same frequency of alternation; and, the greater the frequency, the greater is the screening effect for the same material. If the screen be of copper, of specific resistance 1,640 sq. cm. per second (or electric diffusivity 130 sq. cm. per second), and with frequency 80 per second, what I have called the "mhoic effective thickness"* is 0·71 of a cm.; and the current intensity at depth $n \times 0{\cdot}71$ cm. from the surface of the screen next the exciting magnet is $\epsilon^{-n}$ of its value at the surface.

Thus (as $\epsilon^3 = 20{\cdot}09$) the current-intensity at depth 2·13cm. is one-twentieth of its surface value. Hence we may expect that a sufficiently large plate of copper of 2¼cm. thick or more will be a little less than perfect in its screening action against an alternating magnetic force of frequency 80 per second.

§ 4. Mr. Willoughby Smith's experiments on "Volta-electric induction," which he described in his inaugural address to the Society of Telegraph Engineers of November, 1883, afforded good illustrations of this kind of action with copper, zinc, tin, and lead screens, and with different degrees of frequency of alternation. His results with iron are also very interesting; they showed, as might be expected, comparatively little augmentation of screening effect with augmentation of frequency. This is just what is to be expected from the fact that a broad enough and long enough iron plate exercises a large magnetostatic screening influence; which, with a thick enough plate, will be so nearly complete that comparatively little is left for augmentation of the screening influence by alternations of greater and greater frequency.

§ 5. A copper shell closed around an alternating magnet produces a screening effect which on the principle of § 3 we may reckon to be little short of perfection if the thickness be 2¼cm. or more, and the frequency of alternation 80 per second.

§ 6. Suppose, now, the alternation of the magnetic force to be produced by the rotation of a magnet M about any axis. First, to find the effect of the rotation, imagine the magnet to be represented by ideal magnetic matter. Let (after the manner of Gauss in his treatment of the secular perturbations of the solar

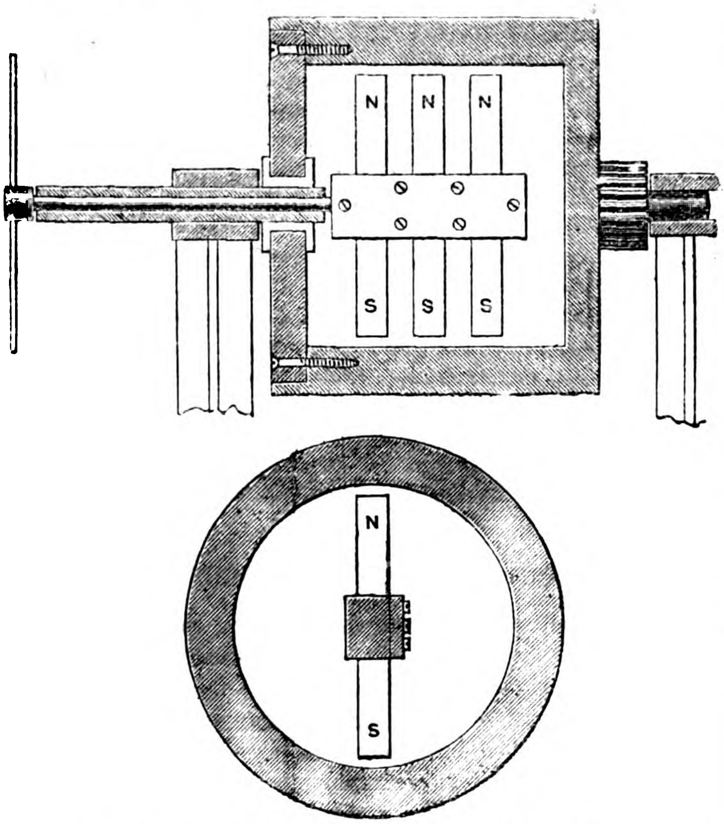
* Paper read before the Royal Society, April 9, 1891.

* "Collected Papers," Vol. III., Art. cii. § 35.

Digitized by Google

system) the ideal magnetic matter be uniformly distributed over the circles described by its different points. For brevity call I the ideal magnet symmetrical round the axis, which is thus constituted. The magnetic force throughout the space around the rotating magnet will be the same as that due to I, compounded with an alternating force of which the component at any point in the direction of any fixed line varies from zero in the two opposite directions in each period of the rotation. If the copper shell is thick enough, and the angular velocity of the rotation great enough, the alternating component is almost annulled for external space, and only the steady force due to I is allowed to act in the space outside the copper shell.

§ 7. Consider now, in the space outside the copper shell, a point P rotating with the magnet M. It will experience a force simply equal to that due to M when there is no rotation, and when M and P rotate together, P will experience a force gradually altering as the speed of rotation increases, until, when the speed becomes sufficiently great, it becomes sensibly the same as the force due to the symmetrical magnet I. Now superimpose upon the whole system of the magnet, and the point P, and the copper shell, a rotation equal and opposite to that of M and P. The statement just made with reference to the magnetic force at P remains unaltered, and we have now a fixed magnet M and a point P at rest, with reference to it, while the copper shell rotates round the axis around which we first supposed M to rotate.




§ 8. A little piece of apparatus, constructed to illustrate the result experimentally, is submitted to the Royal Society and shown in action. In the copper shell is a cylindric drum, 1·25cm. thick, closed at its two ends with circular discs 1cm. thick. The magnet is supported on the inner end of a stiff wire passing through the centre of a perforated fixed shaft which passes through a hole in one end of the drum, and serves as one of the bearings; the other bearing is a rotating pivot fixed to the outside of the other end of the drum. The accompanying sections, drawn to a scale of three-fourths full size, explain the arrangement sufficiently. A magnetic needle outside, deflected by the fixed magnet when the drum is at rest, shows a great diminution of the deflection when the drum is set to rotate. If the (compound triple) magnet inside be reversed by aid of the central wire and cross-head shown in the diagram, the magnetometer outside is greatly affected when the copper shell is at rest; it is scarcely affected perceptibly when the copper shell is rotating rapidly.

§ 8. When the copper shell is a figure of revolution, the magnetic force at any point of the space outside or inside is steady, whatever be the speed of rotation; but if the shell be not a figure of revolution, the steady force in the external space observable when the shell is at rest becomes the resultant of the force due to a fixed magnet intermediate between M and I compounded with an alternating force with amplitude of alternation increasing to a maximum, and ultimately diminishing to zero, as the angular velocity is increased without limit.

§ 9. If M be symmetrical, with reference to its northern and southern polarity, on the two sides of a plane through the axis of rotation, I becomes a null magnet, the ideal magnetic matter in every circle of which it is constituted being annulled by equal quantities of positive and negative magnetic matter being laid on it. Thus, when the rotation is sufficiently rapid, the magnetic force is annulled throughout the space external to the shell. The transition from the steady force of M to the final annulment of force, when the copper shell is symmetrical round its axis of rotation, is, through a steadily diminishing force, without alternations. When the shell is not symmetrical round its axis of rotation, the transition to zero is accompanied with alternations as described in § 8.

§ 10. When M is not symmetrical on the two sides of a plane through the axis of rotation, I is not null; and the condition approximated to through external space with increasing speed of rotation is the force due to I, which is an ideal magnet symmetrical round the axis of rotation. Suppose now a second shell enclosing the first to be caused to rotate about an axis precisely through and precisely perpendicular to the axis of rotation of the first shell. The magnetic force at I is by this second shell perfectly annulled through all the space external to it when the rotation is sufficiently rapid. Thus we arrive at the remarkable result that two closed conducting shells, rotating round axes exactly perpendicular to one another through one point, annul for all external space the magnetic force of any magnet whatever held fixed within the inner shell, when the rotation is sufficiently rapid.

§ 11. Instead of the outer shell, an infinite plane disc of metal might be substituted with the same result; and a disc large enough to produce very nearly the same screening effect as if it were infinitely large is easily arranged for; and an experimental illustration of the result may be shown, by a slight addition to the apparatus before the Royal Society, but there would be no special interest in this illustration. What would really be interesting would be a simple experimental illustration of screening against magnetic force by a rotating disc with a fixed magnet held close to it on one side. A bar magnet held with its magnetic axis bisected perpendicularly by the axis of rotation would have its magnetic force almost perfectly annulled by sufficiently rapid rotation at points in the air as near as may be to it, on the other side of the disc, if the diameter of the disc exceeds considerably the length of the magnet.

## MEETINGS OF SCIENTIFIC SOCIETIES, &c.

**FRIDAY, April 10th** (To-Night).

ELECTRO HARMONIC SOCIETY.

*8 p.m.* Smoking Concert at St. James' Hall Restaurant.

ROYAL INSTITUTION.

*9 p.m.* Evening Discourse. "Electric and Magnetic Screening." By Sir WILLIAM THOMSON, P.R.S.

**SATURDAY, April 11th.**

ROYAL INSTITUTION.

*3 p.m.* Afternoon Lecture. "The Dynamo." By Prof. SILVANUS P. THOMPSON, D.Sc.

**TUESDAY, April 14th.**

INSTITUTION OF CIVIL ENGINEERS.

*8 p.m.* Ordinary Meeting. Paper to be discussed: "The Cost of the Generation and Supply of Electrical Energy." By R. E. B. CROMPTON, M. Inst. C.E.

**THURSDAY, April 16th.**

INSTITUTION OF ELECTRICAL ENGINEERS.

*8 p.m.* Ordinary Meeting.

Digitized by Google

# The Electrician.

Published every Friday, Price Fourpence; Post Free, Fourpence Halfpenny
Editorial, Publishing, and Printing Offices:
SALISBURY COURT, FLEET ST., LONDON, E.C.
*Telephone No.* 2714. *Telegrams:* "ELECTRICIAN NEWSPAPER, LONDON."

*All Letters relating to Subscriptions, Advertisements and other business matters should be addressed to the Publisher,* "THE ELECTRICIAN," *Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to* "THE ELECTRICIAN" *Printing and Publishing Company, Limited, and be crossed* "Coutts and Co." *All other letters to be addressed to the Editor.*

*All letters intended for insertion in* "THE ELECTRICIAN," *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

"THE ELECTRICIAN" *is published every Friday morning, in time for the morning mails. Subscribers should receive their copies by the first post on Friday morning.*

"THE ELECTRICIAN" *is on sale at the railway bookstalls throughout the Kingdom on Friday morning, and can be obtained of all Booksellers and Newsvendors; or direct from the Publishing Offices as above.*

*New Volumes of* "THE ELECTRICIAN" *commence in May and November.*

SUBSCRIPTION RATES.

The rates for Subscriptions to "THE ELECTRICIAN" are as follows:—

| | 3 months s. d. | 6 months. s. d. | 12 months. s. d. |
|---|---|---|---|
| For the United Kingdom | 5 0 | 10 0 | 19 6 |
| For Foreign Parts and Colonies:— Within Postal Union | 6 6 | 12 6 | 24 0 |
| For Aden, Borneo, Ceylon, China, India, Japan, Java, Labuan, Mozambique, New Caledonia, Persia, Philippine Islands, Siam, Transvaal, and Zanzibar | 7 6 | 14 6 | 28 0 |



TO ADVERTISERS.

"THE ELECTRICIAN" *offers exceptional advantages to Advertisers.* **It has by far the largest circulation of any English Electrical paper, and circulates all over the World.**

*Particulars relating to Advertisements will be promptly forwarded on application to the Offices as above.*

TRADE ADVERTISEMENTS *intended for the current issue must reach the Offices not later than First Post on Thursday morning. Renewals of expiring advertisement orders and alterations to standing advertisements should be in the Publisher's hands by Wednesday at latest. No alteration can be made in Wrapper advertisements after Wednesday evening.*

SMALL PREPAID ADVERTISEMENTS *(for Rates see page xvii.) are accepted up to 4 p.m. on Thursday.*

TECHNICAL PRINTING.

"THE ELECTRICIAN" PRINTING AND PUBLISHING COMPANY (LIMITED) *inform Electricians, Electric Light Engineers, &c., that they make a specialty of Technical Printing, and have a large Staff thoroughly acquainted with Electro-Technology. They can, therefore, promise Accuracy and Despatch in the Printing of Electro-Technical Literature, &c.*

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. (Royal 8vo.)

*Early in each year is issued* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. *The* DIRECTORY *was established in 1883, and the 1891 Edition, published on the 23rd February, 1891, consists of 900 pages of printed matter. The names and addresses of all persons engaged in the Electrical Industries at home and abroad may be relied upon as accurate. Useful Tables and Electrical Formulæ, and information specially compiled for this work are given, together with popularly-written Biographical Notices of the leading Electricians, Electrical Engineers, &c., accompanied in many cases by Portraits.*

*The issue for 1891 is ready, and should be ordered at once. Price 5s., post free 5s. 9d. Abroad postage extra. Full particulars on application.*

ELECTRICAL BOOKS AND PUBLICATIONS

*All Books, Newspapers, and other publications, dealing with Electrical and kindred subjects, can be ordered direct of* "THE ELECTRICIAN" *Printing and Publishing Company, who are proprietors of the well-known* "ELECTRICIAN" *Series of Standard Electrical Works, and are agents for all the leading publishing houses at home and abroad.*


CONTENTS OF THE CURRENT NUMBER.


NOTES ... 685
The Magnetic Circuit of Transformers: Closed versus Open. By S. Evershed. Continued. Illustrated ... 690
On Electrostatic Screening by Gratings, Nets, or Perforated Sheets of Conducting Material. By Sir William Thomson, D.C.L., P.R.S. Illustrated ... 692
On Variational Electric and Magnetic Screening. By Sir W. Thomson, P.R.S. Illustrated ... 694
Meetings of Scientific Societies 695
OUR ISOLATED LIGHTHOUSES ... 696
The Electric Current and its Laws.—VI. By John T. Sprague. Illus. Continued. 697
The Separation of Foucault and Hysteresis Losses. By Gisbert Kapp. Illustrated ... 699
Graphic Method for Analysing Losses in Armature Cores, &c. By R. H. Housman. Illustrated ... 700
The Propagation of Hertzian Electrical Oscillations in Air. By MM. E. Sarasin and L. de la Rive ... 701
Notes on the Design of Multipolar Dynamos. By W. B. Esson. Illustrated ... 702
Inductive Disturbances in Telephone Circuits. By J. J. Carty. Illustrated ... 705
The Short Gearless Tramway Motor. Illustrated ... 708
The Cost of the Generation and Distribution of Electrical Energy. By R. E. B. Crompton, M.Inst. C.E ... 708
American Notes ... 709
CORRESPONDENCE—
Sparking Distances—Robert Shand ... 709
Trade Notes and Notices ... 710
PATENT RECORD ... 711
COMPANIES' MEETINGS, &c.—
Elmore's Foreign and Colonial Patent Copper Depositing Company (Limited) ... 711
Poole and White (Limited) ... 712
The Oriental Telephone Company (Limited) ... 712
The New York Belting and Packing Co. (Limited) ... 712
New Companies registered ... 713
City Notes, &c. ... 713
Companies' Share List ... 714



STEEL-PLATE PORTRAITS

*Of W. H. Preece, F.R.S.; Michael Faraday; Sir John Pender, K.C.M.G.; Sir William Thomson, F.R.S. (Past-President of the Institution of Electrical Engineers); C. H. B. Patey, C.B. (Late Secretary of Telegraphs, G.P.O.); Dr. John Hopkinson, F.R.S. (Past-President of the Institution of Electrical Engineers); Dr. Oliver J. Lodge, F.R.S., and Prof. William Crookes, F.R.S. (President of the Institution of Electrical Engineers), have been issued as Supplements to* "THE ELECTRICIAN." *A few Copies of these admirably-executed Steel Engravings can be supplied, price 1s. each, post free on roller, 1s. 2d. Or framed in neat Black Pillar of Brown Ornamental Frames, price, post free, 4s. 6d.*


## OUR ISOLATED LIGHTHOUSES.

We are glad to notice that the appalling shipping disasters which have occurred in distant waters during the past winter have not entirely diverted attention from the more numerous, if less tragic, incidents of the same kind around our own shores. The *Standard*, which has always been forward in pointing out the defects of our coast communication, is again opening its columns to the discussion of this important subject; and we gladly hasten to render what assistance we can to recommend it to the consideration of our professional readers. Last autumn we pointed out that the chief problem to be solved in connection with one aspect of the question was the devising of a practical coupling for cable attachment to the floating lightship. The experiments off Harwich were not entirely successful—or, at all events, failed to an extent which afforded the Trinity House Brethren an excuse for declining to subsidise an extension of the trials. Had that highly useful body been in possession of adequate funds we doubt not that its verdict would have been less critical. But the functions entrusted to Trinity House are of such vital moment that any diversion of its resources to be spent on a new departure would be, perhaps, quite unwarrantable. In other words, we cannot blame the Brethren for not expending money with which they are charged for a definite purpose, upon a quite novel object

outside their strict sphere of operations. That this sphere ought not to be so limited is now self-evident; but as it cannot be enlarged without a substantial increase of funds, the Board naturally confines its attention chiefly to maintaining Lightships and Lighthouses in an efficient condition to serve their original purpose.

But two things more were needed long after these kindly beacons and pathfinders were established—namely, appliances for rescuing those who had gone astray in spite of such provision, and the means of communicating intelligence as to where the rescuing service was needed. Philanthropy has done its part nobly in providing the former; science can now provide the latter. The discovery of the electric telegraph, and, perhaps, still more, the invention of the telephone, have placed at our disposal a prompt and sure connecting link between the danger signals and the relief stations. It requires only that funds shall be forthcoming to make the protecting system complete, and render our shores, if not exempt from shipwrecks, free from the terrible consequences which so often and so needlessly attend them. To some remarks addressed to him on the subject, the Secretary of the Board of Trade is recently reported to have said that he hoped the source from which the money was to come would be indicated by anybody who called upon him to carry out such a scheme. In no other country in the world probably would such a reply have been made. It is reserved for the Ministers of the wealthiest of all nations to put on the airs of the poorest. The fact can be explained only by the charitable assumption that no British Minister can himself initiate an expenditure, but must wait until he receives his orders from the polling booths. Unfortunately, if this is the case, there is a poor look-out for the distressed mariner, for he has no vote. It has been sorrowfully remarked by one of the ablest of living political writers, that while we allow ourselves to be governed by "factory hands," the bravest, the most stalwart, and most loyal of our countrymen are disfranchised. Probably, for this reason, the National Lifeboat Institution is not national at all, but depends largely for its sustenance on occasional legacies and other benefactions, and on the superfluous coppers of visitors to the seaside watering places.

If we were told that the scheme is impracticable, or that it would not serve the purpose intended, the delay in establishing an electrical cordon of communication so long under discussion would be, at all events, arguable. But nobody is bold enough to make either of these assertions except with the manifest object of deprecating the cost. At all events, there can be no question as to the feasibility of attaching and maintaining cable communication with lighthouses—or towers, as they are sometimes more correctly called. Yet it has been left to a private corporation to do all that has hitherto been done in that direction; and even LLOYDS find the enterprise too costly, simply because—so it is alleged—the Post Office rental is too heavy. Granting that it is the business of LLOYDS to supply such a want, and that they alone have an interest in doing so, the Post Office, being employed as a firm of contractors to carry out the work, is not only right in demanding a fair remuneration, but it would be clearly not justified in imposing royalties. But the mere statement of the facts reveals the disgraceful condition into which the whole case has drifted. Nothing but red tape fanaticism can excuse the greatest maritime nation doing nothing—as a nation—to render its shores free from shipping disasters, beyond what is strictly demanded on commercial principles. Lightships and Lighthouses do all that is possible to direct our mercantile marine, but nothing to save the lives of the crews or passengers —is this a matter for private philanthropy?

The motion, of which notice has been given in the House of Commons, by Sir EDWARD BIRKBECK, would, if carried, put this really national question on its proper footing. That telephonic or telegraphic communication should be provided "between the coastguard stations and signal stations on the coasts of the United Kingdom" is desirable, will not be disputed; but that it should be—in the terms of the motion—"provided by the Government" is a proposition which we should like to see fairly discussed and settled in the House. The House of Commons has only to say the word and the thing will be done. Neither the Trinity House nor the Post Office, we are fully assured, will raise the least objection. We have already stated the case of the first-mentioned body. As regards the Post Office, Mr. F. E. BAINES, one of its most competent authorities, has long ago formulated a scheme, by means of which every outlying station, either of coastguardsmen, lifeboat men, or light signalmen, could be put in connection with the main lines of service amply provided by his department. Of course, such a system as that would be serviceable also during a time of war. We have so frequently dwelt upon the necessity of connecting our look-out stations at sea with the naval and military stations on land, that there is no need to enlarge upon it now. It is, perhaps, not so urgent on this ground as on the other; but we rather incline to the belief that when the work is done, if it ever is done, it will be through the instrumentality of the naval and military authorities. The matter has been discussed at considerable length between the Admiralty and the Treasury. As part of the expenditure upon home defences, connecting lines all round the coast would be an insignificant item, as a work of humanity it utterly fails to move the Treasury. It is to be hoped then that, *lucus a non lucendo*, the Minister for War may be induced to give his support to this work of peace.

## THE ELECTRIC CURRENT AND ITS LAWS.—VI.

BY JOHN T. SPRAGUE.

(*Continued from p. 672.*)

§ 50. We have to express the material equivalents in terms of the "gramme," because all our other related measures of the C.G.S. and practical systems are based upon that as the unit of mass and consequently of energy; but we have no real knowledge about the actual "mass" of equivalents; for all we know these are related to quadrillionths of a gramme. Still it is these ultimate units of matter which are the physical basis of "lines of force," and in the case of current, it is by these units of zinc, each taking its place in turn to be dissolved by the acid, that the amperage is generated, and the energy of its voltance transmitted into and along the line of amperage.

This is no assumption or hypothesis; it is simple fact. This is what differentiates linear, dual electric energy from radiant energy, such as heat. The idea that the energy leaves its natural line of action, as a function of amperage, to become radiant as external undulations to be controlled by the current from which it has escaped, *is* pure assumption, adopted for the mere convenience of theorising, in opposition to the principle stated § 42. The theorists are seeking to found their system upon the more complicated phenomena of alternating currents and variable periods, instead of starting from simple facts and their working in nature, and then following the principle so found into more complicated conditions. I have shown that the energy is developed only within a line of force, and I will follow its actions in that line, leaving others to explain why it should leave it in order to come back again.

I prefer another term to "line of force," viz.: "polar or polarisable chain." The central idea of a line is unity acted on externally by an impressed force; the "chain" represents a unity built up of individuals, of links each exerting its own powers.

Digitized by Google

§ 51. I have shown (§ 48) that current is simply the evidence of the material changes going on, and is identical with chemical equivalence; and the known relation of magnetism to current shows that this also is a function of the equivalence of matter and its structure out of units. Current may be readily conceived as a motion of the units, the links of the polar chain, under stress of the voltance energy. A little examination will show that whatever other motions may occur in the chain, there must be (within the electrolyte, starting from the zinc surface, the real seat of the voltance), a semi-rotation of each molecule; the molecule being a pair of equivalent ions, united by their polar forces, and broken up by the superior impressed force due to voltance. If we conceive a new formed molecule of zinc sulphate Zn ($Zn\,SO_4$), it must obviously turn over and become Zn ($SO_4$ Zn) in order to prepare for the next action on the zinc. So we can trace the actions; the superior polar force of voltance breaking up the molecules and reforming them within the polar chain, till a point is reached at the negative plate, where a final disruption must occur, and some ion be released, equivalent to the zinc, whose entrance into the polar order furnished the energy which worked the disturbance.

$$Zn\ SO_4\ Zn\ SO_4\ H_2\ SO_4\ Cu$$

This shows copper released, as in the Daniell; cut off the last molecule, and it shows hydrogen released as in the Smee cell.

§ 52. Precisely the same actions occur in a decomposition cell or voltameter, except that these have re-voltance, energy to be absorbed from the chain instead of voltance, or energy sent into the chain.

I may here refer to, only to dismiss, a theory which presents much fascination to the mathematical mind, and is advocated by many eminent men: viz., the existence in the electrolyte of free uncombined ions of both sorts, each kind charged with + or − electricity. Can anyone really imagine a number of such free charged bodies mingling together and not uniting? We may overlook for the moment the fundamental fact that no such separate charges of electricity have any existence in nature; that a + charge is always definitely related a − charge, and that they are no more separable than N and S magnetic poles.

But the notion is absolutely inconsistent with the established laws of thermo-chemistry; any such free ions would unite and give up their energy as a known value of heat: once combined they can be "dissociated" only by being supplied with the necessary voltance. Whence is this to come in the ordinary conditions? It is supplied by the voltage which disappears at the electrodes, where the real dissociation occurs, and where the ions are found experimentally; but even then, *not as free ions*, but, except possibly for the moment of nascence, as ions united into molecules. *Free* ions are found nowhere except, as Mr. Evershed says of free ether, inside the text books and hypothetical papers. As an instance of how everything can be pressed into the service of a hypothesis, I may refer to the note on "Magnetic Rotation," p. 532. Here we have a difference shown by electrolytes, which give a rotation much higher than that due to the sum of the action of the constituents. That this may show some definite relation of structure to electrolysis is likely enough. But it is actually asserted that "any exceptional value is due to the occurrence of electrolytic dissociation." I may be very dense, but it really seems to me that the free substances ought to give merely the *sum* of their separate actions, not an excess. I can conceive an excess due to some particular structure resulting from combination.

§ 53. To return to our proper muttons, the "stress" of energy in the polar chain depends on the voltance of the reaction, and here we have at once the evidence that it is *in the chain* and not outside. The chemical action which turns chemical affinity into electric voltage is in the chain, at the junction of the zinc with the liquid, where the voltance of the zinc is transformed. Insert one cell after another in the chain, that is in series, and you add its voltage to the circuit; nor does it make any difference what part of the chain you insert them in. Insert them out of the chain, that is in parallel, and you no longer add to the voltage at all; you merely set up fresh polar chains.

We know this; it is no assumption. We know that if the action occurs out of the chain, we do not obtain voltage or electric energy, but waste zinc and waste energy as heat which radiates away. We actually do have both facts in our batteries: what is called "local action" is just zinc going to waste, because out of the polar chain. Why does this energy never find its way to that "waste pipe," the conductors How is it that it altogether escapes the control which prevent? the loss of any energy once put into the circuit, until it has done its work?

§ 54. We may now trace briefly how the same principles operate in other "sources." Take the thermo-pile: what is it but just a polar chain, with points at which the molecular structure changes? viz., the junction of metals with the different capacities for heat. A differential heating induces a differential molecular motion which transmits a part of the energy which has entered the chain, as that motion which we call electric current.

Take the dynamo. We are told that the voltage depends on the number of lines of force cut, and the idea is good enough for mere purposes of calculation. But why should cutting a line of force do anything but break it? Substitute the idea of forcing a polarisable chain into the line of force, so that its links are compelled to form part of the line, just as a regiment entering a formation would have to, and we have something intelligible. The molecules of the wire, in equilibrium under the constant forces affecting them, have suddenly to rearrange themselves in a polar order, which means a motion which is an electric current, because the arrangement is continuously changing. The conditions are identical with those of battery cells, of thermo-piles, of conductors; in all size, that is sectional area affects amperage capacity, or the number of polar chains which can be formed; in all the number in series, the successive inlets of energy on the one chain, means voltage, because it means voltance, the density of the energy which is put into the one chain.

§ 55. We may now follow the transformed "electric energy" into the circuit, considering for reasons given (§ 42), the circuit of simplest conditions, viz., of constant current, which, as is well known, are wholly unconcerned with either inductance or magnetance, these being purely phenomena of, because causes of, the variable period.

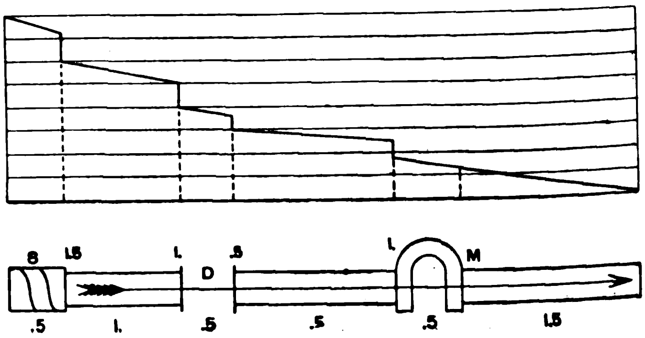



Fig. 5.

We find that the whole energy of the source is accounted for by several outlets: (1), various re-voltances or E.M.F.'s; (2), the true resistance of the circuit $C^2$ R; (3), work done through the agency of the circuit. Let Fig. 5 represent all these in the form of what is called "fall of potential," measurable in voltage lost, which means energy expended, and, therefore, eliminates the expression $C^2R$.

We may look at the matter in another way: if we put the case as a current of one ampere, then fall of potential is $-e$ in volts, and ohmage R, equivalent in value, so that the sum of these equals the gross voltage of the source.

The circuit is represented by the arrow traversing the source S, a voltameter D, and an electro-magnet M, doing work equivalent to a counter E.M.F. of one volt. These re-voltances are stated in figures above the line, while the ohmage of the several parts of the circuit are stated below the line. By some

Digitized by Google

oversight, there is ·5 too much introduced, but this is a detail of no consequence to the principle.

It will be seen that re-voltances appear as dead drops. They reduce the gross voltage, which is the vertical line at the beginning of the slope of potential, because they correspond to energy which is absorbed, and taken out of the circuit; while that absorbed in overcoming the resistance, appears as heat distributed over the whole circuit in the ratio of the ohmage of its several parts, and is shown in corresponding slopes.

§ 56. Let us look at the re-voltances first. Zinc forming zinc sulphate gives a gross voltage of 2·248 according to the old values of the ampere, &c., and it is needless to recalculate for the sake of a matter of 2 or 3 per cent.; this is subject to two reduction (*a*) the reaction of the material of which the – plate of the cell is composed; and (*b*) the voltance of the substance set free at the – plate.

The actual values are of no moment, so I have assumed whole figures; gross voltage 8, subject to re-voltage in the source itself = 1·5, leaving a net voltage = 6·5, furnished by the source. We next enter the voltameter, giving off at one electrode hydrogen with re-voltance = 1, and at the other oxygen with re-voltance = ·5. The known and calculated E.M.F. of what is called the decomposition of water is close on volts 1·5, and I have assumed that this is divided in the ratio of the relative volumes. Then the work of the electro-magnet is assumed to equal one volt of counter E.M.F.; this really means a unit of voltance per unit current, which is tantamount to power reckoned in watts or to any equivalent mode of reckoning energy.

In like manner, the resistance of the circuit, the energy consumed in the mechanical work of transmitting current, which, like other mechanical frictions, appears as heat, absorbs the remaining energy of the source, and tells us why the rate of current is controlled by the resistance of the circuit. Re-voltages are independent of current rate (not re-voltance which is governed by material quantity as well as the density of energy); until they are overcome no current is generated at all, or in Ohm's formula $E - e$ must be a positive value. Then, current must be proportioned to the energy available to force it through the circuit, and we have $\frac{E - e}{R} = C$

§ 57. Why need we go out of the conducting circuit to find a vehicle for energy? In what way, except in the special molecular motion which we call electric current, does the case of electric transmission of energy differ from any other case of transmission of energy?

Does anyone in his senses argue that when a mechanical motor transmits energy by means of shafting or belts, the energy is really transmitted by some imaginary medium, and that the shaft and the belt are mere waste pipes to get rid of some hypothetically superfluous energy which chokes the medium? If some mathematician were to administer that notion to a mechanical engineer, what sort of reception would he get? Yet the cases differ in no respect. Just as the motor puts a stress on the belt, just as the number of rotations of the motor controls the rotations of every wheel in the circuit, so does the electric source put a stress on its circuit, and its molecular reactions control the molecular reactions throughout its circuit. But we must calmly accept an equally baseless imagination on pain of being told we are half-educated electricians, and heretics.

§ 58. "Ah! but what about the variable period?" I hear some of the opposite party say. Well, my friend, what about the variable period? Just go and introduce the element of "frequency" and alternation to some mechanical motor (provided the owner will permit you), and then you shall see what you shall see. Just keep on starting and stopping a steam engine on full duty. Is there any single phenomenon of the variable period that you will not find a mechanical equivalent for? Stresses in any quantity; lost energy as much as you please. Only develop high "frequency" enough, and you will be glad to find any "medium" which will convey away the superfluous energy of the owner of the engine. I will now proceed to show this by examining the conditions of the hydraulic circuit, which is a nearly perfect analogue of the electric circuit.

*(To be concluded.)*

## THE SEPARATION OF FOUCAULT AND HYSTERESIS LOSSES.

BY GISBERT KAPP.

The total loss of power taking place in the armature of a continuous current dynamo beyond the unavoidable loss due to copper resistance, is made up of the following:—

(*a.*) Loss through mechanical friction.

(*b.*) Loss through hysteresis in the armature core.

(*c.*) Loss through Foucault currents, either in the armature core or in all the conductors, or in the conductors under commutation only, if the setting of the brushes is faulty.

A further loss of power is due to air resistance, but this is so insignificant that it may be neglected.

It need hardly be pointed out that any simple method by which we can separately determine these losses is of practical value, and I propose to describe such a method in the hope that some reader of *The Electrician* may find a way to further develop it, so as to become applicable to alternators and transformers, a class of apparatus in which the exact determination of Foucault and hysteresis losses is of even greater importance than it is in continuous current dynamos.

The method is based upon the supposition that the torque required to overcome hysteresis and mechanical friction is independent of the speed, and that, therefore, the work lost through these two causes (if the field strength remains constant) is simply proportional to the speed. Since both mechanical friction and hysteresis are assumed to follow the same law, it is clear that a method based on such an assumption cannot be used to separate these two losses, but can only give their sum. The loss by friction can, however, be determined with a fair degree of accuracy from the dimensions of the bearings, weights, magnetic attraction, speed, the lubrications, &c., and thus we can, at least approximately, get the hysteresis alone, provided we can separate the Foucault losses. It should also be remembered that the purely mechanical loss by friction is generally very small as compared with the other two losses, and an error in the estimate of the friction has only a small effect on the correct determination of the hysteresis loss, and no effect whatever on the determination of Foucault losses.

For the same excitation the Foucault losses must obviously increase as the square of the speed. We have, therefore, the following equation for the total number of watts wasted in the armature, other than by copper resistance:—

$$W = n\,H + n^2\,F.$$

*n* being the speed in revolutions per minute, and H and F coefficient which depend upon the excitation, but do not vary with the speed. The coefficient H refers to the loss due to hysteresis and friction, and the coefficient F refers to the loss due to Foucault currents.

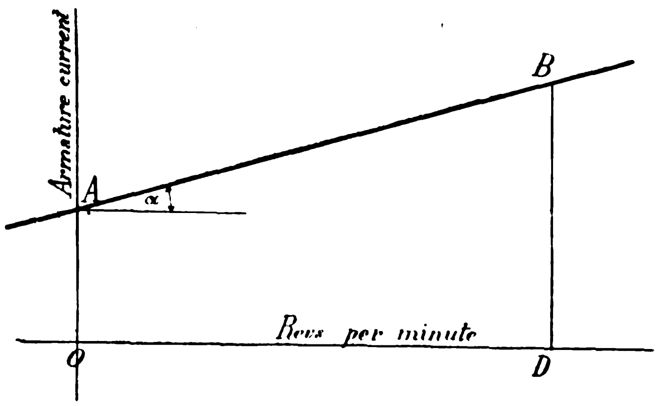
Mr. W. Mordey was probably the first to make use of this equation in order to determine and separate the various losses which occur in the armature. His method is as follows:—He drives the armatures by means of a belt from an electromotor, and notes either the electrical power supplied to the motor, or by means of a transmission dynamometer the mechanical power given to the armature with its field inert, and also with its field excited to various degrees. Provided the transmission dynamometer is correctly calibrated, or the efficiency of the motor is accurately known for these various conditions, and the loss of power in the belt is also known, this method can be used to separate not only Foucault losses from losses due to hysteresis and friction, but also the initial friction loss when the armature is revolving in a non-excited field from the hysteresis and friction loss when the armature is revolving in an excited field. Keeping the excitation constant, Mr. Mordey varies the power supplied to the armature under test, and thus gets a series of values for W and *n*, which are plotted in a curve. Selecting any two points on this curve (not too near each other) it is easy by a trial and error method, or by the solution of a quadratic equation to determine the

Digitized by Google

values of H and F, which will satisfy this curve throughout its range, and having found these values, the above equation enables us at once to separately determine the losses.

There are, however, some objections to this method. In the first place, it pre-supposes the possession of a reliable transmission dynamometer or an exact knowledge of the efficiency of the motor and of the loss of power in the belt, both points on which legitimate doubts may be entertained. In the second place, and this is the more serious objection, the necessity of using a second machine as a motor and rigging up a belt transmission, involves an amount of labour and expense which one would be glad to avoid. In the new method no second machine is required, but it has the disadvantage of being only applicable to armatures which have already received their winding; whereas Mr. Mordey's method can be used to investigate an armature core before it is wound. The method about to be described is also based on the above formula, but the power W is supplied to the armature under test electrically instead of mechanically; in other words, the dynamo to be tested is run light as a motor, and note is taken of the speed and armature current whilst the excitation is kept constant. At least one reading of the pressure at the brushes (preferably at the highest speed and armature current) must also be taken, but more such readings may be taken as a check. Since the dynamo is running light, the armature reaction on the field will be small enough to allow us to neglect it, or, in other words, we are justified in assuming that the field strength remains constant for all speeds. It should, however, be remembered that this is only an approximation, and that the Foucault currents, if they are very strong, will produce a distortion of the field, quite apart from the very small distortion produced by the armature current proper. In fairly good machines such a result need, of course, not be expected.

Assuming, then, a constant field of $z$ (English) lines, and denoting by $\tau$ the number of external armature conductors in




a two-pole machine, we have the E.M.F. at the brushes given by

$$e = z\,\tau\, n\, 10^{-6}$$

if we neglect the very small E.M.F. lost in armature resistance. The power supplied by the current $c$ is

$$W = e\,c,$$

or

$$c\,z\,\tau\,n\,10^{-6} = n\,H + n^2 F,$$

from which it follows that

$$c\,z\,\tau\,10^{-6} = H + n\,F.$$

Since $z$ and $\tau$ are constant, the current is equal to the sum of a constant, $\frac{H}{z\,\tau\,10^{-6}}$ and another factor, which varies directly with the speed. The curve representing the current as a function of the speed must, therefore, be a straight line, as shown in the annexed diagram. The height O A at which this line intersects the vertical axis is a measure of the current required to overcome the torque of friction and hysteresis, and the inclination of the line is a measure of the influence of Foucault currents, or in symbols

$$\tan \alpha = \frac{F}{z\,\tau\,10^{-6}}.$$

Let $c_0 = $ O A be the initial current, then we find directly from the diagram the value of the coefficient $H = c_0\, z\, \tau\, 10^{-6}$, and inserting this in the formula given above, the value of

$$F = \frac{W - n H}{n^2},$$

where $n$ and $w$ are observed values. It should be noted that in practice it is not even necessary to know the winding and field strength. All we need do is to observe the current and speed, in order to determine the position of the straight line A B, and take an accurate reading of the pressure $e$ and current $c = $ D B observed at a particular speed O D. The ratio $c_0/c$ at once gives the ratio of loss due to hysteresis and friction to the total loss which includes the Foucault losses, and since we know the total loss ($w = c\,e$) its two component parts can be found by a simple rule of three, and a subtraction. If the current curve A B is not a straight line, it is a sign that the Foucault currents are strong enough to produce a distortion of the field.

## GRAPHIC METHOD FOR ANALYSING LOSSES IN ARMATURE CORES, &c.

BY R. H. HOUSMAN.

It has long been known that the losses in the armature core of a continuous-current dynamo may be accurately measured by running it as a motor without load, and noting the

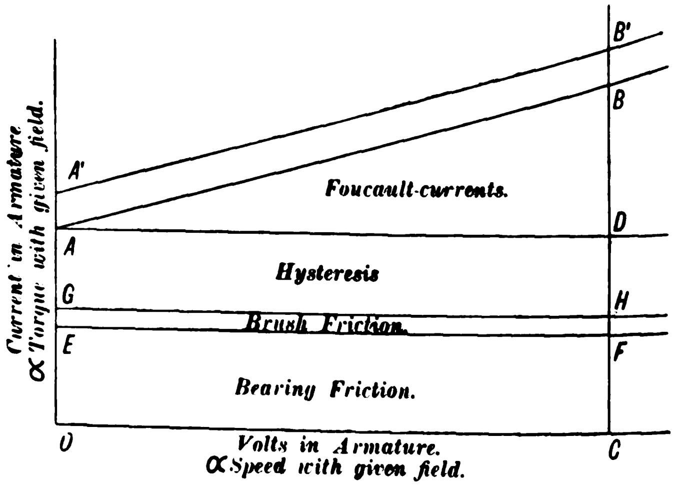



FIG. 1.—Electrical Diagram.

power absorbed. It was also shown by Mr. Mordey some little time ago that by plotting the losses, so measured, at different speeds, those which are proportional to the square of the speed (Foucault currents) may be separated from those which are directly proportional to the speed (hysteresis), by a mathematical process; but this process debars the method from general use.

It is, however, possible, by a simple graphical construction, to separate the different losses without any recourse to mathematics at all. The method is as follows:—Measure the current required to run the armature as a motor light with different volts on the armature, the magnets being separately excited so as to keep the field constant. On plotting the results as a curve, as in A B, Fig. 1, it will be found that the curve is a perfectly straight line, cutting the axis of current at some distance from the origin.

Now, taking any point B on the curve, and drawing B C parallel to A O, it is evident that the total loss is represented by the product O C × C B.

Next draw A D parallel to O C; this divides the area representing the total loss into two parts, one of which, O D, is proportional to O C, and the other, A D × D B, is proportional to the square of O C, since B D is proportional to A D which = O C. The first of these areas represents the waste of energy per

Digitized by Google

second due to hysteresis and friction combined, while the second gives the loss due to Foucault currents. It must be noticed that it is the product of the co-ordinates of any point on A B which represents the waste, and not the area of the figure A O C B. In this respect the diagram resembles the characteristic of a dynamo rather than the diagram of a steam engine.

Friction of bearings and brushes must be determined separately by coupling direct to a similar motor, and observing the increase of current required to drive with the fields unexcited. This will be constant at all speeds.

From this experiment draw O E equal to the current observed as required for friction alone, then E F being drawn parallel to O C the rectangle O F represents loss by bearing friction. By a similar experiment the loss by brush friction may be determined, and G H drawn, so that E H represents the loss from this cause. The remaining rectangle G D will then show the loss due to hysteresis. It will be readily understood that only the losses represented by G H × H B (Foucault currents + hysteresis) appear as heat in the armature.

A second set of experiments may be made with a different strength of field, and plotted in a curve A′ B′, which is in general parallel to A B, showing that Foucault currents are constant for given volts. A′ B′ will be above or below A B, according as the change of field intensity has increased or diminished, the sum of the losses due to hysteresis and friction, these two varying inversely, though not in simple inverse ratio.

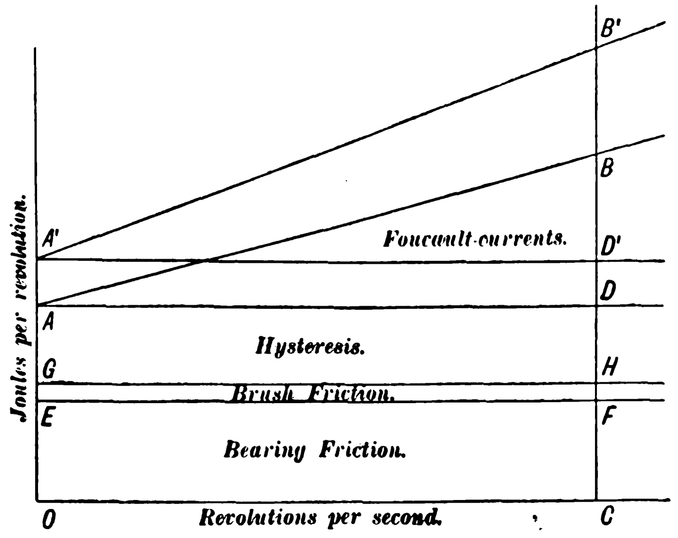



FIG. 2.—Mechanical Diagram.

At a certain intensity the total losses for given volts will be a minimum ; this in practice seems generally to occur between 15,000 and 16,000 lines per sq. cm. in the iron of the armature, but the exact figure depends on whether friction is large or small. In machines with little friction, the best intensity may be much lower. There is a curious point about the Foucault currents at high intensities (18,000 or 20,000) ; they show a decided tendency to *increase*, the slope of the curve A B becoming much steeper. This is probably due to the increased stray field in the shaft and flanges at the ends of the armature, which being solid metal may have large currents in them when the field through them reaches 200 to 300 lines per sq. cm.

In Fig. 1. all the quantities have been measured electrically, hence it may be called the electrical curve to distinguish it from another diagram which may be derived from it, in which the quantities are measured in mechanical units. The electrical diagram has the disadvantage that, for each intensity of field, a separate friction line has to be drawn, which makes it difficult to distinguish how much of the whole loss is electrical and how much frictional, when there is more than one curve drawn on the same diagram. This difficulty is obviated by plotting revs. per sec. instead of volts along the horizontal axis, and work per revolution in Joules instead of current along the vertical axis. It will be noticed that the product of these two is expressed in watts (or work per second), as before, but it only requires an alteration of scale to make the co-ordinates revolutions per minute and foot-pounds per revolution respectively, in which case the product ÷ 33,000 gives horse power.

In this diagram the same friction line holds good for all intensities, and the frictional and electrical losses are separated by the line G H (Fig. 2). It will also be seen that the quantities G A and G A′ represent the losses by hysteresis, in Joules per cycle, at the two intensities, for which A B and A′ B′ are drawn respectively. The loss per cubic centimetre from this cause is always found to be much greater than that generally given.

## THE PROPAGATION OF HERTZIAN ELECTRICAL OSCILLATIONS IN AIR.*

BY MM. E. SARASIN AND L. DE LA RIVE.

We have already had the honour of presenting to the Academy the first results obtained by us on repeating the beautiful experiments of Hertz on rapid electrical oscillations†. We confined ourselves on that occasion to the case of electrical oscillations transmitted along a conducting wire. Since then we have repeated another of Hertz's experiments, which consists in following the propagation of the electric induction across air in the absence of any metallic conductor. The primary exciter is placed in front of a large plane metallic sheet arranged parallel to it. The electric waves which emanate from it are propagated across the air, and impinge on the sheet of metal, which acts as a mirror, the reflected waves forming, with the direct waves, a stationary system, the first node of which is at the mirror itself. In order to study this system of concamerations which is established in front of the mirror, a circular resonator is moved about in two different principal positions, (1) constantly parallel to the mirror and to the primary, *i.e.*, in the plane of the wave, (2) displaced into the plane drawn nominally to the mirror through the axis of the primary, *i.e.*, plane of vibration. In both cases the results are absolutely concordant so far as concerns the equidistant positions of maximum and minimum E.M.F.'s. In addition to these two methods of proceeding, Hertz employed a third, which consisted in causing interference between waves arriving at the same resonator from the same exciter, either directly across the air or along a conducting wire. From these experiments Hertz concluded by the great wave length, that the rate of propagation across air in the absence of any conducting wire, was almost twice that observed along a wire, the two speeds being in the ratio of about 7:4. This disagrees with Maxwell's theory which makes the two speeds equal.

In view of its great theoretical importance we have applied ourselves specially to the verification of this particular point. Having proved by our previous experiments in connection with oscillations propagated along wires that the oscillatory period of a given circular resonator is constant, whatever the primary exciter by which it is energised, the same exciter permitting us to observe as many wave lengths as we possess different sized circles, we set to work to compare the length of a wave given by the same circular resonator when the impulse was propagated along wires, with that given when the impulse was propagated in air without wires. As reflecting surface we employed a large screen of sheet lead 2·8m. high and 3m. broad, kept plane and vertical by its own weight. The primary exciters and the large Ruhmkorff coils were the same that we employed in our previous investigations. The exciter was placed in front of the mirror, with its axis horizontal and its spark gap on the normal to the centre of the metal screen. Its distance from this was varied between 4m. and 10m. The circular resonator was fixed on a carriage sliding along a large wooden optical bench, already described. We widely varied the conditions of the experiment, and repeated the observations a great number of times, and we

* From the *Comptes Rendus*, Vol. CXII., No. 13.

† *Comptes Rendus*, January, 1890. See also *The Electrician*, Vol. XXIV., page 316.

Digitized by Google

| Diameter of circle D. | 1m. thick wire 1cm. d. | ·75m. thick wire. | ·5m. thick wire. | ·35m. thick wire. | ·35m. thin wire 2mm. d. | ·25m. thick wire. | ·25m. thin wire. | ·2m. thick wire. | ·2m. thin wire. | ·1m. thick wire. |
|---|---|---|---|---|---|---|---|---|---|---|
| First internode | 2·11 | 1·60 | 1·11 | 0·76 | 0·75 | 0·46 | 0·54 | 0·39 | 0·42 | 0·21 |
| First node | 4·14 | 3·01 | ... | 1·49 | 1·51 | 0·94 | 1·17 | 0·80 | 0·93 | 0·41 |
| Second internode | ... | ... | ... | 2·30 | 2·37 | 1·63 | 1·89 | 1·24 | 1·55 | 0·59 |
| Second node | ... | ... | ... | 3·04 | 3·10 | 2·15 | 2·40 | 1·69 | 2·05 | 0·79 |
| Third internode | ... | ... | ... | ... | ... | 2·71 | 2·94 | ... | 2·46 | 0·95 |
| Third node | ... | ... | ... | ... | ... | 3·14 ? | ... | ... | ... | ... |
| ¼λ wire | 2·03 | 1·41 | 1·11 | 0·76 | 0·80 | ... | 0·60 | 0·43 | 0·51 | 0·19 |
| ¼λ air | 1·92 | 1·48 | ·98 | 0·73 | ... | ... | 0·56 | ... | 0·45 | ... |
| 2 D | 2·00 | 1·50 | 1·00 | 0·70 | 0·70 | ... | 0·50 | 0·40 | 0·40 | 0·20 |

summarise in the table above the results which we obtained with ten different circles.* We give in this table the mean of the results obtained with each circle, and in order to abbreviate we have not separated out the measurements made with primary exciters of different dimensions, which did not exhibit any systematic difference. In these last investigations in air as in our previous ones with wires, we have, in fact, proved that *a circular resonator always gives the same wave length*, even when the dimensions of the primary exciter is varied within certain limits.(†) We have, therefore, again observed what we have termed *multiple resonance*. In the case of large wave lengths (circles of 1 metre and ·75 metre in diameter), which are very rapidly carried a long distance from the mirror and approach the direct action of the primary, one can only verify with any degree of precision one internode and node besides the node at the mirror itself. With smaller circles, for which the size of the mirror is more suitable, one can easily determine three internodes and nodes, including that at the mirror. The equidistance of the internodes and nodes is, as one can see, fairly satisfactory.‡

The most important result of our investigation arises from the comparison of the figures in the last three lines of the table. These show that the wave length obtained is in every instance sensibly equal in the case of propagation, through air and along wires, the quarter of either wave length being nearly equal to twice the diameter of the corresponding circle. From this it follows that *the rate of propagation of Hertzian electrical oscillations, through air, is very sensibly the same as that of those transmitted along a conducting wire.*§

## NOTES ON THE DESIGN OF MULTIPOLAR DYNAMOS.||

BY W. B. ESSON.

Though comparisons have frequently been made of the capabilities of machines having two poles and those having a greater number, I am not aware that the design of multipolar dynamos has yet received systematic treatment in any communication, or that a very satisfactory basis for comparison of the two types has up to the present been suggested. A perusal of the notes scattered about in technical journals, proceedings of societies, and text-books shows that the ideas on this subject are of the vaguest character, their expression having a most uncertain tone, and generally manifesting some erroneous notion. It is with a view of clearing the ground a little, and inducing some expression of correct ideas from members present, that these notes are brought before the Institution.

1. *Prevention of Sparking in Machines generally.*

In the Paper which I submitted for your consideration 12 months ago, attention was directed to certain empirical formulæ relating to the armature loads for direct-current machines. From the data furnished by a large number of examples, some of which were given in the Paper, an expression for the load which could be safely carried by armatures without causing sparking was obtained; this expression, though admittedly of an arbitrary character, having been proved by my own experience, and that of my colleagues, to have been of some service. In that Paper the term "ampere-turns" was employed to denote the product of the number of conductors on the exterior of the armature and the current carried by each, and I am afraid this may have led to some confusion; at least, so it appears from the discussion. In order that there shall be no misunderstanding in the present case, I shall call this product, quite irrespectively of the number of poles, the *volume* of current carried. The volume is, therefore, the total current flowing parallel to the armature shaft, independently of direction and whatever the number of poles, and it is obtained by multiplying the conductors on the exterior of the armature by the current flowing in each; or, considering the exterior winding as a copper cylinder, it is the total current flowing in it parallel to the axis.

In his Paper on "Armature Reactions," read here last year, Mr. Swinburne had worked out the limiting load from a theoretical point of view, and those who were present will remember that to obtain the results given in his Paper, the author assumed that the brushes were placed almost close to the polar tips. So far as the practical consideration of the subject goes, it matters little, I think, whether this is strictly accurate or not; because, while moving the brushes back from the tips increases the ampere-turns producing the cross field, the magnetic resistance of the cross circuit is at the same time increased, due to the interposition of an increased air-gap. For the moment, however, it will be assumed that the brushes are somewhere near the pole-tips—in their vicinity, let us say—and that the only conductors concerned in producing the cross field are those covered by the pole-pieces. This is sufficiently near the truth for our purpose. Under these circumstances the magnetising force in ampere-turns producing a cross field is, of course, $\frac{v\,\phi}{360}$, where $v$ is the volume, and $\phi$ the angle embraced by each pole-piece in degrees. Call $l$ the length of the air-gap, measured from the surface of the armature core to the polar surface, and I the induction per square centimetre which would be produced in the gap due to the field magnets alone. When a current flows in the armature the field is weakened at the pole-tips nearer the brushes, and strengthened at those farther from them. Imagine that the armature is loaded so that the forward induction under the nearer pole-tips is just balanced by the cross induction, and we have $\frac{v\,\phi}{360} = 2\,l \times \cdot 8\,\mathrm{I}$, assuming that the components of the cross circuit, other than the air-gap, have no resistance. According to this equation, with a value $v = \frac{576\,l\,\mathrm{I}}{\phi}$,* the forward and cross induction at the pole-tips would be equal, the field would be *nil* at the brushes, and, the machine being unstable, any increase of current would at once cause great sparking.

The above expression gives what might be called the theoretical load limit, on the assumption that no field is required for reversing

* The sensitiveness of the micrometer screw is a very important element in this branch of research, especially with small circles which only give very feeble sparks. We employed finally a screw giving $\frac{1}{150}$th of a millimetre.

(†) The intensity of the spark being weaker in this experiment than in the case of wires, and diminishing, moreover, much more rapidly as one goes further from the primary, observations are always less clearly defined than with wires. In order, therefore, to work under good conditions it is necessary to give the primary dimensions appropriate to the resonator. The limits between which one can conveniently observe the phenomenon of multiple resonance are less wide than with wires, but they can easily be made to vary by 100 per cent. or even more.

‡ Hertz places the first node at a certain distance behind the mirror. This disturbance of the extremity does not seem to be deducible from our experiments. As is to be seen from the table, the first quarter of a wave length does not show any sensible systematic difference compared with the rest.

§ We have already made this statement in a preliminary communication on this subject, made to the Société de physique et d'Histoire Naturelle de Genève, at its meeting of May 1, 1890 ("Archives des Sciences Physiques et Naturelles," Vol. XXIII., p. 557), but we have entirely reinvestigated the matter, varying the conditions of the experiment in a number of ways, and it is this work which we summarise here. Lecker, of Vienna, for his part has found by an entirely new method that the rate of propagation of the electrical oscillation along a wire is that of light.

|| Paper read before the Institution of Electrical Engineers, April 9, 1891.

* I have pointed out to Mr. Swinburne that the equations $\mathrm{A} = \frac{10\,b\,g\,\mathrm{B}_a}{\theta^2\,r}$ and $\mathrm{A}_2 = \frac{10\,\mathrm{B}_a\,r\,\mathrm{R}\,l}{v^2}$, which he gave last year on page 266 of his reply, ought to be $\mathrm{A} = \frac{5\,b\,g\,\mathrm{B}_a}{\theta^2\,r}$ and $\mathrm{A}_2 = \frac{20\,\mathrm{B}_a\,r\,\mathrm{R}\,l}{v^2}$ respectively. In looking over his Paper and reply, Mr. Swinburne finds other slips, which he will probably correct as discussion on the present Paper proceeds.—W. B. E.

Digitized by Google

the current in the sections as they pass the brushes, but it need scarcely be pointed out that in practice the volume is always much under what would be given by the formula. In the nature of things, one expects in the dynamos of different makers a considerable variation in the relation which the actual load bears to the limit above indicated, and such differences undoubtedly exist; but while one finds, on examining a large number of machines, several under, in few cases are there any having for $v$ a greater value than half that given by the equation. This large margin must be considered in the light of a safety factor, for it would be folly to build machines the commutators of which would be liable to ruin by an occasional increase of current over the normal. No one expects machines to stand, in continuous working, a current of 50 per cent. over their normal output, for the rise in temperature would then be excessive; but, from the sparking point of view, this increase in a well-designed machine ought to make but little difference to it. Generally, the relation existing between the volume, gap dimensions, and induction in the best machines is expressed approximately by the equation,

$$v = \frac{288\, l\, I}{\phi} \quad . \ . \ . \ . \ . \ . \ . \ . \quad (1)$$

which gives, I consider, a very good rule for use in practical work. According to this, the working volume has about half the value expressing the absolute limit, this relation indicating the margin of safe working dictated by practice and experience. The formula expresses, in fact, an empirical relation which has a certain degree of flexibility. But with such a large margin it will be readily perceived that the strict accuracy of our assumption about the position of the brushes is of trifling importance, as is also our assuming that the whole of the magnetising force of the cross field is spent in the air-gap.

It is easy to translate the above expression into the form I previously used for cylinder armatures. Call $r$ the radical depth of the armature core, $w$ the width of the pole-piece, and $I_2$ the induction in the core. The induction I in the gap is $\frac{2\, r\, I_2}{w}$; and substituting for I its value, we have

$$v = \frac{576\, r\, I_2\, l}{w\, \phi} \quad . \ . \ . \ . \ . \ . \quad (2)$$

Taking the induction in the armature core at from 17,000 to 18,000 C.G.S. per square centimetre, and inserting an average value of $\phi$, we get for bi-polar Gramme-wound machines the expression,

$$v = \frac{r\, l\, 85{,}000}{w} \quad . \ . \ . \ . \ . \ . \ . \ . \quad (3)$$

which I had used for some time, and which was given in my last year's Paper. This is only a rough approximation, for, as Mr. Swinburne has pointed out, to be quite accurate the angle should appear in the denominator as in (1) and (2). The simplest form the expression can take is given in (1). This contains nothing but the length of the air-gap, the induction in it, and the angle of the pole-piece. It will be observed that it takes no notice of the diameter of the armature or of the number of poles. So far as the sparking limit is concerned, it gives a rule which may be employed in designing machines of any size and with any number of poles.

### 2. *The Relation of* v *to the Diameter of the Armature.*

But besides taking care that the armature load does not approach the sparking limit, we must provide ample surface for getting rid of the heat generated in the conductors. The first thing to be settled in designing a new machine is what this amount of heat shall be; or, in other words, we must fix the ratio which the energy appearing at the terminals shall bear to the total electrical energy produced. Having settled this, sufficient radiating surface must be allowed to prevent too great a rise in temperature—a point to which due consideration has already been given.

The principal factors which determine the relation of the volume to the diameter of the armature are efficiency and temperature. It will be seen that the equation (1) gives no direct information respecting the diameter for a given volume, and as long as I, $l$ and $\phi$ remain unchanged, the tendency to sparking would be the same whatever the diameter. But it is not so with the heat generated or the temperature rise, for assuming $v$ and $l$ to be related as shown, the smaller the diameter, the greater would be the temperature. To carry a given volume we must have, consistent with the waste of power permissible, a certain section of copper; and this copper should be disposed so that a cooling surface is provided sufficient to keep the rise in temperature within the specified limit, while the gap, being of sufficient length to prevent sparking, should have only the dimensions necessary for accommodating the conductors and allowing of proper clearance.

Through the kindness of members of the Institution and others, who have liberally supplied me with figures, I have been able to ascertain the nature of the relation between the diameter and volume existing in all the best known machines, from the smallest to the largest sizes. The figures refer to both cylinder and drum-wound armatures, and include machines with two, four, six, and eight poles. Though I am not at liberty to publish the data in full, the general results are given. There is not so much agreement between the dynamos of different makers in respect to this relation as might have been expected, and for $v$ we have all kinds of values, ranging from 200 to 1,000 times the diameter of the armature in centimetres. If full advantage of the length of the air-gap were taken, and the thickest possible conductor used in each case, the diameter, to give a uniform temperature for all sizes, would be about proportional to the square root of the volume; but there are several reasons why this proportion should not obtain in practice. With this relation the ratio of the stray to the useful field would increase with the diameter, thus entailing an extravagant expenditure of energy in producing the requisite gap induction. Again, while the total field through the armature would increase simply as the diameter, the volume carried would increase as the *square* of the diameter, this being at variance with the well-established rule that the total field through the armature increases rather than diminishes relatively to the volume as the size is increased. It will be understood, of course, that precisely the same result is arrived at whether we consider the volume fixed and endeavour to find the best diameter, or consider the diameter fixed and seek for the best volume. It is simply a question of obtaining the most economical construction, having regard to cost of materials, efficiency, prevention of sparking, and temperature limit, though the figures at my disposal show estimates of the relative values of these several factors to be by no means uniform.

Though the relation lacks definiteness to some extent, I find in the data of a large number of machines indications sufficiently pronounced to justify us in regarding the volume carried by the armatures of two-pole dynamos as proportional to the diameter for all sizes. In designing cylinder machines the value of $v$ may be taken as 400 times the diameter of the armature in centimetres, while for drum armatures the volume is obtained by multiplying the diameter by 600.* The cylinder armature has for a given volume a larger diameter, because of the influence of the interior wires. These being heaped inside to one and a-half or twice the depth of the exterior winding, also being longer, a larger diameter is required for a given volume, both from efficiency and temperature considerations. Necessarily, the relations here given are not of a hard-and-fast character, and may be varied considerably. But whatever the proportion adopted, it is absolutely essential that the sparking limit already considered be not too closely approached.

In machines having four and six poles the same average relation between the volume and diameter holds in practice for both cylinders and drums. In the calculations which follow these figures will therefore be adopted.

### 3. *Output of Direct-Current Armatures.*

If we call N the total number of lines of force entering the armature from all the poles, however many, and $n$ the number of revolutions per second, the average E.M.F. generated in each conductor is, of course, $N\, n\, 10^{-8}$. If C be the total current flowing, each conductor will carry with the sections coupled in the ordinary way $\frac{C}{p}$ amperes, $p$ being the number of poles. The electrical work due to each conductor, is $\frac{C}{p} \times \frac{N\, n}{10^8}$; and the total work, $\frac{w\, C}{p} \times \frac{N n}{10^8}$, where $w$ is the number of conductors, counted all round the exterior of the armature. The quantity $\frac{w\, C}{p}$ is what we have called the *volume*, and we get for the total electrical output in watts the expression,

$$W = N\, n\, v\, 10^{-8} \quad . \ . \ . \ . \ . \ . \quad (4)$$

which is quite independent of the manner of coupling up the armature sections. It will be evident, I think, that with the same relation existing between $v$ and $d$ for two, four, and six poles, the output of an armature of given diameter and length, running at the same speed, is quite independent of the number of poles. It matters not whether N be furnished by two poles only, or by four poles of half the angular width, provided its value remains unaltered.

The volume, then, may be expressed in terms of the diameter. The quantity N may be expressed in terms of the diameter × length of the armature. Taking an induction of 5,000 C.G.S. units per square centimetre in the air-gap—a very usual figure—and assuming that the fraction of the armature circumference covered by the pole-pieces = 2·25 $d$, we get, calling L the length of the armature in centimetres, 11,250 $d$ L as the total number of lines of force entering the core. Call this, in round numbers, 12,000 $d$ L. Substituting for N and $v$ their values, the output becomes for cylinder armatures

$$W = \cdot 048\, d^2\, L\, n \quad . \ . \ . \ . \ . \ . \quad (5)$$

* In my last Paper the number given was 570. This I now amend as above.—W. B. E.

Digitized by Google

and for drum armatures

$$W = \cdot 072\, d^2 L n \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

This applies to all direct-current machines, whether bi-polar or multi-polar; though it will be understood, of course, that the induction in the gap may be greater or less than what has been assumed. In that case the coefficients ·048 and ·072 would be altered, without changing, however, the form of the expression.

4. *Output of Alternating-Current Armatures.*

The armature loads for alternators, though producing a cross magnetisation, as in direct-current machines, raise no considerations, of course, as regards sparking. But on account of the greater proximity of the poles, and the greater stray field resulting, it is desirable to make the layer of copper on the armature core as thin, and the air-gaps as short as possible. As a consequence, probably, of the increased ratio of stray to useful field, the induction is less in the gaps of alternating than in those of direct-current machines. Here it will be assumed that the virtual induction is 4,000 C.G.S. units per square centimetre, meaning that this represents the induction to which the resultant E.M.F. is due. The impressed E.M.F. is greater than the resultant, and the induction due to the field magnets alone is greater than 4,000; but what I am dealing with is the field resulting from the inter-action of the magnet and armature fields; it is the field to which the resultant E.M.F. = C R is due, this and the current being coincident in phase. Usually the poles cover a fraction of the circumference = 1·5 *d*, the value of N for alternators being then 6,000 *d* L. About half the circumference being covered with wire, under usual conditions of temperature and efficiency we have for *v* a mean value of 400, which gives for the product of mean resultant E.M.F. and mean current = ·024 $d^2$ L *n*. In some cases, as in the Westinghouse machine, the conductors cover considerably more than half the circumference, and *v* is therefore greater. But here, on account of the differential effect produced on the separate wires of the same section, the added turns have nothing like a proportionally increased value, and the expression will give approximately the value of the product of mean resultant E.M.F. and mean current, even in these machines. Assuming that the E.M.F. is a sine function of the time, to get the watts we must multiply by $\frac{\pi^2}{8}$, which gives us, therefore, as the output of the alternator,

$$W = \cdot 0296\, d^2 L n \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

or rather over 40 per cent. of the work done by a drum-wound direct-current machine having an armature of the same external dimensions. Some comparisons have been made of the output of direct and alternating machines of the same weight, but these, in the nature of things, must be misleading. The two types are quite unlike in their proportions, as Figs. 1 and 2 show, and no one would think of making them the same. Fig. 1 represents the magnetic system of a four-pole direct, and Fig. 2 that of a 12-pole alternating machine of the same output; and while it will be observed that the iron parts—core and yoke-rings—are much heavier in the former, it will be noticed that the copper in the magnet coils is much heavier in the latter. In fact, though the iron in the alternator is only 55 per cent. of that in the direct-current machine, the copper required is no less than 250 per cent. It is difficult, then, to understand what useful purpose is served by comparisons such as I have alluded to.

FIG. 1.

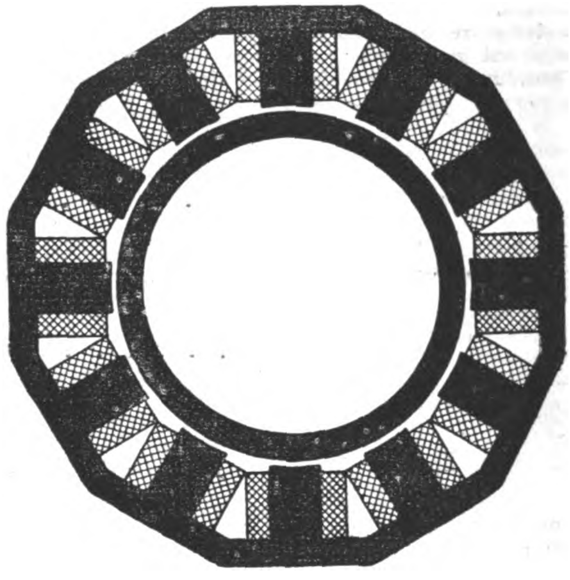


FIG. 2.

5. *Relation of Air-gap to Diameter of Armature and Number of Poles in Direct-Current Machines.*

Having established the proportionality of the volume and diameter, it is easy to find the relation which must exist between the diameter and length of air-gap for any particular angle of embrace in order that sparking may not occur. I need not take up time ringing changes on the several equations, as to obtain the relation now referred to, all that has to be done is to substitute for *v* in (1) its value in terms of the diameter accordingly as the winding is of the cylinder or drum type, and find the connection between *l* and *d*. Preserving the same safety factor throughout, it will be found that two-pole dynamos with a mean gap induction of 5,000 C.G.S. units per square centimetre, and pole-pieces embracing an angle of 130deg., must have—the volume being related to the diameter as described—a gap of not less than ·036 *d* if cylinder-wound, or ·054 *d* if drum-wound. As will have been observed, the air-gap may diminish as the induction is increased or as the volume is reduced.

But, as is also seen from the equation, the gap required for any particular volume is proportional to the angle of embrace, and if we substitute for two poles a greater number of correspondingly less angular width, working with an increased diameter and volume without a proportionally increased gap is made possible. This is where the advantage of the four, six, or even eight-pole machine comes in. Keeping to two poles, increasing the diameter requires either a proportional increase in the gap, whether the space is required for the conductors and clearance or not, or an increased induction, or a diminished polar angle, or a combination of these. In either case, the magnetising force spent in the gap is increased; and, other things remaining the same, obviously it would be of some advantage to adopt a construction which, while producing no greater tendency to sparking, would admit of the air-gap being reduced until its length was just sufficient to accommodate the conductors and allow of the necessary clearance. The work done by an armature of given external dimensions we have seen to be quite independent of the number of poles, and the choice of this number can only be a question, therefore, of structural and working economy.

6. *Dimensions of the Armature.*

It has been observed that the output of an armature is proportional to $d^2$ L; and the induction being the same, the weight of the core for a given number of poles must be proportional to the output, the radial depth increasing directly as the diameter, so that a proportionally increased field may be carried. The number of poles being fixed, the weight of the core for a given output may be taken, therefore, as approximately constant, whatever the ratio of L to *d*.

As the number of poles is increased, the induction remaining the same, the radial depth of the core is diminished in proportion, and, within the limits of practice, we may make the further assumption that the weight is inversely as the number of poles. The money value of a reduction in the weight of material due to increasing the poles can easily be arrived at.

Digitized by Google

The power wasted in hysteresis is proportional to the weight of iron magnetised, and to the number of reversals per second. The weight being inversely, and the reversals directly, as the number of poles, the power wasted is for a given output the same; furthermore, as the output is proportional to the speed, we may say that for a given induction the loss in hysteresis is about proportional to the output only, without reference to speed of rotation, weight of core, or number of poles. If it be more important to reduce the loss by hysteresis than to reduce the weight of material, it can, of course, be done. It is a point for the designer to consider.

So much for the core; let us now consider the copper part. Taking Gramme-wound armatures having an interior opening equal to ·66, or two-thirds of the core diameter, it is found—the output, speed, and temperature being predetermined—that the ratio of L to $d$ may vary through a considerable range without making any great difference in the weight of copper or efficiency. For instance, the most efficient relation being $L=\frac{d}{3}$, it may be varied on the one hand till $L=d$, or on the other till $L=\frac{d}{6}$, without increasing the copper by more than about 10 per cent. Of course the watts wasted in the armature are correspondingly increased, but within the limits of the large variation mentioned the reduction in the electrical efficiency of the machine is under one-half per cent. In two-pole machines L varies from ·5 to 1·5 $d$, the normal relation being about $L=d$. As has been seen, the gap has to be increased in proportion to the diameter, unless a greater number of poles be employed; and the disadvantage of an increased magnetising force would, in machines with only two poles, counterbalance the slight advantage of getting the armature dimensions nearer the best proportion. When the poles are increased, however, the gap may remain fixed, and if the radial depth of the core be correspondingly diminished, the proportions for least copper and highest efficiency are altered: thus in a four-pole Gramme we can work from $L=\frac{d}{3}$ up to $L=\frac{d}{12}$ without a greater variation than 10 per cent. in the weight of copper. Observe, this is a question differing altogether from the one which was considered in my former Paper. In that case the length and radial depth of the armature over the winding were fixed, the problem then being to find the best relation of copper to iron. Here both radial depth and length of core alter, also the peripheral velocity, though the revolutions per minute remain the same. Why the velocity is allowed to alter will be immediately apparent; I only show at the moment that the dimensions of the armature may have their relations altered considerably without making any considerable difference to the weight of copper or efficiency.

To drum-wound armatures precisely the same reasoning applies. Here, speed and temperature being fixed as before, the best proportion for two-pole machines is about $L=3{\cdot}3\,d$; but because of the distance between the bearings which such a relation would necessitate being inconveniently great, we rarely find $L=2\,d$ exceeded. The latter requires about 5 per cent. more copper than the former; while for the usual proportion, $L=1{\cdot}5\,d$, 12½ per cent. more is required than for $L=3{\cdot}3\,d$. The variation which can be made without overstepping the limits of economy has a smaller range in drum than in cylinder machines, owing to the greater relative importance of the end wires, because of their greater length. If the length of the core is reduced below $L=1{\cdot}5\,d$, the copper in machines with two poles increases rapidly; but if the number of poles be increased, the length of the end wires being shortened nearly in proportion, the core length may be reduced to a fraction of the diameter without sacrifice of copper or efficiency. In a four-pole machine, for instance, the same copper is used with $L={\cdot}5\,d$ as in a two-pole one with $L=2\,d$; while for six poles, without increasing the copper, the relation may be as small as $L={\cdot}25\,d$. The effect of adding poles when the diameter is relatively great is not so noticeable in Gramme-wound machines, as the end wires are less important.

All the above facts go to prove that if there is anything to be gained, as regards the production of the field, by increasing the diameter of the armature and the number of poles, there is nothing, considering the armature by itself, to be lost by it. It may, in fact, be rather an advantage, because the weight of the iron core is reduced. It is true the peripheral velocity is increased; but this does not matter in the least, provided a certain limit is not exceeded. Opinions differ as to what the limit should be, some machines working at 50 feet per second, others at 100, and a few as high as 125. But there is no reason whatever why any properly constructed armature should not run at a periphery speed of 100 feet per second; and provided this velocity is not exceeded, any advantage which may be obtained by a relatively large armature and increased number of poles should be secured.

*(To be continued.)*

## INDUCTIVE DISTURBANCES IN TELEPHONE CIRCUITS.*

BY J. J. CARTY.

It was not known until 1838 that the earth might be used instead of a return wire in the circuit of a telegraph line. This fact was discovered by Steinheil, while making experiments to determine whether the track of a railroad could be used to complete the circuit instead of a return wire. Steinheil's discovery has been considered as one of the most important in the art of telegraphy, and since his time it has been the almost universal practice to use the earth as a return in telegraph circuits. When, however, the earth return is used with the telephone, it is found that owing to the extreme sensitiveness of that instrument, many foreign currents, which would produce but little effect on telegraph instruments, become a source of serious trouble. For this reason, in telephony it is often necessary to use a complete metallic circuit. Thus it has come to pass that a return to the original practice of employing metallic circuits, as in the case of the crudest telegraph instruments, is now regarded as a most important improvement in connection with that most highly developed of telegraph instruments, the telephone. To obtain complete freedom from inductive

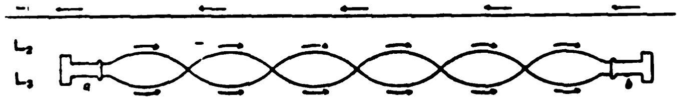


FIG. 1.

disturbances in the telephone, it is necessary not only to use a metallic circuit, but to place the two wires composing the circuit in a special relation to the source of disturbance. One of the methods of so arranging the wires is shown in Fig. 1. In this case the two sides of the circuit $L_2$ and $L_3$ are twisted spirally about each other, so that their average distance from the dirturbing wire $L_1$ shall be the same. With such a plan, the telephones $a$ and $b$ are not affected by induction from the wire $L_1$. This fact has usually been explained by assuming that a current, commencing to flow in $L_1$, tends to induce two currents in the opposite direction to itself, one in the wire $L_2$ and the other in the wire $L_3$; that both currents are of the same strength because the average distance of $L_2$ and $L_3$ from the disturbing wire $L_1$ is the same; and that the telephones $a$ and $b$ are silent because they are acted upon by two equal and opposite forces. The above theory seems at first sight to be correct, and indicates the line of explanation adopted in many works treating of the subject.†

I have made a number of experiments which seem to prove that in the case described, the inductive action, instead of tending to produce a simple current in each side of the metallic circuit, actually does produce a number of different currents in each wire and in both

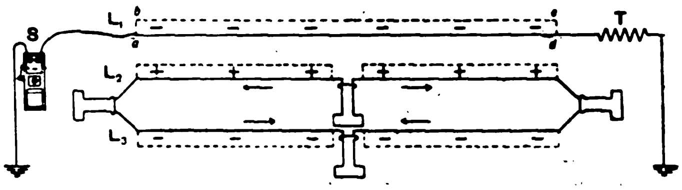


FIG. 2.

directions. In Fig. 2, $L_2$ and $L_3$ are two well insulated copper wires, 500ft. long and 3ft. apart. These wires are joined together at each end through an ordinary telephone. $L_1$ is a well-insulated wire similar to the other two, and placed within one-half an inch of $L_2$. At one end of $L_1$ is placed a Blake transmitter T, and at the other end is placed a subscriber's bell, S; $L_1$ being grounded at both ends as shown. When the transmitter T is operated, either by speaking into it, or by vibrating a powerful tuning fork in front of it, disturbances are produced at the end telephones.

If telephones are inserted at the centre of $L_2$ and $L_3$ it is found that at these points no sound is heard, while the noise of the end telephones continues as before. This constitutes a simple case of inductive disturbance, and can only be explained by assuming that the wire $L_1$ acts electrostatically upon the circuit composed of $L_2$ and $L_3$, or in other words, that we are dealing with a system of condensers in series, of which $L_1$ constitutes one plate, the earth another and the wires $L_2$ and $L_3$, two intermediate plates, which are

* Paper read before the American Institute of Electrical Engineers, March 17, 1891.

† "A Handbook of Practical Telegraphy," R. S. Culley, 1885, p. 330. "The Telephone," Preece and Maier, 1889, p. 134. "Die Technik des Fernsprechwesens," Dr. V. Wietlisbach, 1886, p. 135.

Digitized by Google

joined together through the end telephones. Let us assume that at a given instant the height of potential along the wire $L_1$ is represented by the lines *a b* and *c d*, and the charge upon $L_1$ by the rectangle *a b c d*. The presence of this charge, which we will say is of the minus sign, is accompanied by an equal but plus charge on $L_2$. This produces a minus charge on the wire $L_3$, which in turn acts upon the earth. Now we will assume that the potential of $L_1$ reduced to zero. This causes a restoration of the equilibrium in the circuit composed of $L_2$ and $L_3$, which is accompanied by a set of currents as represented by the arrows. The plus charge on $L_2$, flowing through the end telephones, neutralises the minus charge on $L_3$, thus leaving a neutral point at the centre of each of the wires $L_2$ and $L_3$.

In this and the succeeding experiments the induced charges are represented by rectangles. This is not a strictly accurate method, but as an error in this respect only affects the result quantitatively, and cannot alter the conclusions, I have adopted it on account of the simplicity of treatment which it permits. The potential along the wire $L_1$ at a given instant is represented as being constant, as it is found that owing to the high impedance in the instrument S, there is practically no fall of potential in the wire itself. Furthermore, it was found in the experiments about to be described that

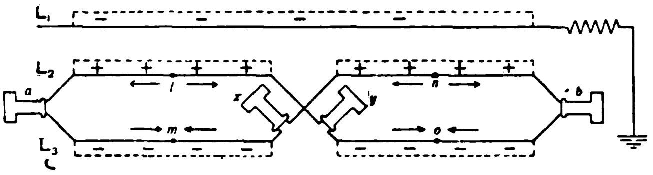


Fig. 3.

the results were the same, whether the disturbing wire was open or connected to earth through the bell S. There would be a fall of potential along the wire $L_1$ if it were of such a length as often found in practice, and the distribution of the charge would be modified accordingly. But as this fact would only affect the location of the neutral points, the question of the fall of potential will not be taken into consideration, and the disturbing wire will be shown open at one end.

Fig. 3 shows the same circuits as used in the previous experiment, except that the wires $L_2$ and $L_3$ are caused to change places at their centres, but are continued in the same plane, as in Fig. 2. This is what is called a "transposition." The telephones at the ends and in the middle are retained as before. Under these conditions, when the transmitter is operated, a diminished sound is heard at *a* and *b*; and *x* and *y*, instead of being silent as in the first case, now emit a sound of the same intensity as *a* and *b*. When telephones are placed at the quarters *l*, *m*, *n*, *o*, the sounds at *a b* and *x y* continue as before, but nothing is heard at *l*, *m*, *n*, *o*. The effect of this one transposition has been to reduce the disturbance at the end telephones *a* and *b*, and to cause a shifting of the neutral points from the centres to the quarters, and an increase of their number from two to four.

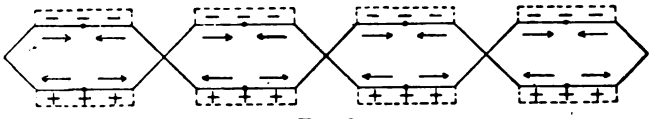


Fig. 4.

An examination of the induced charge shows how these results have been brought about. It will be seen by reference to Fig. 3, that there is on the first half of $L_2$ a positive charge, and on the second half a negative charge, and on the first half $L_3$ a negative charge, and on the second half, a positive charge. When the positive charge on $L_2$ discharges, half of it goes through the telephone *a*, and half through the telephone *y*. The positive charge on $L_3$ escapes in a similar manner, half going through telephone *x*, and half through telephone *b*. This produces four currents, two starting from point *l* and two starting from the point *n*. One of currents from *l* meets a current at *o* coming from the point *n*, and one of the currents starting at the point *n* meets a current at *m*, which started from *l*. The currents flowing through the end telephones in this case are not so strong as when no transposition is employed, because they are due to an induced charge which is represented by an area half as great. It is found that as the number of transpositions is increased, the number of neutral points is also increased, and that the area representing the charge which escapes through the end telephones is reduced. To obtain silence, therefore, it is necessary to increase the frequency of transpositions until the discharge through the end telephones is so small as not to produce sounds therein. Fig. 4 shows a circuit containing three transpositions, one at the centre and one half-way between the centre and each end. In this case, if we could neglect the resistance of the telephones, the current going through the ends would be reduced to one-fourth of its original proportions, and eight neutral points would be produced, one in each wire at the centre of each transposition.

In practice the impedance of the telephones must be taken into consideration, so that if in Fig. 3 the middle telephones *x* and *y* were omitted, the neutral points would be found to move towards the ends, and the currents flowing through the end telephones would be correspondingly reduced.

According to this theory of transpositions, if the instruments and distances between wires on a given circuit remain constant, for a given period of alternations in the disturbing wire, the number of transpositions necessary to obtain silence will depend on the E.M.F. of the disturbing wire, and the specific inductive capacity of the dielectric. An increase in the value of either of these factors will, if silence is to be maintained, require additional transpositions, their number depending upon the value of the change which is made.

Where the disturbing wire is placed at an equal distance from both sides of a metallic circuit, no noise is produced in telephones located in that circuit, and a balance once being obtained, it is

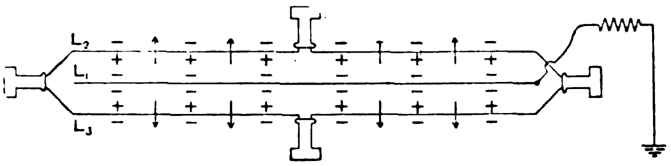


Fig. 5.

independent of both the E.M.F. of the disturbing wire and the specific inductive capacity of the dielectric. Fig. 5 shows such an arrangement of circuits—$L_2$ and $L_3$ are the two wires composing the metallic circuit placed the same distance apart as before, and the disturbing wire is at an equal distance from both. When the disturbing wire is in operation, no sound is heard at the end telephones, or at telephones located at the centres. This may be accounted for by assuming that at a given instant a negative charge is on the disturbing wire, which produces a positive charge on the inside of $L_2$ and $L_3$ and a negative charge on the outside of those wires; and that when the charge is removed from the disturbing wire, a set of currents is set up in the wires $L_2$ and $L_3$ in a direction at right angles to their axes, as shown by the arrows. In this case the flow is lateral, and no current passes through the end telephones or through telephones located at the centres. It will thus be seen that this method of arranging wires differs essentially in its action from the plan of using transpositions. Unfortunately, however, its practical application is limited to two circuits.

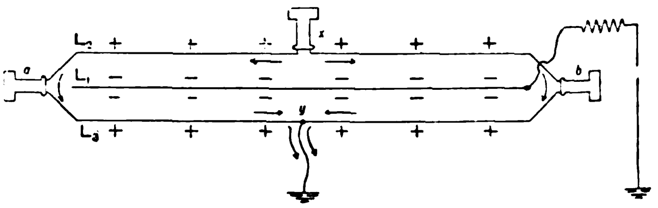


Fig. 6.

Where the disturbing wire occupies the position shown in Fig. 5, the flow in the conductors is lateral only when the wires $L_2$ and $L_3$ are insulated from the earth. If a ground be attached to the centre of $L_3$, as shown in Fig. 6, the flow of current becomes longitudinal, and the telephones *a* and *b* are found to be affected by loud disturbances, while the telephone *x*, at the centre of $L_2$, is found to be silent. This is because the disturbing wire, which we will say is negatively charged, induces a positive charge upon $L_2$ and $L_3$ and a negative charge upon the earth. The discharge in this case is effected by two currents starting from *x*, which thus becomes a neutral point, and passing through the end telephones to the ground as shown by the arrows. If the ground be removed from the point *y* toward the telephone *a*, the neutral point will be found to move toward telephone *b*, and if the ground be put at the centre of resistance of the telephone *a*, the neutral point will be found to be at the centre of the telephone *b*. This is well illustrated in Fig. 7, where *a* and *b* are telephones of special construction, admitting of the attachment of grounding-keys $K_1$ and $K_2$ at their respective centres. In this instance, when the disturbing wire is in operation and both keys open, no sound is heard at any of the telephones, the flow of current being lateral. If the key $K_1$ be closed, sound is immediately heard at telephones *x* and *y* located at the centres of $L_2$ and $L_3$, but the telephones

Digitized by Google

*a* and *b* are still silent. This is because the charge and discharge take place along the conductors $L_2$ and $L_3$ to and from the earth at $K_1$, thus passing through *x* and *y*, *a* being silent because the currents go through it differentially, and *b* is silent because it is located at a neutral point. To prove that current flows through telephone *a*, another telephone may be inserted in the ground branch at $K_1$, and it will be found to be loudly affected. If both keys $K_1$ and $K_2$ are closed, silence is again obtained in the four telephones *a*, *b*, *x*, *y*. In this case the charge and discharge from the wires $L_2$ and $L_3$ divide at the centre and flow back and forth at both ends, *x* and *y* being silent because they are at neutral points, and *a* and *b* are not affected by the currents which flow through them because of the differential action referred to.

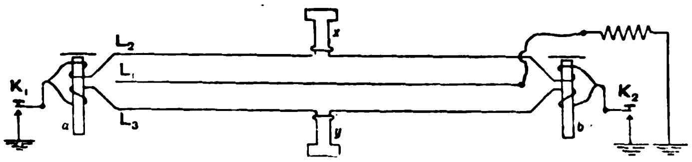


FIG. 7.

Two systems have now been described, one in which the induced current is lateral, and the other in which it is longitudinal. I think it follows from the foregoing experiments, that where wires are twisted about each other as shown in Fig. 1, both of these actions are combined. At the left hand of Fig. 8, a cross-section of the three wires $L_1$, $L_2$, and $L_3$ [Fig. 1] is shown. In this position the wires occupy a place with reference to each other exactly as in Fig. 2, and the tendency of the disturbing wire is to cause a longitudinal flow in $L_2$ and $L_3$. If repeated cross-sections of these wires are made, a point will be reached at which the three wires are disposed as shown at the right hand of Fig. 8, where it is seen that the disturbing wire $L_1$ is at an equal distance from $L_2$ and $L_3$, and the tendency is to produce a lateral flow. The actual currents produced must be the resultant of these two actions.

FIG. 8.

Fig. 9 shows a plan quite different in principle from anything heretofore employed. It is of interest not so much on account of any practical application which it may have at present, but because it is a very striking proof of the electrostatic nature of inductive crosstalk between telephone circuits. $L_1$, $L_2$, and $L_3$ are the same wires as used in the previous cases, $L_1$ being half an inch from $L_2$, with the addition of an extra wire $L_4$ placed half an inch from $L_3$ and joined by a conductor *w* with the disturbing wire $L_1$. $L_2$ and $L_3$ are three feet apart. When in this condition the transmitter is operated, no disturbance whatever is heard in the end telephones; if the wire *w* be disconnected, the usual noise is heard, but is found to disappear as often as $L_1$ and $L_4$ are joined together. This action is explained by the fact that $L_4$ is at the same potential as $L_1$, on account of being joined to it by the wire *w*, and acts with

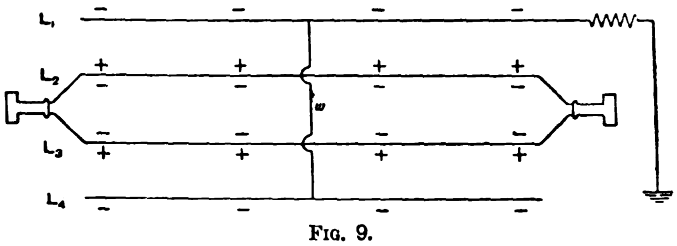


FIG. 9.

the same force on $L_3$ that $L_1$ does on $L_2$. The flow in this case is lateral, as indicated by the arrows; and the telephones are silent.

Neutral points may be produced in a circuit by the use of shunts. Fig. 10 shows the usual arrangement of circuits with the telephones *a* and *b* at the ends, and another telephone *x*, of equal impedance, branched between the two wires at the centre. In this case four neutral points are found, two in each wire. The currents produced by the discharge are indicated by the arrows. Thus by the addition of one shunt, the disturbing currents in the end telephones have been reduced one-half. If similar shunts were placed at the quarters, the currents at the end telephones would be still further reduced to one-quarter of their original strength. This plan is not a practical one, because of its shunting effect on the telephone current, but is of value as showing one of the actions which occur when instruments are bridged into metallic circuits. It is interesting to note that in Fig. 10 the telephone *x* is affected by a current twice as great as that which flows through either of the end telephones.

Before closing I shall describe one more experiment. In Fig. 11, $L_1$ is the disturbing wire and $L_2$ is a grounded telephone circuit placed one-half an inch from $L_1$. At the centre of $L_2$ there is an ordinary telephone repeating-coil or transformer C, containing two windings *e* and *f* of copper wire, each having a resistance of 160 ohms. One end of each winding is grounded, and the other end is connected to the line as shown. Assuming that the impedance of each telephone is equal to that of each coil of the transformer, a neutral point will be found at the centre of each half of $L_2$,

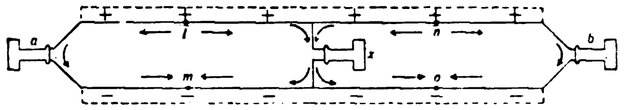


FIG. 10.

and the disturbing currents flowing through the end telephones will be only half as strong as though the transformer were omitted. If now the connections of the transformer be reversed so that the discharges from the two sections of the line pass through it in opposite directions, no magnetism will be produced in the core *k*, and consequently the transformer coils offer an easier path to the discharge. This causes the neutral points to move toward the end telephones, and consequently reduces the disturbance still further. I have not had an opportunity of trying this experiment with a transformer whose coils contained a low copper resistance and a high inductance; but, according to theory, we might expect that such a transformer having its coils connected

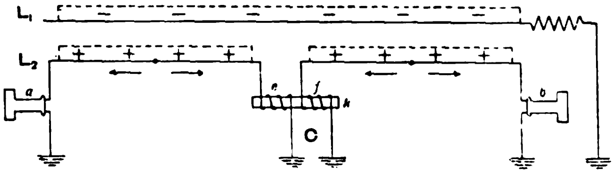


FIG. 11.

differentially, should free a grounded line of considerable length from cross talk and other electrostatic disturbances. The number of such coils which can be worked in a given line is, of course, limited, but with properly designed apparatus a large number of them might be used. This arrangement is also interesting when considered with reference to electro-magnetic induction, and brings to mind a question as to whether we may not at some future time abandon the use of metallic circuits and again make use of Steinheil's discovery.

### SUPPLEMENTARY NOTE, COMMUNICATED BY MR. T. D. LOCKWOOD.

If Mr. Carty continues to hold the views of two years back, I understand him to believe that electrostatic in contradistinction to electro-magnetic induction is chargeable with the major amount of discredit as an agency in disturbances on telephone lines. From long experience and observation, it appears to me that the several agencies in causing disturbing phenomena in telephone circuits which manifest themselves in the telephone receiver preponderate largely in accordance with the conditions of the circuit; that the environment (to use the language of social science) of a telephone circuit has a good deal to do with its behaviour. Thus a line which has considerable leakage uniformly distributed throughout its length will suffer very little from electrostatic induction either manifested as a disturbance, or as a retarding agency. If we exhaustively examine the literature of the subject we shall find that the idea that electrostatic phenomena are concerned in disturbances of telephone and telegraph circuits, is by no means new. Mr. Culley presented a Paper once upon this subject, before the Society of Telegraph Engineers, which Paper, together with a most instructive discussion, is published in the journal of that Society, and Mr. Preece and myself from time to time have also repeatedly referred to it.

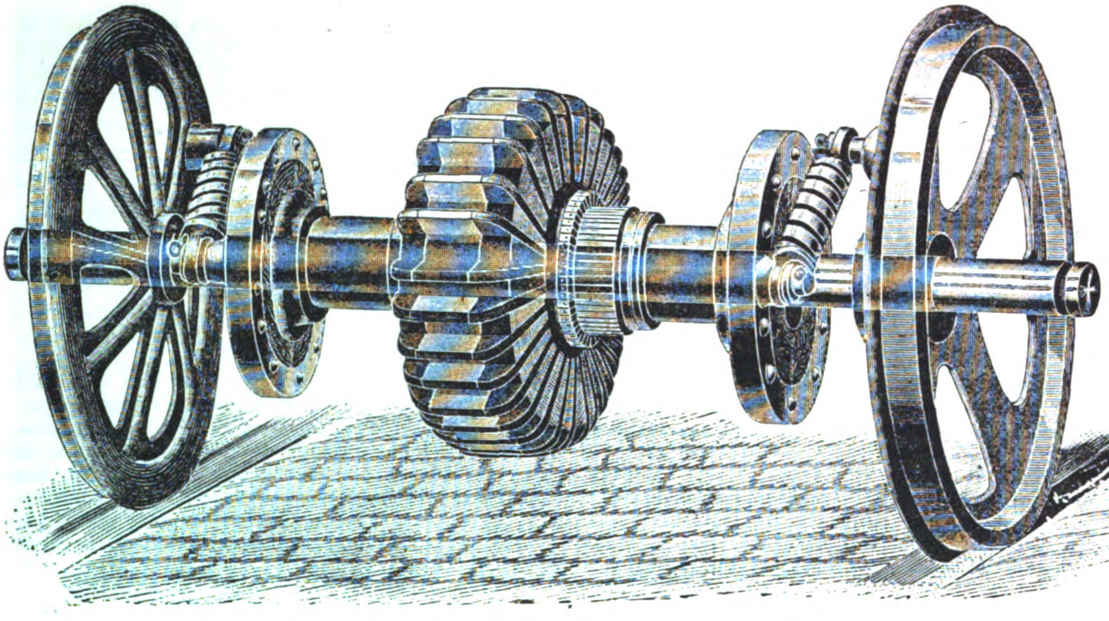
I think, while he is undoubtedly right in attributing a large share of inductive disturbance in telephone lines, that he does not give sufficient weight to the equally undoubted fact, that electro-magnetic induction is also an important factor; and that, as I have already pointed out, the conditions of any individual circuit largely govern its action. An interposed plate for an envelope of metal between the disturbed and disturbing circuits will, if sufficiently thick, and if united to earth, screen so much of the induction as is electrostatic in its origin; but it will not screen electro-magnetic induction; and thus whenever it is worth while, the sources of inductive disturbances can be analysed. And while the inductively neutral metallic circuit—the circuit with two wires closely

Digitized by Google

adjacent and twisted together—is indeed a specific against electro-magnetic inductive disturbance, it also tends to increase the retarding effect of electrostatic induction exercised between the two wires of the circuit. In conclusion, I wish to suggest that inasmuch as the telephone only notes electrical changes, we cannot accurately say that sounds can be produced in it by electrostatic charge. It is the fact that it is the motion caused in the act of forming and dissipating charge that produces the disturbing sound. But a charge in the act of formation or dissipation is practically a current; and as a current in the act of change, it necessarily varies also the magnetic field constituted by the circuit within which it is circulating; and as a further consequence therefore sets up in an adjacent and disturbed circuit electro-magnetic induction currents. Thus the disturbing action is a compound one; operating first by the successive inductive charges and discharges induced in the disturbed circuit, by the changes occurring in the disturbing circuit; and secondly, by electro-magnetically induced currents developed in the disturbed circuit by changes in the magnetic field constituted by the disturbing circuit.

## THE SHORT GEARLESS TRAMWAY MOTOR.*

In the accompanying figure is represented the latest type of railway motor constructed by the Short Electric Railway Company, of Cleveland, O. All gearing has been eliminated from this motor. It is placed directly upon the car axle and makes 100 to 150 revolutions per minute. Referring to the accompanying illustration, it shows a pair of wheels with their axle running through the hollow armature shaft of the gearless motor. This hollow shaft is made of steel, and is about six inches in diameter on the outside, with an opening inside of nearly five inches, so that there is a clearance between the axle of the car and the inside of this hollow shaft of an inch air-space all round. In the centre of this shaft the armature and the commutator are fastened, and on each end of the armature shaft is keyed two heavy crank discs made with an iron hub and rim, and a wooden web. This thoroughly insulates the armature shaft from the rim of the crank wheel. This crank wheel rim, as will be seen, has upon one side a crank pin. The car wheel has a crank pin also, and between the two is stretched a heavy coil spring, capable of pulling with a very slight elongation 2,500 or 3,000 pounds. The power of the motor in turning the wheel is transmitted through these springs, and the wheel is readily turned in the direction in which the armature tends to rotate. Just inside of the crank discs are the bearings of the hollow armature shaft in the motor frame. The motor frame is made of two peculiarly-shaped castings of steel, with arms projecting forward and backward. These arms rest on rubber cushions placed on channel bars which go from side to side of the motor frame. In this way the armature is held up in the frame and away from the axle, and the entire weight of the motor is supported by these spring cushions and by the car boxes outside of the wheels at the points where the car body is supported. None of the weight of the motor falls on the axle inside of the wheels. The spring cushions upon which the motor frame rests are limited in their movements to a fixed distance so that the inside of the armature shaft cannot come down upon the axle. By these means the motor is carried entirely on springs. Our contemporary does not describe the magnets. We presume they are of the ordinary Short pattern.



Short Gearless Tramway Motor.

* From the *Western Electrician.*

## THE COST OF THE GENERATION AND DISTRIBUTION OF ELECTRICAL ENERGY.*

BY MR. R. E. B. CROMPTON, M.INST. C.E.

Machinery for the supply and distribution of electrical energy came under two heads, namely, the generating-plant, comprising boilers, steam dynamos and switching-apparatus, and the distributing-plant, consisting of a network of conductors, supplemented in some cases by accumulators, and in other cases by transforming-apparatus to change energy from high-pressure to low-pressure.

*Part I.—Cost of Generation.*—With the high efficiency of 96 per cent. which was now attainable in dynamos, the cost of the electrical energy ought only to be a small fraction in excess of that of a corresponding amount of mechanical energy. The wide difference between the calculated amount and the figures attained in practice were considered. The three items of cost, namely, material, labour, and up-keep, were influenced chiefly by the "load-factor," the design and arrangement of the plant, and the local cost of material and labour.

The author had given the name of load-factor to the relation which the actual output of any given plant bore to what would be its output if it were worked continuously at the full load. In order to compare the relative economy of fuel, water, or other material used in generating electrical energy, he had fixed on a consumption of 25lb. of water and 2½lb. of Welsh coal per unit generated as a standard which might be reached in the future, although nothing approaching those figures had yet been attained in practice.

He then proceeded to describe the electrical supply stations from which the data for the Paper had been obtained, namely, the Kensington and Knightsbridge Electric Lighting Company, and the St. James's and Pall Mall Electric Lighting Company. The load-factor of these stations varied from the exceedingly low figure of 2·5 for the Kensington station in the month of August to 41·5 on one occasion, which was the best load-factor of the St. James's and Pall Mall Company's station, and showed how these varying load-factors affected the cost of productions. It was pointed out that a limited use of storage-plant could reduce the consumption of fuel, &c., and shown by a diagram that the proportion of accumulators should be about 20 per cent., or 1-5th of the whole generating plant. The author recommended a return to the older type of internally-fired boilers; the chief cause of the small evaporation, in low load-factor stations, was the loss of heat incurred in getting

* Abstract of a Paper read before the Institution of Civil Engineers, April 7, 1891.

Digitized by Google

up steam in several boilers for only short periods every evening. Several types of boilers which had been found to have special advantages were described, one important consideration being that in electric light stations the space from front to back was frequently limited, so that a boiler which could be built up to a height of from 14 to 16 feet offered several advantages.

*Distribution.*—The cost of distributing electrical energy was made up of that of the up-keep of the distributing-plant and of the percentage of the energy which was lost by the fall of pressure in the conductors. It followed that the merit of competing systems was inversely as the cost of generating the units so wasted divided by the up-keep of the conductors. For instance, if in distributing 20,000 units to a given distance, system A wasted 1,000 units in a given time, the cost of up-keep for the same time being £10, whereas system B wasted 3,000 units at a cost of up-keep of £3, B was slightly better than A, because $\frac{3000}{10} : \frac{1000}{3} :: 300$ to 333. It was difficult to apply the method of comparison to the systems now in use as the cost of up-keep was not yet known with sufficient accuracy. The author's opinion was that whenever underground mains consisted of continuously insulated cables, the sum required for up-keep would be not less than 4 per cent. of the original cost, and was not likely to exceed 7 per cent. When, however, the underground mains took the form of bare copper conductors with glass or porcelain insulators the cost of up-keep might be as low as from 1 to 2 per cent. In this connection the distribution system of the Kensington and Knightsbridge Company was described, and reference was made to the systems of supply for St. James's and Pall Mall, Westminster, Notting Hill, and for the St. Pancras Vestry, also that in use at Birmingham.

The Author had found difficulty in obtaining accurate accounts of the cost of distribution by the alternating-transformer system, but all the published accounts had shown that the total net cost per unit was greatly in excess of that of the low-pressure system. The Author had under his charge a plant of generating and distributing machinery on the alternating-transformer system for the public lighting of Chelmsford, a small private demand existing in addition. In this case the machinery was worked for long periods at a high load-factor, so that the cost of generating was exceptionally low, and as the load in the transformers was perfectly regular it had been possible to so proportion them as to be worked continuously at their maximum efficiency. A table showed the load-factors for this station for the months of August and December, 1890, and a 24 hours' load-diagram, taken on the 20th of January, 1891, was exhibited. The annual load-factor was found to be 31·0, and the pounds of coal per unit generated, 8·88; the pounds of coal per unit delivered, 10.70, hence the efficiency reached 83 per cent. But this was an extremely favourable example, and an alternating-transformer installation in a medium-sized private house in the Kensington district, tested by Professor Ayrton, was found to have a mean annual efficiency of only 53 per cent. The remedy for this defect in the alternating system consisted in what had been called "banking" the transformers. This meant that a district to be supplied with electricity should be laid with a low-pressure net-work, in all respects similar to that provided for the direct low-pressure system; but in place of the feeders, and at the point where the feeder-mains were connected to the network, a fireproof and incombustible chamber should be formed under the surface of the roadway. In this a number of transformers of graduated sizes were arranged, with the high-pressure mains connected to them, so that the transformers might be switched into action automatically as required, that was to say, during the hours of light load the smallest only would be in action, the others being automatically added as the demand increased.

Summarising his experience, the Author endeavoured to show:—(1.) The actual cost of generating and distributing electrical energy on the scale at which it was now produced, and with the machinery that was already installed. (2.) The direction in which improvements might be introduced to secure greater economy. (3.) The important effect of a variable load-factor, which might be almost entirely eliminated from the cost-sheets of those who desired to employ electrical energy continuously. (4.) That the losses on distribution in low-pressure supply were already so low that further improvement could not be expected. (5.) That the existing systems of alternating supply would have to be greatly modified if they were to be used in residential neighbourhoods having low load-factors.

## BOOKS, &c., RECEIVED.

"Traité Elémentaire d'Electricité." By J. Joubert. Second Edition. Revised and Enlarged. (Paris: G. Masson.)

## AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *March* 30, 1891.

**The Overhead Trolley System in New York.**—It is again rumoured that an attempt will be made to introduce the trolley system on the Broadway and Third Avenue lines in this city, instead of the proposed cable. The advocates of electric traction have been decidedly encouraged by the action of the authorities regarding the proposed electric road in the upper part of New York City. Permission has been granted for the erection of the necessary overhead structure, and work will probably begin in the coming spring. Of course, to propose the use of overhead wires on Broadway means flying in the face of a certain section of public opinion, one, however, that is, for the most part, anything but intelligent in its opposition, and is only led on by newspaper excitement. No serious opposition is likely to come from the municipal government.

**Edison Slow-Speed Motor.**—The Edison Company announce the appearance of a new slow-speed motor. Mr. Edison has been for several weeks at the works in Schenectady, perfecting its details, and it is likely that something of a surprise is in store for us. Among other new machines a very neat little alternating current fan motor will be shortly placed upon the market. It is designed by Mr. William Stanley, jun. Mr. Stanley is also at work on a similar design of larger dimensions.

**Rapid Alternations in Transformer Work.**—Another active worker in the alternating field, Mr. Nikola Tesla, is continuing his very interesting experiments on extremely rapid alternations, and seems to be gradually evolving not only a vast amount of information, but some things that promise practical results from these extraordinary conditions. He has certainly done a great service if his work has convinced electricians of the desirability of increasing the frequency in alternating systems. Already the American practice employs nearly double the frequency common in Europe, and the figure is likely to be raised rather than lowered. The senseless opposition to alternating currents seems to have somewhat subsided now, and there is opportunity for more work in that line than ever before. The Thomson-Houston Company, too, is busily engaged in extending its alternating work.

**Storage Battery Traction in New York.**—Storage battery traction in New York seems to have come to grief. The cars that have been running on the Fourth Avenue line have practically suspended operations, and nothing is being done with them, or with the system. Financial troubles are reported to be at the bottom of the difficulty. Attempts have recently been made to utilise the alkaline storage battery. At least two inventors, Messrs. Entz and Slattery, have been working actively in that direction, although neither of them has seen fit to make public any results of interest. The alkaline battery did not meet with so signal a success in France that one feels much encouraged to expect any extraordinary results here.

## CORRESPONDENCE.

### SPARKING DISTANCES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Your issue of the 27th ult. contains an extract of a Paper, published in the *Electrical World*, of New York, describing some experiments on the striking distance of alternating electromotive forces, which were carried out at the laboratory of Prof. Elihu Thomson; and in your note concerning the same you refer to the importance (as pointed out by De la Rue) attaching to the form of the discharge points, as affecting the length of the sparks produced, also the need of more information regarding the form of the points used in the experiments described, &c.

In the published description of the experiments, it was stated that "the points were as sharp as the means at command rendered it possible to make them." I may add here that they were conical in shape, having a diameter at base = ·075in., and a height from base to point = ·5in. They were first shaped in

Digitized by Google

the lathe, and, while still kept slowly rotating, rubbed vertically on a fine whetstone until the sides of the cones were perfectly straight and smooth, and the points sharp. The points thus formed were sharper than ordinary needle-points, and, to keep them so, to prevent deformation when bringing them together, a little cushion of soft lead was slipped between them, the thickness of which was, of course, considered when computing the distance separating the points.

With what is said regarding the importance attaching to the shape of the points, I entirely agree; the curves shown clearly indicate the importance of this consideration. You do well in emphasising its importance, however, because the various statements which one finds on the subject indicate that its importance is not sufficiently recognised; thus, the writer of an excellent Paper recently published in one of our technical Journals states, quite briefly, that "to produce a spark one inch in length required a potential of about 100,000 volts." This may undoubtedly be true when particular forms of discharge surfaces are employed; if very sharp points are used probably less than one-fifth of the potential stated would suffice. When points become blunted—become more or less hemispherical in shape—the spark becomes shorter, and a curve showing maximum values of the ratios less irregular than is the case with very sharp points, when blunt points are used. Curves showing maximum and minimum resultsapproximate each other closely; with very sharp points, however, the discharges are erratic.

One result obtained while making the experiments described (discharge between point and sphere at about 700 volts) subsequent attempts failed to reproduce. It would certainly appear in this case that an unusual combination of favourable conditions conspired to precipitate the discharge. The object of the experiments, however, was to find the maximum striking distance; consequently, the greatest spark lengths observed are those shown in the curves. I would here point out that when data of this kind is wanted for application under working conditions, the thing which it is generally required to be known is not the average spark length, but the greatest spark length which the electromotive force used may be expected, under the most favourable conditions, to produce.

Concerning disruptive discharges, Mr. J. E. H. Gordon aptly quotes Prof. Clerk Maxwell, who has compared such experiments to the splitting of a piece of wood by a wedge. The possibility is stated of determining the average force necessary to split the wood, also the impossibility of saying how closely the force required in any particular experiment will approximate that average. If we think of the wedge as represented by the axe of the wood-chopper, it becomes obvious how much the force of the blows necessary to split the wood depends upon the more or less perfect condition of the axe's edge. Everyone who is at all familiar with the experiment of splitting thick glass plates with Ruhmkorff coil discharges, and the precautions which are to be taken to concentrate the potential to what is virtually a point on each side of the dielectric layer, will readily understand that the analogy of the wedge is by no means a far-fetched comparison.

The subject of disruptive discharge is so seldom discussed without some allusion (generally speculative in its nature) being made to the discharges occurring in the great laboratory of nature, that the writer is tempted to be orthodox, and in order to attest the same, will here introduce an idea which he has heard expressed by Prof. Elihu Thomson, to the effect that the phenomenal values of potential which have sometimes been spoken of as producing lightning discharges may be more fanciful than real. May not a potential only sufficient to break down a first layer of the dielectric, act as a sort of electric wedge capable of opening a path for itself, as it were, through many hundreds of feet? Suppose, for example, a highly electrified cloud to be passing in the atmosphere over some prominent object situated on the earth's surface, and that the attractions of the electricities of the earth and of the oppositely charged cloud cause a depression of a part of the latter's surface, at a point situated over such prominence, we have then a set of conditions analogous to those obtaining in the experiment before referred to, of splitting the glass plates. If now, some rain-drops fall, may not they assist in making up the wedge, which, entering the dielectric, begins to make the path for the discharge to pass? It has been observed that during a storm the most brilliant discharges are usually seen amidst the densist rain, and that frequently an unusual flurry of rain-drops immediately succeeds the discharge, as though the charge remained upon the cloud until the falling drops brought it within striking distance, when it flashed to earth, the rain-drops, which had first assisted it, arriving later. If the charged rain-drops do assist the clouds' discharge, and such an assumption does not seem unreasonable, it becomes quite thinkable that a true discharge between earth and clouds may be effected by a potential, moderate indeed compared with the millions of volts often spoken of as necessary to effect a discharge.—Yours, &c. ROBERT SHAND.

Lynn, Mass., March 23, 1891.

## TRADE NOTES AND NOTICES.

### "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY & HANDBOOK for 1891

The new edition of our well-known Directory and Handbook is now ready, price 5s., postage extra. The book consists of over 900 pages, and has entailed this year a heavy amount of work. The HANDBOOK DIVISION contains a mass of most useful information. The DIRECTORY DIVISION consists of 430 pages, and contains a very carefully compiled Alphabetical and Classified List of Firms and Persons engaged in the Electrical and Allied Trades in all parts of the world. This Division has been corrected up to date, and the book is thoroughly reliable, the very numerous changes which take place at the beginning of the year being incorporated. By the aid of this Directory, makers of Electrical Machinery, Apparatus, Instruments, Fittings, Sundries, Novelties, and other goods, may safely communicate direct with probable customers without the annoyance and great expense consequent upon using books which are mere lists of Members of Scientific Societies repeated again and again. The Colonial and Foreign Division of this Directory will be found extensive and reliable. *Orders should be forwarded at once.*

PLANT FOR SALE.—Messrs. Wheatley Kirk, Price and Goulty announce in our advertisement columns that they have for sale four horizontal high-pressure engines, each 35 horse-power nominal, two coupled together as a pair, and two single, with three steel Lancashire boilers, each 24ft. by 7ft. 2in. diameter; these are all of Marshall, Sons and Co.'s make, and are in excellent condition. There are also four Babcock-Wilcox boilers, each of 164 horse-power nominal, and four Siemens alternating dynamos, each for an output of 2,500 volts and 33 amperes. Particulars as to prices, orders to view, &c., may be obtained of Messrs. Wheatley Kirk, Price and Goulty, 52, Queen Victoria-street, London, E.C., who have also for sale valuable plant and machinery at 4, Station-buildings, Acton-street, Kingsland, London, N.

AN ALUMINIUM ELECTRIC COMPANY.—A private Company has been formed for the manufacture of aluminium, and promises to supply this metal at 2s. per lb. The Company, whose offices are at 11, Great Sutton-street, Clerkenwell, also promises an aluminium storage battery.

ATLAS ELECTRICAL MANUFACTURING AND SUPPLY COMPANY (LIMITED).—We are glad to learn that the fire which occurred at this Company's works on Friday last will not in any way prevent the Company from executing orders sent on to them immediately, as they have made arrangements in order to prevent unnecessary delay.

CHANGE OF ADDRESS.—Mr. Magnus Volk informs us that he has removed from Manor Cottage, Halliford, Shepperton, Middlesex, to Volks' Electric Laboratory, 17, Eglantine-road, Wandsworth, S.W.

THE LUMMER-BRODHUN PHOTOMETER.—This instrument, illustrated in our last issue, was first described in "Zeitschrift für Instrumentenkunde." Messrs. O. Berend & Co., of 61, Fore-street, E.C., inform us that it is made by Hartmann & Braun, and is supplied by them.

MESSRS. PRIESTMAN BROS.—We have received from this firm illustrated particulars of the latest type of their well-known oil engine, together with prices and general dimensions. The particulars are accompanied with extracts from certificates of experts, and a number of very flattering testimonials from users of the engine. Amongst others who have adopted the engine are included the English, Victorian, New Zealand, Egyptian, and Norwegian Governments, the Trinity House, the Northern and the Irish Light House Boards.

Digitized by Google

# PATENT RECORD.

## APPLICATIONS FOR PATENTS.

March 10, 1891.

4,214. J. F. BENNETT and E. P. HIDES. Sheffield. Improvements in telephones.

4,215. A. D. MACDONALD and J. DODD. Liverpool. Automatic electrical block signalling on railways, with mechanical arrangement for testing the same.

4,235. G. E. FLETCHER. Liverpool. Improvements in transmitter for electric step-by-step telegraphs.

4,256. F. J. NASH. London. Improvements in insulation of electric conductors.

4,259. H. H. LAKE. London. Improvements in electric motors (The Giant Electric Motor Company, United States).

4,263. I. F. WRIGHT and E. G. WILSON. London. Improvements in means for preventing induction in telephones.

4,269. F. J. NASH. London. Improvements in insulated electric wires.

4,271. P. A. NEWTON. London Improvements in electrical railway signalling (The American Electric Railway Signal Company, United States).

4,306. W. BOGGETT. London. Improved methods of and apparatus for obtaining electricity and in connection therewith.

March 11, 1891.

4,367. W. H. MUNNS. London. An improved electric signal and searchlight lantern (G. W. Martin and J. Knight, United States).

4,392. W. ENTWISTLE. London. Improvements in electrical bell and electrical alarm clock apparatus, applicable for use either in combination or separately.

4,407. F. LINKE. London. Improvements in the electric connection of lightships with the mainland.

4,410. W. W. HORNE. London. An improved telephone enunciator or indicator (G. B. Lawrence and C. H. Oakwood, United States).

March 12, 1891.

1,051A. S. Z. DE FERRANTI. London. Improvements in testing electrical transformers and dynamos during the manufacture of the same. [This application having been originally included in No. 1,051, dated January 20, 1891, takes, under Patents Rule 23, that date].

4,468. C. D. ABEL. London. An improvement in casing for electrical switches, safety fuses, ceiling roses, and similar fittings (H. Messing, Germany).

4,469. J. CLEGG. London. An improvement in resistances employed for electrical measurements.

4,471. W. WHITE. London. Improvements in electrical switch-boards and fuse-boards.

4,479. L. F. H. C. MORGAN-GRENVILLE. London. Improved means for insulating underground electrical conductors.

4,482. C. J. PRICKETT. London. Improvements in and relating to telephonic switch-boards.

March 13, 1891.

4,551. H. KING. London. An improved tablet or pad for use in connection with telephones.

4,554. G. F. REDFERN. London. Improvements in armatures for electrical machinery (Wirth and Co., Agents for W. Lahmeyer and Co., Germany.)

March 14, 1891.

4,579. G. BINSWANGER and C. H. SMEETON. London. Improvements in switches for electric cigar lighters and like purposes.

4,583. J. PERRY. London. Improvements in electric supply meters.

4,588. J. M. M. MUNRO. Glasgow. An improved counterweight arrangement for electric lamps.

4,605. R. J. RAE. London. Improvements in electric lighting and for other like purposes.

## SPECIFICATIONS PUBLISHED.

1890.

5,135. BELFIELD (Westinghouse Electric Company). Cores for converters, &c. (Price 8d.)

5,368. KELLOGG. Telephony. (Price 11d.)

5,369. KELLOGG. Telephony. (Price 8d.)

5,925. KELLOGG. Telephony. (Price 11d.)

6,945. APPLETON. Electric switch. (Price 8d.)

7,599. BELFIELD (Lange). Electric arc lamps. (Price 8d.)

9,861. BOULT (Tommasi and another). Electrical storage batteries. (Price 8d.)

13,791. LAKE (Hobby). Incandescent electric lamps. (Price 6d.)

15,413. GRANT. Arc electric lamp. (Price 6d.)

18,890. JOHNSON (Automatic Electric Exchange Company). Telephone connectors. (Price 2s. 9d.)

19,191. WHEELES and WHEATLEY. Electric railways, &c. (Price 1s. 1d.)

21,046. WALTON. Electrical conductors. (Price 6d.)

1891.

1,963. DEWEY. Electrically soldering cans, &c. (Price 8d.)

2,061. THOMPSON (Moore). Electric lamp holders. (Price 8d.)

# COMPANIES' MEETINGS & REPORTS.

## Elmore's Foreign and Colonial Patent Copper Depositing Company (Limited).

Extraordinary general meetings of the holders of Priority shares and of Founders' shares were held at the Cannon-street Hotel on the 6th inst., under the presidency of Sir John H. Morris.

The SECRETARY (Mr. J. SHURMER) read the notice convening the meeting, which intimated that the following resolution would be submitted thereto. Resolved :—

*That the Articles of Association be altered in manner following :—*

(a) *Article 109 shall be cancelled.*

(b) *In place thereof the following Article shall be substituted, namely—"(109).—All dividends shall be payable out of profits only ; but such dividends may be declared and paid either in cash or by the distribution of specific assets taken at their par value, and in particular of shares, debentures, or other securities of any other company, or partly in one way and partly in the other."*

(c) *Article 110 shall be altered by inserting after the words "until they have received a return" the words following, namely, "(either in cash or in shares, debentures, or other securities taken at their par value.)"*

The CHAIRMAN stated that the meeting had been called for the purpose of carrying out the wishes of the shareholders as unanimously expressed at the general meeting of the Company last January. The Board were then urged to take measures for distributing securities held by the Company, but it was pointed out that this could not be done under the existing Articles of Association, when it was resolved unanimously by the shareholders who were present on that occasion that the Directors should take the necessary measures for having the Articles altered, so as to enable the securities to be distributed. He dwelt upon this point because objection had been taken to the action of the Directors, who had been accused of rather "rushing" the matter on the shareholders. Whatever action had been taken, however, had emanated from the shareholders, whose wishes it was the only object of the Board to carry out. Acting on the shareholders' wish, the opinion of counsel had been taken, which was to the effect that a distribution of securities could be made after certain specific alterations in the Articles of Association, and these alterations were embodied in the resolutions now before the meeting, as read by the secretary. It struck him as quite possible that they might agree to alter Clause 109, and yet not agree to alter 110, or they might propose that Article 110 should be altered in some other way than that proposed in the resolution. If this were the wish of the shareholders it must emanate from themselves. He then proposed the cancelling of Article 109.

Mr. JOHN MACFARLAN seconded the motion.

Sir THOMAS H. FARRER, Bart., stated that as he had not attended the last meeting he had had some difficulty in understanding precisely what the object of the alterations was. What occurred to him when he saw the proposal in the first instance was that it was very questionable for a body of shareholders, consisting of two different sets with somewhat diverse interests, at this early period of the history of the Company to alter what was a fundamental relation between the two sets of shareholders when the Company was started. He happened to hold Priority Shares and Founders' Shares in such a proportion that he believed it made absolutely no difference to him whether an advantage was given to the Priority or to the Founders' Shares, and therefore he could treat the matter impartially. As he understood the matter, the suggested distribution would, if it were at present carried into effect, alter in some degree the relation which, by the deed of settlement, existed between the two classes of shares—an alteration which, in itself, unless there were very good reasons for it, he regarded as a considerable evil. As far as he could understand it, if the distribution was such as had been proposed, the Priority shareholders would at once receive. in the form of shares and debentures, some thing which might, or might not, as events turned out, be more than they would have received if the present state of things continued. At the present moment, undoubtedly, they would receive less, because the shares which would be contributed were at a discount, and, as he understood some of them were Vendors' Shares, and on that account could not be sold and turned into money for a considerable period after the arrangement was made. They would, therefore, be postponing their right, and further, they would be giving to the founders something which the latter had as yet no right to. They would be consenting to the distribution amongst the founders of a certain proportion of the assets of the Company to which the owners of Founders' Shares were not entitled until another £5 in cash had been given to the Priority shareholders. He could not but believe that the Company was quite certain to realise a further £5 in cash upon the Priority Shares, the holders of which he advised not to insist, therefore, upon an immediate distribution. Moreover, he did not think it desirable in the present state of the Company that these shares and debentures should be hawked about in the market. From all he could gather there was every probability that the difficulties which had existed would be overcome, and nothing but harm could be done, meanwhile, by putting into the hands of shareholders, who really knew very little about the business, shares, many of which could not be sold at present, and which, if sold, would be disposed of at a great disadvantage. He had, therefore, come to the meeting determined to oppose anything like an immediate distribution, but if the shareholders agreed to it, he saw no reason why the Board should not, in the future, after the Priority Shares had received the additional £5 per share in cash, to which they were entitled, distribute shares in lieu of distributing cash.

Digitized by Google

He had come, therefore, to the meeting prepared to vote for the abolition of Article 109, and for the alteration which was proposed in Article 110, but he also came prepared with an amendment to Article 110, which would have the effect of preserving to the Priority shareholders their right to the £5 in cash. Having intimated the wording which he desired, he concluded by moving an amendment to this effect.

Prof. LAMBERT expressed his readiness to second the amendment, which he thought was a compromise that would meet both the desire of the Board and the question of justice.

The CHAIRMAN repeated that the desire of the Directors was to do everything in the interests of the shareholders, and he thought he might inform them that the amendment which had been proposed had been in reality suggested by himself.

The proposed alterations in Article 109 were then agreed to; and the alteration in Article 110 was also approved, modified as suggested by the amendment. Clause 110 will, therefore, read as follows:—"The Priority Shares shall be entitled to all profits until they have received a return in cash equal to the amount paid on the shares, and in addition 100 per cent. premium, also in cash, before the Founders' Shares receive any return, and, in addition, the Priority Shares shall receive one-fourth of all the surplus profits, the remainder being then divided among the holders of the Founders' Shares."

Mr. F. L. RAWSON observed that his own idea was that it was the duty of the Directors to distribute the shares as rapidly as possible. It might be necessary to call further meetings, because although they themselves knew what they wanted and what they meant, yet the alteration which had been made in Clause 110, when legally interpreted, might not carry out the intention. One of the chief objections to the distribution of the securities was the fear that they would be still further lowering the price of the shares; but an effectual way out of this difficulty would be the formation of a Trust Company, as had been done in the case of the Globe Telegraph and the Dynamite Trust Company.

The resolutions were afterwards submitted, as already agreed to, to separate meeting of holders of the Founders' Shares and to an aggregate meeting of the holders of both Priority and Founders' Shares.

## Poole and White (Limited).

This Company held their first annual general meeting privately at the offices of the Company, 58, Bread-street, Cheapside, on April 7th; Mr. Tryon, the Chairman of the Company, presiding.

The CHAIRMAN informed the shareholders present that the great success which had attended the Company's operations during the past year would necessitate the taking of much larger works than at present, and that for this purpose it was proposed to issue further capital.

We are informed that the meeting unanimously adopted the report, and before the close it was announced that the greater part of the further capital required was already subscribed.

## Oriental Telephone Company (Limited).

The following is the report of the Directors for the year ending 31st December last, to be presented at the eleventh ordinary general meeting of the Company to be held at the Cannon-street Hotel, E.C., on Wednesday, the 15th inst., at 1 o'clock.

The Revenue Account shows a balance to credit of £8,835. 8s. 11d., which, together with £1,237. 2s. 8d. brought forward from 1889, shows an amount of £10,072. 11s. 7d. available for disposal, which the Directors recommend should be dealt with as follows:—To add £2,500 to the Reserve Fund; to write off £832. 19s. 7d. in reduction of Capital Expenditure; and to pay a dividend of 2½ per cent. free of Income Tax on the total paid-up capital of the Company, which will absorb £4,488. 12s. 3d., leaving £2,250. 19s. 9d. to be carried forward.

The Shareholders will notice that an alteration has been made in the mode of appropriating the profits. They will have gathered from former reports of that the Directors have been endeavouring to come to some arrangement with the holders of Vendors' Shares for a re-adjustment of Capital Account. A conference was held last autumn with one of the largest holders, and at his suggestion the services of an Actuary were called in, in order that a disinterested opinion might be obtained of the relative values of the two classes of shares. The Actuary having raised a question as to the correct interpretation of the Agreements with the Vendors relating to the payment of dividends, the point was submitted to Counsel, and in pursuance of the advice received, it has been deemed necessary to declare the dividend rateably on the paid-up Capital of the Company, Vendors' Shares included, and to carry the dividends declared upon the Vendors' Shares to a separate account, from which it will be distributed to the holders of the Ordinary Shares until their claims, according to the Agreements with the Vendors, have been discharged. By this arrangement the deficiency to which those agreements relate has to be made up exclusively out of the dividends upon the Vendors' shares, without any obligation on the part of the holders of Ordinary shares to bring the dividends on these shares into account for the purpose of making up such deficiency. The distribution now recommended on the total paid-up capital of the Company is equal to £3. 12s. 2d. per cent. on each Ordinary share issued prior to February 4, 1886, as compared with £3 per cent. last year.

The Indian Companies during the past year show an improvement, the Bengal Telephone Company having paid 5 per cent. against 4½ per cent the previous year, and the Bombay Company 4 per cent. as against 3 per cent. The increase would have been larger but for the action of the Indian Government, to which the Directors have called attention in previous reports. The Telephone Company of Egypt has declared a dividend of 6 per cent. for the past year on its Preferred shares, carrying forward £1,508. 5s. 5d. All the foregoing dividends on the shares held by this Company have been brought as usual into the accounts appended.

The branches worked directly by the Company nearly all exhibit an improvement on previous returns, which is partly due to the rise in silver.

In order to provide the Telephone Company of Egypt with further working capital for extensions in that country, your Directors have taken £1,500 of its 6 per cent. Debentures.

The accounts of the China and Japan Telephone Company have not yet been closed, but they point to a small surplus after paying Debenture Interest.

By a recent Act of Parliament, Companies are enabled, at a moderate expense, to amend their Memoranda of Association. The Directors, whilst they will always bear primarily in mind the original objects of this Company, have come to the conclusion that it is desirable that the powers of its Memorandum of Association should be extended so as to authorise the supply of electric apparatus and material, and the application of electric power generally.

The resolution below will therefore be submitted to the meeting:—

*"That the Company's Memorandum of Association be altered as follows:—By adding at the end of paragraph (b) of clause 3 the words 'or generation, employment or utilisation of electricity or magnetism.' By inserting after the said paragraph (b) the following additional paragraph (b 1.)—'To carry on any business or manufacture relating to the generation, employment or utilisation of electricity or magnetism or the apparatus connected therewith.'"*

Should the above resolution be passed by the requisite majority, it will be submitted for confirmation as a special resolution to an extraordinary general meeting which will be subsequently convened.

PATENT

SILICIUM BRONZE AND SILICIUM COPPER WIRE.

The best for overhead Telephone and Telegraph Lines,

AND ALL ELECTRICAL PURPOSES.

Hard Drawn High Conductivity Copper Wire.

ROLLED AND DRAWN PHOSPHOR BRONZE.

PHOSPHOR BRONZE — VULCAN — PHOSPHOR — DURO METAL

PHOSPHOR BRONZE BEARINGS, BUSHES, AND OTHER PARTS OF ELECTRICAL MACHINERY

*SOLE PROPRIETORS of the British, Indian and Colonial Patents,*

THE PHOSPHOR BRONZE COMPANY (Limited),

*87, Sumner Street, Southwark, London, S.E.*

WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

Digitized by Google

The retiring Directors at the present meeting are the Right Hon. G. A. F. Cavendish Bentinck, M.P., and Mr. B. St. John Ackers, both of whom being eligible offer themselves for re-election. The Auditors of the Company, Messrs. Deloitte, Dever, Griffiths and Co., also retire, and offer themselves for re-election.

## New York Belting and Packing Company (Limited).

The first ordinary general meeting of this Company was held on Tuesday last, at the Cannon-street Hotel, under the presidency of Samuel Pope, Esq., Q.C.

The CHAIRMAN said: As a quorum of members is not present I can only, previous to adjourning this meeting in accordance with the law, say a few words in a general conversational way. Our general manager is in America, and has been there for the last two months, and if it had been possible to postpone this meeting for two or three days longer we should have done so, because we expected his arrival home in the course of the present week. As, however, our four months expire to-morrow, we were obliged to hold our statutory meeting to-day. In a week's time we shall probably be able to furnish the report of our manager in America. Meanwhile, speaking generally, the general manager reports to us that he has found everything in order, that the books have been admirably kept, that as far as he can judge there has been no over-valuation of assets, that we are in possession of one of the finest industrial concerns in the United States, and under an instruction from us he made a special inquiry with respect to some disquieting rumours which reached us as to a bad debt by the old company which might come to the disturbance of the new. I am happy to say that he writes us that there is no reason for any ground of apprehension that the bad debt which has been rumoured is one that will affect the new company in the least, but that the whole responsibility of it has been taken and secured by the old company before the business was transferred. I may also say that we expect that Mr. Belmont, the banker, of New York, who is largely interested with us, will take a seat on the Board, and give us the advantage of his great financial experience on the other side. We shall get more information, of course, when the manager arrives here, as he will then give us a detailed report.

The CHAIRMAN then notified that the regular meeting stood adjourned to 2.30 on Tuesday next.

The Secretary (Mr. JOHN C. WYLDE) then read the notice convening the meeting, and after a few remarks from the Chairman, the meeting adjourned.

## NEW COMPANIES REGISTERED.

**FROUDE-HURRELL TORPEDO COMPANY (LIMITED).**—Registered with a capital of £10,000 in £10 shares. Among the objects are the manufacturing establishing, and working apparatus for the distribution and utilisation of electric and other power, and the constructing, establishing, purchasing hiring, and dealing in railways, vessels, telegraphic and telephonic wires, &c. The registered office is 2, South-square, Gray's Inn, W.C.

**NEW COMPANIES REGISTERED DURING MARCH.**—Among the new companies registered during March dealing with electricity or engineering were the following:—

| | Capital. |
|---|---|
| Alexander Mathieson and Sons (Limited), in £10 shares | £120,000 |
| Dermatine Company (Limited), in £5 shares | 55,000 |
| Edinburgh and Leith Safe Deposit Company (Limited), in £5 shares | 20,000 |
| Froude Hurrell Torpedo Company (Limited), in £10 shares | 10,000 |
| Jarrow Forge and Engineering Company (Limited), in £10 shares | 80,000 |
| John Priest and Son (Limited), in £10 shares | 30,000 |
| Liverpool and District Pulsion Telephone Company (Limited), in £1 shares | 6,100 |
| London Rubber and Packing Company (Limited), in £5 shares | 3,000 |
| Langness Copper Company (Limited), in £1 shares | 35,000 |
| Weybridge Electric Supply Company (Limited), in £5 shares | 15,000 |

**WEYBRIDGE ELECTRIC SUPPLY COMPANY (LIMITED).**—Registered by Henry F. Kite, 11, Queen Victoria-street, E.C., with a capital of £15,000 in £5 shares. Object: To carry into effect an agreement made March 20th between the Laing, Wharton, and Down Syndicate (Limited), of the one part, and Percy Mossop, of Thames-street, Weybridge, on behalf of the Company of the other part, for the acquisition of the Electric Lighting Depôt, Weybridge, and to develop and extend the same. Registered without articles of association.

## CITY NOTES, &c.

**BRAZILIAN SUBMARINE TELEGRAPH COMPANY.**—The receipts of this Company for the week ended April 3rd amounted to £5,136.

**CITY AND SOUTH LONDON RAILWAY COMPANY.**—The traffic receipts of this Company for the week ended April 5th amounted to £901.

**DIRECT SPANISH TELEGRAPH COMPANY.**—The traffic receipts of this Company for the month of March, 1891, amounted to £1,930, as against £2,382 in the corresponding period of last year, or a decrease of £452.

**EASTERN TELEGRAPH COMPANY (LIMITED).**—The traffic receipts of this Company for the month of March, 1891, amounted to £58,447, as against £58,471 in the corresponding period of 1890, or a decrease of £24.

**EASTERN EXTENSION TELEGRAPH COMPANY.**—This Company notify that the accounts to the 31st December last show, subject to audit, a balance of profit of £106,257 after payment of three interim dividends. The directors propose to distribute on the 22nd April the usual dividend of 2s. 6d. per share, making a total dividend of 5 per cent. for the year 1890. It is also proposed to pay a bonus of 4s. per share, or 2 per cent., making a total distribution of 7 per cent. for the past year. The balance of £25,007 has been carried to the reserve fund, which now stands at £495,239. The general meeting of the shareholders takes place on the 22nd instant. We refer our readers to our advertisement columns for full particulars of the recent drawing of 320 Debentures of £100 each. These Debentures will be paid off at par on the 1st July next. The receipts of this Company for March, 1891, amounted to £44,716, as against £41,133 in the corresponding period of last year, showing an increase of £5,583.

**ELMORE'S AUSTRO-HUNGARIAN PATENT COPPER DEPOSITING COMPANY (LIMITED).**—It is announced that the title of this Company will in future be Elmore's German and Austro-Hungarian Metal Company (Limited), and that the offices of the Company have been removed to 64, Cannon-street, E.C.

**FOREIGN ELECTRIC DATE AND TIME STAMP COMPANY (LIMITED).**—The statutory general meeting was held on Tuesday at the offices, 90, Queen-street, London, E.C. The meeting was simply held to conform with the Act, no business being transacted.

**GLOBE TELEGRAPH AND TRUST COMPANY.**—The directors of this Company have declared an interim dividend of 2s. 6d. per share.

**GREAT NORTHERN TELEGRAPH COMPANY.**—The traffic returns of this Company are as follows:—Receipts in March, 1891, £22,800; 1st January to 31st March, 1891, £64,400; corresponding months, 1890, £60,200; corresponding months, 1889, £63,000.

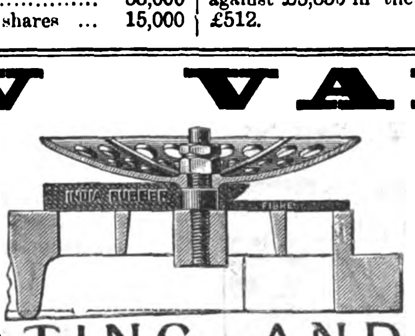
**ST. JAMES' AND PALL MALL ELECTRIC LIGHT COMPANY (LIMITED).**—The allotment letters for the 10,000 £5 Preference shares recently offered by this Company have been posted.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY.**—The traffic receipts of this Company for the week ended April 3, 1891, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £4,165.

**WEST INDIA AND PANAMA TELEGRAPH COMPANY.**—The receipts of this Company for the half-month ended March 31st, were £3,338, as against £3,850 in the corresponding period of last year, or a decrease of £512.

NEW VALVE

No Rubber, Percha, or Leather.




One-half the price of Rubber or Metal.

FOR CIRCULATING AND AIR PUMPS.

Unaffected by any Lubricating Oils. Does not Expand in diameter. Feed Water may be worked at any temperature Suitable for any shaped guards. Only one quality manufactured.

"12, John-street, Sunderland, 26th Sept. 1886.

"DEAR SIRS,—In reply to your letter of the 25th inst., the Valves I got from you have done their work well, and ARE AN UNQUALIFIED SUCCESS. I will continue get them from you as required.—Yours faithfully, JAMES WESTOLL."

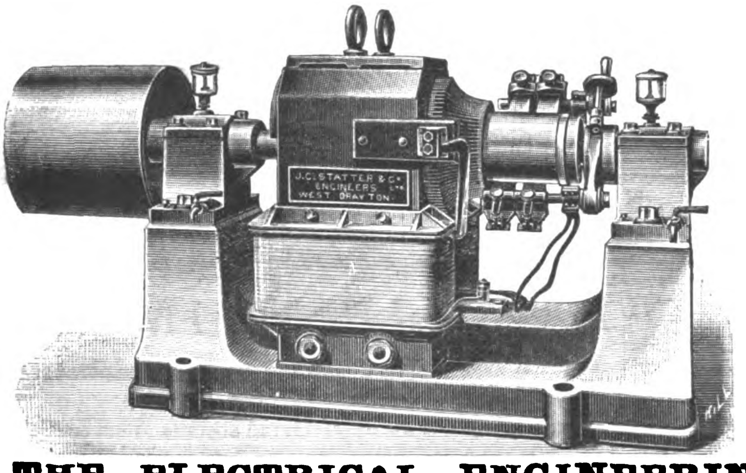
For further Testimony and Prices, apply to MOSSES & MITCHELL, 68-71, Chiswell Street, London.

Digitized by Google

# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name. | Previous Week's Price, April 1. | | Price Wednesday, April 8. | | Rate per Cent Yielded | Dividend Due. | Business Done During Week Ending April 8. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **TELEGRAPHS.** | | | | | £ s. d. | | | |
| £1,381,380 | Stock | 15/0 | Anglo-American | 47 | 48 | 46½ | 47½ | .. | Jan., Apr., July, Oct. | 47¾ | 47¼ |
| £2,809,310 | Stock | 30/0 | Do. Preferred | 84½ | 85½ | 84½ | 85½ | 6 14 6 | " " | 85½ | 84½ |
| £2,809,310 | Stock | .. | Do. Deferred | 11 | 11½ | 11 | 11½ | .. | .. | .. | .. |
| £250,000 | 100 | 4% | African Direct, Telegraph 4% Debentures | 99 | 102 | 99 | 102 | 3 18 5 | January and July .. | .. | .. |
| 130,000 | £10 | 3/0 | Brazilian Submarine | 11¾ | 12 | 11½ | 12 | 6 5 0 | Mar., June, Oct., Dec. | 12 | $11\frac{15}{16}$ |
| £84,500 | £100 | 5% | Do. 5 per Cent. Bonds | 100 | 103 | 100 | 103 | 4 17 1 | January and July .. | 101 | .. |
| £75,000 | £100 | 5% | Do. 5 per Cent. Bonds (2nd Series, 1906) | 103 | 107 | 103 | 107 | 4 13 6 | June and December | .. | .. |
| $7,216,000 | $100 | 7% | Commercial Cable Capital Stock | 107 | 109 | 107 | 109 | 6 2 4 | April and October .. | 109 | 103⅛ |
| 16,000 | 10 | 8/0 | Cuba Submarine | 10½ | 11½ | 10½ | 11½ | 6 19 2 | February and August | 10¾ | .. |
| 6,000 | 10 | 10% | Do. Preference 10% | 16½ | 17½ | 16½ | 17½ | 5 14 3 | " " | 17 | 16¾ |
| 12,931 | 5 | 2/4¾ | Direct Spanish (£4 paid) | 3¾ | 4¼ | 3¾ | 4¼ | 6 11 9 | April and October .. | 4⅛ | 3⅜ |
| 6,000 | 5 | 10% | Do. Preference 10% | 9 | 10 | 9 | 10 | 5 0 0 | " " | .. | .. |
| 60,710 | 20 | 3/6 | Direct United States | 10⅛ | 10⅝ | 10⅛ | 10⅝ | 6 15 0 | Jan., Apr., July, Oct. | 10⅜ | $10\frac{5}{16}$ |
| 400,000 | 10 | 2/6 | Eastern | 14⅛ | 14⅜ | 14⅛ | 14⅜ | 4 10 5 | " " | 14⅜ | 14⅛ |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference | 15¼ | 15¾ | 15¼ | 15¾ | 3 16 2 | " " | 15⅝ | 15⅜ |
| £1,200,000 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock | 107 | 110 | 108 | 111 | 3 12 1 | May and November | 110 | 106½ |
| £200,000 | 100 | 5% | Do. 5 per Cent Debentures, 1899 | 107 | 110 | 107 | 110 | 4 10 11 | February & August | 109 | 107¾ |
| 250,000 | 10 | 2/6 | Eastern Extension | 14¾ | 15¼ | 14¾ | 15¼ | 4 13 4 | Jan., Apr., July, Oct. | 15½ | $14\frac{15}{16}$ |
| £320,000 | £100 | 4% | Do. 4 per Cent. Debenture Stock | 105 | 108 | 105 | 108 | 3 14 1 | .. | 106½ | 105½ |
| £91,800 | 100 | 5% | Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900 | 103 | 106 | 103 | 106 | 4 14 4 | January and July .. | .. | .. |
| £145,300 | 100 | 5% | Eastern & S. African 5 per Cent. Mor. Deb., 1900 | 103 | 106 | 103 | 106 | 4 14 4 | " " | .. | .. |
| 180,227 | 10 | 1/9 | Globe Telegraph and Trust | 9⅛ | 9⅜ | 9¼ | 9½ | 5 7 10 | Jan., Apr., July, Oct. | $9\frac{7}{16}$ | $9\frac{3}{16}$ |
| 180,042 | 10 | 6% | Do. 6 per Cent. Preference | 15 | 15¼ | 14⅞ | 15⅛ | 3 19 4 | " " | $15\frac{1}{16}$ | $14\frac{13}{16}$ |
| 150,000 | 10 | 5/0 | Great Northern | 17¼ | 17¾ | 17¼ | 17¾ | 4 5 9 | Jan., April, and July | 17⅝ | .. |
| £15,000 | 100 | 5% | Do. 5 per Cent. Debentures, 1881 | .. | | .. | | .. | January and July .. | .. | .. |
| £230,000 | 100 | 5% | Do. 5 per Cent. Debentures, 1883 | 103 | 106 | 103 | 106 | 5 13 2 | March & September | 105½ | 104½ |
| 17,000 | 25 | .. | Indo-European | 39 | 41 | 40 | 42 | 5 19 1 | May and November | 41 | 40¾ |
| 38,348 | 10 | 2/6 | London Platino-Brazilian | 6½ | 7½ | 6½ | 7½ | 5 14 4 | " " | .. | .. |
| £100,000 | 100 | 6% | Do. 6 per Cent. Debentures | 105 | 108 | 105 | 108 | 5 11 1 | March & September | .. | .. |
| 9,000 | 8 | 4/0 | Reuter's | 9 | 9½ | 9 | 9½ | 5 6 10 | April and October .. | .. | .. |
| 3,381 | £100 Cert. | 6% | Submarine Cables Trust 6% | 115 | 120 | 115 | 120 | 5 0 0 | " " | 117 | .. |
| 15,609 | 10 | 4/0 | West African Telegraph | 8 | 9 | 8 | 9 | 5 11 1 | January and July .. | .. | .. |
| £290,900 | 100 | 5% | Do. 5 per Cent. Debentures | 97 | 100 | 98 | 101 | 4 19 0 | March & September | .. | .. |
| 30,000 | 10 | 3/0 | West Coast of America | 2½ | 3½ | 2½ | 3½ | .. | January and July .. | .. | .. |
| £150,000 | 100 | 8% | Do. Debentures 8% 1902 | 92 | 97 | 92 | 97 | .. | June and December | 94½ | 93 |
| 88,321 | 10 | .. | West India and Panama | 2⅞ | 3⅛ | 2¾ | 3 | .. | .. | $2\frac{15}{16}$ | 2⅞ |
| 34,563 | 10 | 6/0 | Do. 1st Preference 6% | 11½ | 12 | 11½ | 12 | 5 0 0 | May and November | .. | .. |
| 4,669 | 10 | £3 | Do. 6 p. c. 2nd Pref. | 11½ | 12½ | 11½ | 12½ | 4 16 0 | " " | .. | .. |
| 64,174 | 15 | 6/0 | Western and Brazilian | 12 | 12½ | 12 | 12½ | 4 16 1 | " " | 12¼ | 12⅛ |
| 27,873 | 7½ | 6/0 | Do. 5 per Cent. Cumulative Preferred | 6¾ | 7¼ | 6¾ | 7¼ | .. | — | 7 | .. |
| 27,873 | 7½ | 4/6 | Do. 5 per Cent. Deferred | 5¼ | 5¾ | 5¼ | 5¾ | .. | .. | $5\frac{9}{16}$ | .. |
| £200,000 | 100 | 6% | Do. 6 per Cent. Debs., Series "A" 1910 | 103 | 106 | 103 | 106 | 5 13 2 | February & August | 104½ | .. |
| £250,000 | 100 | 6% | Do. 6 per Cent. Mort. Debs., Series "B" 1910 | 103 | 106 | 103 | 106 | 5 13 2 | " " | 105 | .. |
| $1,336,000 | $1,000 | 7% | Western Union 7 per Cent. 1st Mortgage | 120 | 125 | 120 | 125 | 5 12 0 | May and November | .. | .. |
| £175,100 | £100 | 6% | Do, 6 per Cent. Sterling Bonds | 100 | 104 | 100 | 104 | 5 15 5 | March & September | .. | .. |
| | | | **TELEPHONES.** | | | | | | | | |
| 224,850 | 14/0 | 0/4½ | Consolidated Telephone Const. & Maintenance. .. | $1\frac{7}{16}$ | $1\frac{9}{16}$ | $1\frac{7}{16}$ | $1\frac{9}{16}$ | .. | May and November | .. | .. |
| 220,000 | £1 | 3% | Oriental (11s. paid) | $1\frac{5}{16}$ | $1\frac{7}{16}$ | $1\frac{5}{16}$ | $1\frac{7}{16}$ | 4 8 7 | Yearly | .. | .. |
| 438,984 | 5 | 2/6 | National | 4⅜ | 4⅝ | 4⅜ | 4⅝ | 5 18 11 | June and December | 4⅝ | 4½ |
| 15,000 | 10 | 6/0 | Do. 6 per Cent. Cumulative 1st Pref. | 13 | 13½ | 13 | 13½ | 4 8 11 | " " | $13\frac{7}{16}$ | 13¼ |
| 15,000 | 10 | 4/9¾ | Do. 6 per Cent. Cumulative 2nd Pref. (£8 pd) .. | 10 | 10½ | 10 | 10½ | 4 11 7 | " " | 10 | .. |
| 209,750 | 1 | ½% | South of England, Ordinary | ⅛ | ¼ | ⅛ | ¼ | .. | — | .. | .. |
| 20,000 | 5 | 2/1 | Do. 6 per Cent. Cumulative Pf. (£3 10s. pd) .. | 3 | 3½ | 3 | 3½ | .. | .. | .. | .. |
| 58,000 | 5 | 1/0 | United River Plate | 2½ | 3½ | 2½ | 3½ | .. | January and July .. | .. | .. |
| £146,128 | Stock | 5% | Do. 5 per Cent. Debenture Stock | 85 | 95 | 85 | 95 | 5 5 3 | .. | .. | .. |
| £3,200 | 100 | 7% | Do. 7 per Cent. Debentures | .. | | .. | | .. | — | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | | | |
| 19,900 | £5 | .. | Electricity Supply Co. of Spain | 4½ | 5 | 4½ | 5 | .. | .. | .. | .. |
| 111,000 | 5 | .. | London Electric Supply | 2⅜ | 2⅝ | 2⅜ | 2⅝ | .. | .. | 9⅛ | 9 |
| 43,900 | 10 | .. | Metropolitan Electric Supply (£9 paid) | 8¾ | 9¼ | 8¾ | 9¼ | .. | — | .. | .. |
| 7,730 | £5 | .. | St. James' and Pall Mall | 6¼ | 6¾ | 6¼ | 6⅝ | .. | — | .. | .. |
| 42,853 | 5 | .. | Westminster Electric Supply (£4 paid) | 3⅞ | 4⅛ | 3⅞ | 4⅛ | .. | — | .. | .. |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | | | |
| 63,416 | 3 | .. | Brush Electrical Engineering | 2⅜ | 2⅝ | 2⅜ | 2⅝ | .. | .. | 2½ | 2¼ |
| 63,416 | 2 | 1/1 | Do. 6 per Cent. Preference | 1¾ | 2 | 1⅝ | 1⅞ | 6 8 0 | June and December | 1¾ | 1½ |
| 20,000 | 5 | 3/6 | Crompton and Co., 7 per Cent. Pref. Shares | 5 | 5½ | 5¼ | 5¾ | 6 1 9 | January and July .. | .. | .. |
| 17,130 | 5 | .. | Edison and Swan United | .. | | .. | | .. | .. | .. | .. |
| 45,000 | 10 | 6% | Electric Construction | 5½ | 6½ | 5½ | 6½ | .. | .. | $3\frac{1}{16}$ | 2⅞ |
| 70,000 | 2 | 10/0 | Elmore's Patent Copper Depositing | 3 | 3½ | 2¾ | 3¼ | .. | .. | .. | .. |
| 20,000 | 5 | .. | Fowler-Waring Cables (£4 paid) | 2½ | 3½ | 2½ | 3½ | .. | .. | .. | .. |
| 41,600 | 10 | 10/0 | India Rubber, Gutta Percha & Telegraph Works | 18½ | 19½ | 18½ | 19½ | 5 2 7 | February & August | 19½ | 19 |
| £200,000 | 100 | 4½% | Do. 4½ per Cent. Debentures, 1896........xd | 102 | 104 | 102 | 104 | 4 6 7 | March & September | .. | .. |
| 11,334 | £10 | 6/1 | International Okonite Limited Ordinary | 7½ | 8½ | 7½ | 8½ | .. | .. | .. | .. |
| 11,334 | £10 | 5/0 | Do. Preference | 9¼ | 9¾ | 9¼ | 9¾ | 8 4 1 | .. | .. | .. |
| 78,949 | 5 | 4/10⅛ | Swan United (£3. 10s. paid) | 4½ | 5 | 4½ | 5 | 6 19 10 | May and November | 4⅞ | $4\frac{11}{16}$ |
| 37,350 | 12 | 36/0 | Telegraph Construction and Maintenance | 45 | 47 | 45 | 47 | 5 0 0 | March and July..... | 46½ | 45½ |
| £150,000 | 100 | 5% | Do. 5 per Cent. Bonds, red. 1894 | 102 | 105 | 102 | 105 | 4 15 3 | January and July . | .. | .. |
| | | | **RAILWAYS.** | | | | | | | | |
| 50,000 | £10 | .. | City and South London Railway | 5½ | 6½ | 5½ | 6½ | .. | .. | 6 | $5\frac{1}{16}$ |


IMPROVEMENTS IN DYNAMOS




STATTER-BRUNTON DYNAMO.

**The latest design in the market, made with all the advantages of the latest scientific knowledge and the highest mechanical skill.**

The woodcut represents our B TYPE DYNAMO. A most efficient machine, working noiselessly, and without sparking or overheating; is highly finished and well proportioned. The output is so rated in our Catalogue that the machines may be worked very much in excess of their stated full output for short periods.

STOCK SIZES UP TO 77 KILOWATTS.
MACHINES BUILT TO 500 KILOWATTS.

THE ELECTRICAL ENGINEERING CORPORATION, LIMITED,
[STATTER'S] [UNITED
68, Victoria Street, London, S.W. WORKS:—ALLIANCE ENGINEERING WORKS, WEST DRAYTON, NEAR LONDON.


Digitized by Google

# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 674.—Vol. XXVI. FRIDAY, APRIL 17, 1891. Price Fourpence.


## NOTES.

If the theory of cycles in the history of human affairs be a true one, we are now between two periods of inventive activity, and are rising on a wave of litigation. Two cases of interest were tried this week, one has been adjourned and the other ordered to stand over, while to-day, unless his opponents are allowed to continue their policy of pleading for delays and extension of time, Mr. Lane Fox will succeed in getting a hearing for his action.

The case of Savory and Moore *v.* The London Electric Supply Corporation is one which might have established a serious precedent by attaching the stigma of "nuisance" to a transformer sub-station. In the hands of unscrupulous experts, or of ignorant and prejudiced witnesses, the judge might have been persuaded that the presence of 10,000 volts and a number of transformers and switches was so "highly dangerous" that the building containing them was comparable to a nitro-glycerine factory. It appears that a good case was made for the safety of the fireproof room containing the transformers, but the intentions of the Supply Company as to the use to which the upper part of the building would be put, were not disclosed.

Advocates of transformer sub-stations are fond of saying that it is easy enough to rent a cellar "somewhere," and it is well that Mr. Justice Kekewich has been satisfied that proper fireproof construction is all that is needed to eliminate any possible danger or damage to neighbouring property. It is not surprising that Messrs. Savory and Moore, who have been seriously inconvenienced by noise and vibration when the machinery was running, and who were placed in a very awkward position during the recent fire, should vigorously oppose the construction of a sub-station. The public ought to learn that a transformer *may* burn out, but it does not burst into flames when such an accident happens. Switches and fuses ought not to contain any inflammable material, and no combustible substance other than the insulation of the cables need be found in the station. Insulation, when arranged as it is in the Ferranti mains, is not in the least likely to catch fire.

At a meeting of the Society of Telegraph Engineers on May 9, 1877, Prof. Abel in the chair, a communication was made by Mr. J. Sivewright, the then acting secretary, on "A new form of electric light." This was the Jablochkoff candle. In the course of the description, the following words are to be found :—"He introduced into the centre circuit of the machine the primary wires of a series of induction coils, and sent the electric current from the induced current on to a slip of kaolin placed between the two ends of the outside wire of each coil. . . . . . The result thus obtained between the two ends of the wire of the coil is a splendid band of light. . . . . . As to its power, that only depends on the number of the spirals and the diameter of the coils used. . . By using alternating currents the interrupter and condenser of the coils are not required." This communication was well known, but it was generally thought that it had been made seven days *after* the date of Jablochkoff's patent, for the blue book bears the date May 2, 1877. It now appears plainly enough that this is a misprint, for the real date, May 22nd, is to be found three times on the first page of the specification. The petition for prolongation of this patent, a report of the proceedings in connection with which will be found in another column, is to be amended by adding thereto a prayer for confirmation, without which the patent is invalid.

There would hardly seem to be enough in the subject of screening of electric and magnetic forces to yield matter for two Papers before the Royal Society, and a discourse on the following day before the Royal Institution, but Sir William Thomson made three such communications last week. The manner in which the subject was handled varied from the very stiff mathematical Paper which appeared in our last issue, to the popular lecture, which was of a typical "Friday evening" character.

It is to be feared that some of the delicate pleasantry of the discourse was lost upon many of the audience at the Royal Institution. The fifth kind of screens—fire-screens and window-blinds—was merely alluded to, and the lecturer did not explain that the radiations which are obstructed by such screens are, in fact, electro-magnetic. Of a similar character was the neat remark that it was fitting that opticians should sell magnets.

The screening of electric and magnetic force has not attracted much attention from those who are concerned with the practical applications of these forces. Faraday's cage has been looked upon as an elaborate experiment which merely proves that a passive condition exists within a conductor, and as a type of a building thoroughly protected from lightning. Wire and tinfoil cages have been used in electrometer work, and there practical electrostatic screening has ended. Magnetostatic screening has been exemplified in the Thomson marine galvanometer and in iron-cased watches.

Digitized by Google

THE apparent permeability of all ordinary substances to magnetic force has always been a mystery to the uninitiated, and has frequently been confounded with electrical conductivity. Many persons imagine that the red sealing-wax varnish on an ordinary horse-shoe magnet is a magnetic insulator, and accounts for the absence of any free magnetism along the parts thus protected. We have seen a perpetual-motion machine consisting of six magnets and seven iron balls suspended on a frame. One side of each ball was covered with sealing-wax varnish, the idea being that when a ball had passed a magnet it would no longer be attracted owing to the interposition of the varnish. The inventor wanted financial assistance to procure stronger magnets.

THE facts put forward by Sir W. THOMSON with regard to the variation of the screening power of substances for periodically varying electrostatic forces of different frequencies, are of great interest. A body may be opaque to very slow vibrations, transparent to quick ones, and again opaque to excessively rapid vibrations, such as occur in light. We are here fringing on the subject of the colour of bodies, since colour is merely due to the selective absorption of substances for light waves of different periods. The reason why a body should permit waves of certain frequencies to pass through it unchanged, while absorbing others altogether, is a mystery which is likely to remain unexplained for a long while.

THE new method of measuring electrical power, described in the Paper by Prof. AYRTON and Dr. SUMPNER, at the Royal Society, last week, is remarkable in two respects—first, that it had not been thought of before; and secondly, that while the Paper was yet unread the method had been published in the columns of our contemporary, *Industries*. It is, we believe, unusual to allude to the contents of Papers which have been presented to the Royal Society before they have been read; but allusion having been made during the discussion on Mr. SWINBURNE's Paper at the Institution of Electrical Engineers, he at once set to work, and, in consequence probably of the well recognised way in which discoveries seem to hang in the air and occur to several minds almost simultaneously, he hit on the very method, and lost no time in publishing it. The authors of the Paper are perhaps to be congratulated that under the circumstances of previous publication their Paper was read; but there was probably no precedent for such a case. The fact that the method only requires the use of an ordinary alternate-current voltmeter, and that it is applicable to all kinds of currents, however complex the law of their variation may be, are great points in its favour. It is a pity that the resistance required should absorb as much power and as many volts as the part of the circuit under test, but this happens in nearly all tests of electrical power.

A MATTER incidentally alluded to during the discussion on this Paper at the Royal Society was the need for some general word denoting a portion of an electrical circuit. It is desirable to reserve the word "circuit" for the complete path of the current, and the words "resistance" or "conductor" are hardly comprehensive enough to designate any portion of the circuit absorbing power.

THE experiments on arc lamps, referred to by Prof. AYRTON and Dr. SUMPNER, are of great interest, and show the need of some such a method of test for investigating the phenomena of the arc. It is difficult to understand how an arc can act as an inductive coil, unless, as Sir W. THOMSON suggested, the arc can be regarded as an intermittent series of spark discharges. The experiments conclusively show that the current through an arc is far from sinuous, and in estimating the power by any ordinary method serious errors may arise.

WHATEVER may be the exact amount of importance which should be attached to the meeting held at Cannon-street Hotel, on Wednesday afternoon, the objects of the proposed Telephone Association, and the course which it is intended to pursue in order to attain them, are worthy of general support. An Association is not, indeed, required to convince London telephone subscribers that either the rates should come down or the efficiency of the service go up; but united action *is* requisite to give effect to this wide-spread feeling. Mere agitation would not, however, have much chance of success, and the promoters of the Association have, therefore, done well to draw the following oracular pronouncement from the only quarter likely to influence the National Company. "As to any action which the Post Office itself might be prepared to take," writes the Secretary to the Post Office, "I am to say that the POSTMASTER-GENERAL could not be indifferent to a clearly expressed demand for the establishment of a telephonic service in London, but he regards it as premature at present to state what the charge for such service would be." In short, the Association proposes first of all to test the efficacy of "sticking together," but should that fail to secure metallic circuits and reduced rates for the long-suffering Londoner, the aid of the Post Office will be invoked, and that department, we are told, will not be "indifferent to a clearly expressed demand."

THE result of the dispute between the POSTMASTER-GENERAL and the Boy Messenger Companies, as announced in our Legal Intelligence, must certainly be considered eminently satisfactory to all concerned. The Companies have received a gratuitous advertisement, and the licences they have been fighting for; the ATTORNEY-GENERAL has vindicated the majesty of the law, the POSTMASTER-GENERAL has levied his tribute, and last, but not least, the public will get an efficient express service. All's well that ends well, so that it is unprofitable to inquire why the present arrangement could not have been arrived at in a less tempestuous manner.

THE series of articles by Mr. SPRAGUE is concluded in the present issue. They originated in a letter which appeared in *The Electrician*, January 16th, p. 340, and gave rise to a correspondence which seemed likely to go on indefinitely. We therefore asked Mr. SPRAGUE to state his case, and suggested that his opponents should just hear him and then reply. His views are of a thoroughly common-sense character, but are not in accordance with the received teachings of the present day. Mr. SPRAGUE has done his best to shake the orthodox doctrines, and has not hesitated to reject definitions and to coin new expressions. The controversy is on this

Digitized by Google

account in danger of degenerating into a difference of opinion as to the use of words. Dr. OLIVER LODGE, in alluding to Mr. SPRAGUE's first letter, remarked that "the best service that one can do to a true theory after its promulgation is to pick holes in it, or suggest a rival one." If Mr. SPRAGUE's articles induce electrical students to think out the *pros* and *cons* of the present orthodox theories for themselves, instead of receiving them on faith, they will have served a good purpose.

**Our Telephonic Defences.**—The Spithead forts are about to be placed in telephonic communication with the head-quarters of the Royal Artillery, at Portsmouth.

**Electrical Bills in Parliament.**—In the House of Commons on Tuesday, the London Overhead Wires Bill was ordered for third reading, and the West Metropolitan Tramways Bill was read a second time.

**National Telephone Electrical Society.**—On Friday, April 10th, Mr. W. Johnstone, inspector-in-charge of Kidderminster, and late Secretary of the Society, read a Paper on "Some forms of Switchboards for small Exchanges."

**Brazilian Submarine Telegraph Company.**—The fifth drawing for payment of the Five per Cent. Debentures of this Company will take place on Friday next. Further particulars will be found in our advertisement columns.

**Proposed Universal Exhibition at Berlin.**—A proposal to hold a universal exhibition at Berlin in 1894 or 1895 has been favourably received. The Minister of Commerce approves of the idea, as do nearly all the Chambers of Commerce throughout the Empire.

**Leamington.**—At the last meeting of the Town Council the Watch Committee reported that the contract with the Midland Electric Light and Power Company for street lighting expired on March 25th, and the Parade and Bath-street were once more lighted with gas.

**The Junior Engineering Society.**—On Monday, 6th inst., a large party of members of this Society visited Messrs. Siemens Bros. and Co.'s electrical engineering works at Charlton. Every facility was afforded for enabling the numerous departments of the extensive establishment to be seen.

**Damage by Lightning.**—Needwood Church, near Burton-on-Trent, was struck by lightning during service on Sunday last. It was found that the lightning conductor had been destroyed, some of the lead on the roof had been torn up, and the stone step at the entrance door had been smashed.

**Bath.**—A fatal accident occurred at the Bath Electric Light Works on Saturday morning last. An engine-driver had ascended a short ladder for the purpose of lubricating. The ladder slipped, the driver overbalanced and fell upon the rope gear, and was immediately drawn under the fly-wheel.

**Bristol.**—Arrangements have been made by Mr. Preece by which Mr. Gisbert Kapp will co-operate with him in preparing plans and specifications for the electric lighting of this city. High-pressure alternate currents will be used with sub-stations for distributing, and nothing will be omitted in either the mechanical or the electrical work to make this a model central station.

**Institution of Electrical Engineers.**—A general meeting of the students was held on Friday, April 10th, when a Paper was read by Messrs. Matthews and Seaman on "Photometry," some apparatus being kindly lent by Messrs. Alex. Wright and Co., Westminster. The next meeting will be held on the 24th inst., when a Paper will be read on "Alternate Current Motors," by Mr. G. U. Yule.

**Davis and Stokes' Safety Commutator.**—We are informed that a motor fitted with Davis and Stokes' safety commutator is working satisfactorily at All Saints' Works, Derby. A number of electrical engineers have been to view the machine; and, as the motor will be running until the 24th inst., it is possible that others may like to avail themselves of this opportunity of inspecting a motor so fitted in actual operation.

**Hull.**—At a meeting of the Electric Light Committee of the Town Council last week a letter was read from the Board of Trade asking the Corporation what system of lighting they had adopted. After considerable discussion, it was resolved, "That the sub-committee be requested to report to the committee at an early date as to the system they would recommend the Council to adopt, and that they be authorised to retain such professional assistance in the matter as they see fit."

**Transvaal Telegraphic Statistics.**—The statistics published by the General Manager of Telegraphs in the last Transvaal *Staatscourant* for the year 1890, show that the total number of telegrams despatched during that year was 513,479, while 486,929 were received. The total number of telegrams received and despatched from the different offices of the Republic, including Government messages, were 1,445,336. At Johannesburg 230,819 telegrams were despatched and 217,561 received. Pretoria comes second in the list with 97,225 despatched and 100,392 received.

**The Suez Canal Traffic and the Electric Light.**—During the years the electric light has been permitted for transit, the number of vessels using the canal and the light are as follows:—

| | Total transit. Vessels. | Using electric light. Vessels. | Using electric light. Per centage of total Vessels. |
|---|---|---|---|
| 1887 | 3,137 | 395 | 12·7% |
| 1888 | 3,440 | 1,611 | 47·0% |
| 1889 | 3,425 | 2,445 | 71·4% |
| 1890 | 3,389 | 2,836 | 83·5% |

**The International Railway Congress.**—The fourth meeting of this Congress will take place in June next year, at St. Petersburg. The following items of the programme are of electrical interest:—*Signal Lighting:* Methods of increasing the visibility of signal and train lights in foggy weather, and of avoiding extinctions; the employment of electricity. *Special Modes of Tractions:* What are the results obtained since the last Congress with the various special modes of traction, and especially with electric traction? The progress of electricity as a motive power from the practical, technical, and economical point of view.

**The West End Street Railway of Boston.**—The West End Street Railway of Boston seems to neglect nothing which is likely to render its service efficient. On the occasion of a great fall of snow in March, arragements having been made for such contingencies, it had an hour and a-half notice from the Blue Hill Observatory of the approach of the snow, and had its track sweepers, snow ploughs, and patrol sleds in readiness, and the snow flakes were whisked from the track almost as soon as they fell; so that no delay occurred directly on account of the storm. In this, as in previous storms, the trolley wires were oiled, and what little ice formed on them readily dropped at a light stroke.

**Leeds.**—At a meeting of the Parliamentry Committee of the Leeds County Council, held on Friday last week, the following resolution was moved and carried unanimously:—"That the Council be recommended, as the Local Authority for the Borough of Leeds, under the Electric Lighting Acts, 1882 and 1888, to consent to the grant by the Board of Trade of a Provisional Order authorising the Yorkshire House-to-House Electricity Company (Limited) to construct and maintain electric lines and works, and to supply electricity within the Borough on such terms and conditions as the Parliamentary Committee may approve." The resolution will be submitted to the Council to-day.

**A Fountain of Electricity.**—An amusing report, says the *Electrical World*, comes from Boston that the much-abused trolley wire has appeared in the *rôle* of a public benefactor. This romance states that a certain citizen living along the line of the West End road found an ever-active and unceasing fount of electricity in his cellar, coming from one of the iron posts of the railway company, and flowing into his private domain. He promptly corraled the current, and, charging a storage battery with it, lights his house, runs motors, bells and burglar alarms. The item further states that the railway company is powerless to prevent the leak. A thoroughly trained and well-

Digitized by Google

educated reporter (says our contemporary) would not have stopped at such common-place and altogether prosaic evidence of electrical leakage. He would have seen the magnificent possibilities of the situation, and developed them.

**Waste Cork Lagging for Steam Pipes.**—Messrs. R. Bolton and Co., of Leadenhall-street, have recently made some experiments on the comparative efficiency of asbestos lagging and the cork lagging which they have introduced into this country. This material is made from the waste cork from the Spanish cork factories by compressing it into slabs with some glutinous material. The experiments were made by connecting three closed vertical tubes, each 5in. in diameter, with a supply of steam. One pipe was uncovered, another was covered with asbestos lagging, and the third with the cork lagging. The amount of steam condensed in 10 minutes was $11\frac{1}{2}$oz. of water in the uncovered tube, 6oz. in the asbestos-coated tube, and $3\frac{1}{2}$oz. in the cork-lagged tube. The material can be obtained in sheets of from $\frac{3}{16}$in. to $\frac{3}{4}$in. thick, and in widths of from $2\frac{3}{8}$in. to 10in.

**Leclanche Cells without Manganese.**—In the *English Mechanic* for March 27th, Mr. T. H. Nash states that for the last four or five years he has had cells ringing bells containing no manganese, and they have done their work well. He has tried broken carbon in a calico bag surrounding an ordinary Leclanché carbon, though the best results were obtained by using two carbon plates with a zinc plate between them—in fact, a bichromate, but using salammoniac solution as the exciting fluid. Two cells of this description worked well for 16 months, and were still good at the end of that period. In order to gain some information as to the recuperative power of such cells, Mr. Nash took one, and connected it up to a bell, which it rang well. He then connected the carbons and zinc by a wire, and left it all night. In the morning it had, of course, run down, and would not ring the bell at all. At five o'clock in the afternoon, after resting, it rang the bell as strongly as ever.

**The Manchester Exchange of the Mutual Telephone Company.**—We have received from the Mutual Telephone Company a list of some twenty testimonials received by them from their more important Manchester subscribers. In considering these testimonials it should be remembered, the Company remark, that they refer to a service which was declared to be impossible until after the lapse of the Edison Patent next July, and that the service, good as it already is, will be markedly improved when the use of carbon, now prohibited, becomes free towards the close of the month named. The following testimonial from Messrs. Goldschmidt, Hablo and Co. is a sample of the rest:—"We have much pleasure in informing you that after about six weeks' experience with your telephone, we find the same most satisfactory in every respect. Firstly, the instruments speak clear and the sound is distinct. Secondly, there is no overhearing of others speaking, hence conversations are absolutely private. Thirdly, the instruments are clear, and there are no disagreeable or rasping sounds. Fourthly, we find the attention at the Exchange most prompt."

**Patent Fees.**—In the House of Commons last week Mr. Morton asked the President of the Board of Trade whether it was correct that a patentee in this country had to pay a sum of £154 for 14 years' protection, whereas in the United States of America the cost was only £7 for 17 years' protection; and, if correct, would the Government, having regard to the keen competition between this country and the United States, take steps to put British inventors in a more favourable position. In reply, Sir M. Hicks-Beach said that the sums stated were accurate as regards the whole period of protection, but the position was not quite fairly represented, because protection was given for periods less than 14 years for sums less than the amount set out. Protection for four years, for instance, was given in an ordinary case for £4, whereas the payments required to be made within the same period in the United States amounted to £6 or £7. The whole scale of fees was carefully considered in 1883 when the Act was passed, and it was held that there were reasons, from the point of view both of the public and of inventors, against encouraging a lengthened protection of patents which were not likely to be worked. It did not appear desirable that a patentee who could not make his patent available for public use should occupy the ground for a long time to the exclusion of others.

**The Granting of Competing Provisional Orders.**—In the House of Commons last week, Mr. Spencer Balfour asked the President of the Board of Trade whether the Board intended to grant a third Provisional Order under the Electric Lighting Acts in any district in London where there were already two electric lighting companies empowered by Provisional Orders to supply electricity; and whether, if so, he would explain why it was now intended to depart from the principle laid down by the Board of Trade, after the Westminster Inquiry of 1889, that there should only be two companies, each on a different system, in one district, and also from the policy of the Board of Trade as stated by the President on May 12th last. Sir M. Hicks-Beach stated, in reply, that it was not intended to grant a third Provisional Order under the Electric Lighting Acts in any urban district where there were already two electric lighting companies empowered by Provisional Orders to supply electricity, unless there were strong reasons to suppose that one of such electric lighting companies would be unable to exercise their powers within a reasonable time. Where, however, this was the case, he did not think that it was desirable that the inhabitants of a district should be entirely debarred from all advantage of competition.

**Athens.**—The electric light, which made its first public appearance in Athens in September, 1888, when it was temporarily employed to light the Greek National Exhibition, has met with considerable favour there. Such was the demand for current that after endeavouring to meet it by the erection of several small improvised stations, it was found necessary in August, 1889, to commence a large central station, which came into operation in the autumn of that year. The present plant comprises six 60 kilowatt Edison dynamos, each pair being driven by a 150 H.P. compound vertical Pelong engine, by Weyher and Richemond, of Paris, and four 30 kilowatt Edison dynamos. During the hours of small output the load is taken by a battery of 130 Julien accumulators. The boilers are of the Babcock and Wilcox type. The feed water is drawn from the Ilissus, $1\frac{1}{4}$ miles distant. In summer this supply is somewhat short, and water has to be obtained from a still greater distance. The three-wire system is employed. The mains are almost entirely underground, and are run largely along the sewers, though where no sewers exist lead-covered cables run in asphalted wooden conduits are employed. Edison meters are employed throughout, the charge per 1,000 watt hours being a little over a shilling.

**American Patent Office Statistics.**—The following table, prepared by the American Patent Office, shows the number of patents issued during the year 1890 to citizens of the different States, with the ratio of such patents to the population:—

| | One patent to every | | One patent to every |
|---|---|---|---|
| Alabama | 14,689 | Nebraska | 4,706 |
| Arkansas | 11,875 | Nevada | 3,813 |
| California | 1,887 | New Hampshire | 2,189 |
| Colorado | 2,240 | New Jersey | 1,299 |
| Connecticut | 796 | New Mexico | 9,599 |
| Delaware | 3,303 | New York | 1,308 |
| Dist. of Columbia | 980 | North Carolina | 21,864 |
| Florida | 7,674 | North Dakota | 4,567 |
| Georgia | 11,135 | Ohio | 2,084 |
| Idaho | 7,032 | Oklahoma | 15,458 |
| Illinois | 1,778 | Oregon | 3,826 |
| Indiana | 3,272 | Pennsylvania | 1,990 |
| Iowa | 4,375 | Rhode Island | 1,235 |
| Kansas | 4,054 | South Carolina | 15,348 |
| Kentucky | 7,375 | South Dakota | 5,573 |
| Louisiana | 8,164 | Tennessee | 9,819 |
| Maine | 3,443 | Texas | 7,258 |
| Maryland | 3,509 | Utah | 6,930 |
| Massachusetts | 1,068 | Vermont | 3,291 |
| Michigan | 2,136 | Virginia | 9,355 |
| Minnesota | 3,434 | Washington | 5,459 |
| Mississippi | 23,147 | West Virginia | 8,029 |
| Missouri | 3,311 | Wisconsin | 2,660 |
| Montana | 2,493 | Wyoming | 7,588 |

Digitized by Google

**Electro-chemical Effects on Magnetising Iron.**—In a Paper recently read before the Royal Society, Mr. Thomas Andrews, F.R.S., gave the results of some experiments carried out by him on the effect of magnetisation on the relative electro-chemical position of a pair of bright iron bars, one magnetised by a coil, the other unmagnetised, when simultaneously exposed to the action of various powerful oxidising agents and saline solutions. He employed long polished rods of soft wrought scrap iron 0·261in. in diameter. Each pair of pieces was adjacently cut from the same iron rod, so that they might as near as practicable be of identical chemical composition and molecular constitution. The pieces were placed in the legs of a U tube containing the electrolyte, every care being taken to check any E.M.F. which might occur owing to the rise of temperature in one leg caused by the current in the magnetising coil. The solutions employed were potassium chlorate + one-fifth and one-third nitric acid, potassium chlorate and hydrochloric acid, 25 per cent. and 20 per cent. aqueous solutions of nitric acid, a 50 per cent. aqueous solution of hydrochloric acid, concentrated sulphuric acid (Sp. gr. 1·84). The magneto-chemical effects were very small, being usually of the order of $1 \times 10^{-3}$ volt. The magnetised rod was in every instance, except when dilute hydrochloric and concentrated sulphuric acid were employed, the positive element. In the exceptional instances alluded to, the electro-negative effect occurs, possibly owing to the presence in the solution of such reducing agents as nascent hydrogen.

**The Ferranti System at Havre.**—To carry out electric lighting at Havre, with its numerous docks, and suburbs scattered along the coast, no other system than that of the alternate current transformer was feasible, unless a large number of small separate stations were to be erected. The Société l'Energie Électrique, which had obtained a 40 years' concession, during the first 14 of which they were given exclusive rights, therefore decided to employ the Ferranti system. The central station is near the railway station, and in close proximity to coal yards and to the sea, whence it is proposed to draw the water necessary for condensing purposes. The plant at present comprises four Berendorff boilers working at 114lbs. pressure; two single cylinder Corliss engines, taking steam at 86lbs. pressure, and capable of developing 350 H.P or 450 H.P. at one-ninth and four-tenths cut-off respectively; two 224 kilowatt (2,400 volts) Ferranti alternators, excited by small six-pole Sautter-Lemonnier machines mounted on the same bed-plate. The dynamos are driven direct through rope gearing (10 ropes of 1·4in. diameter). Each engine is fitted with a fly-wheel 22ft. in diameter, and weighing 15 tons. Special arrangements are made for running non-condensing in times of neap tides and when otherwise necessary. Great attention has been paid to securing efficient lubrication. A small pump, fitted to each dynamo, takes the lubricant from the large reservoir in the pedestal, which holds some 1,800lbs. of oil, and forces it into the bearings at a considerable pressure. The measuring instruments comprise a Sir William Thomson electrostatic voltmeter, and a Carpentier dead-beat electrometer.

**Reduction of Telegraph Rates to Australia.**—The Eastern Extension Telegraph Company (in connection with the Indo-European Telegraph Department of Her Majesty's Indian Government and the Eastern and Indo-European Telegraph Companies) notify that the negotiations with the Australasian Colonies for a substantial lowering of the tariffs, have resulted in an agreement being concluded with the Governments of Victoria, New South Wales, South Australia, Western Australia, and Tasmania, and that the rates to those Colonies will consequently be reduced from May 1st proximo, as follows:—For ordinary telegrams:—From 9s. 4d. to 4s. per word for South and Western Australia; 9s. 4d. to 4s. 1d. for Victoria; 9s. 6d. to 4s. 2d. for New South Wales; 9s. 11d. to 4s. 8d. for Tasmania. For Press telegrams:—From 2s. 8d. to 1s. 10d. per word for South and Western Australia; 2s. 9d. to 1s. 11d. for Victoria; 2s. 9d. to 1s. 11d. for New South Wales; 3s. 4d. to 2s. 6d. for Tasmania. The contracting Colonies guarantee the Indo-European Telegraph Department and the Companies against one-half the risk of any loss should the receipts at the reduced rates fall short of the present earnings from the Australasian traffic, and the Indo-European Telegraph Department and the Companies undertake the other half. The agreement is for a tenative period of one year, to be extended if found to work satisfactorily; consequently, the continuance of the reduced rates depends upon the telegraphing public making the experiment a success by giving it their hearty support. It was hoped that Queensland and New Zealand would have taken part in the arrangement, but as they have declined to do so, the rates to these Colonies will remain unchanged.

**Exeter.**—At a recent meeting of the Town Council a report was presented by the Parliamentary Committee, in which it was stated that they had submitted the following terms to the Electric Lighting Company:—"That the Council have the option of purchasing the works and undertaking of the Company at the end of 25, 30, and 35 years from the time of the granting of the Order, upon the terms set out in section 2 of the Electric Lighting Act, 1888, with the following additions:—If the option is exercised at the end of 25 years, the Council to pay the Company a sum equal to the net profits made by the Company during the preceding five years. If at the end of 30 years, a sum equal to the net profits made by the Company for the preceding three years. If at the end of 35 years, a sum equal to the net profits made by the Company in the preceding two years." The Company replied that they would agree to the Council's proposal if the earliest period for the option of purchase was fixed at 28 years, the option only to arise at 28 and 35 years. The Committee resolved to recommend the Council to accept the proposal submitted by the Company. The adoption of the report having been moved, an amendment was proposed to the effect that, while retaining the first period of optional purchase by the Council of the Company's undertaking at 25 years, the Council were willing to make the second optional to arise at the end of 32 years instead of 30 years; thus giving the interval of seven years for which the Company ask. The added profits at the two periods to be those of five years and three years respectively. The amendment was carried by 22 votes to 16. The Company being unable to accede to this proposal, the matter has, by mutual consent, been left to the Board of Trade to settle.

**The Interior Conduit System.**—Considerable mention has recently been made in the American electrical press of a method of indoor wiring known as the interior conduit system, great advantages being claimed for it. The following particulars, taken from a report of the Science and Arts Committee of the Franklin Institute, and from a Paper read at that Institute, may be of interest:—The system is merely a carefully worked-out scheme of supplanting the usual practice of attaching insulation to the wire itself, by a system of insulated raceways, into which the wires can be drawn. The tubes are made of paper or similar material soaked in a hot bath of bituminous compounds. They are hard, strong, and tough. The tubes are secured in position by brass clips. For large mains there is one tube for the positive and one for the negative conductor, but for small branches the two wires are run in the same tube. The wires have merely a light textile insulation. Frequent experiments have shown that it is difficult, owing to the want of air, for a short circuit to start a fire in these tubes. A similar system has now been extended to underground work. In this case a series of tubes is racked in a frame so as to be held at a uniform distance apart. The bundle of tubes is then pushed into a cast-iron pipe and the whole is immersed in a bath of hot insulating compound. When withdrawn from this bath, only that portion of the compound which has entered the interior of the tubes is allowed to escape, the portion which has filled the interstices solidifying. In addition to this consolidated section, individual tubes, the length of which is the same as the consolidated ducts, are employed. These individual tubes are coated at the moment of laying with an insulating compound, and are then telescoped into the consolidated ducts to the depth of just one-half their length in each section. The abutting individual tubes at one end of a section are then telescoped into the consolidated ducts of the adjacent section, and the joints cemented with insulating compound. A complete system of manholes has also been worked out to suit the requirements of this method of laying mains.

Digitized by Google

## ELECTROMAGNETIC THEORY.—VIII.

BY OLIVER HEAVISIDE.

*(Continued from page 634.)*

§ **46.** A second way of arriving at the motional electric force is by a consideration of the work done in moving a conducting circuit in a magnetic field. It results from Ampère's researches, and may be independently proved in a variety of ways, that the forcive (or system of forces) acting upon a conducting circuit supporting a current, may be accounted for by supposing that every element of the conductor is subject to what Maxwell termed "the electromagnetic force." This is a force perpendicular to the vector current and to the vector induction, and its magnitude equals the product of their tensors multiplied by the sine of the angle between them. In short, the electromagnetic force is the vector-product of the current and the induction. Or, by the definition of a vector-product,

$$\mathbf{F} = \mathrm{V}\mathbf{CB}, \qquad (9)$$

if **F** is the force per unit volume, **C** the current, and **B** the induction. Here **F** is the force arising from the stress in the magnetic field. Its negative, say **f**, is therefore the impressed mechanical force, or

$$\mathbf{f} = \mathrm{V}\mathbf{BC}, \qquad (10)$$

to be used when we desire to consider work done upon the electromagnetic system.

The activity of **f** is **fq**, if **q** be the velocity; or, by (10),

$$\mathbf{fq} = \mathbf{q}\mathrm{V}\mathbf{BC}, \qquad (11)$$

This is identically the same as

$$\mathbf{fq} = \mathbf{C}\mathrm{V}\mathbf{qB}, \qquad (12)$$

by a fundamental formula in vector-analysis. Here, on the left side, the activity is expressed mechanically; on the right side, on the other hand, it is expressed electrically, as the scalar product of the current and another vector, which is the corresponding force; it is necessarily an electric force, and necessarily impressed. So, calling it **e**, we have

$$\mathbf{e} = \mathrm{V}\mathbf{qB}, \qquad (13)$$

again, to express the motional electric force.

It should be observed that we are not concerned in this mode of reasoning with the explicit connection between **e** and **C**; and in this respect the process is remarkably simple. As it, however, rests upon a knowledge of the electromagnetic force, we depart from the method of deriving relations previously pursued. But, conversely, we may by (11) and (12) derive the electromagnetic force from the motional electric force.

§ **47.** A third method of arriving at (13) is by considering the rate of change of the amount of induction through a moving circuit. We need not think of a conducting circuit, but, more generally, of any circuit. Let it be moving in any way whatever, changing in shape and size arbitrarily. The induction through it is altering in two entirely distinct ways. First, there is the magnetic current before considered, due to the time-variation of the induction, so that, if the circuit were at rest in its momentary position, we should have the second law of circuitation true in its primitive form

$$-\operatorname{curl} \mathbf{E} = \mathbf{G}, \qquad (14)$$

when expressed for a unit circuit. But now, in addition, the motion of the elements of the circuit in the magnetic field causes, independently of the time-variation of the field, additional induction to pass through the circuit. Let its rate of increase due to this cause be **g** per unit area. If, then, we assume that the circuitation of the electric force **E** (of the flux) equals the rate of decrease of the induction through the circuit *always*, whether it be at rest or in motion, the equation (14) becomes altered to

$$-\operatorname{curl} \mathbf{E} = \mathbf{G} + \mathbf{g}, \qquad (15)$$

where the additional **g** may be regarded as a fictitious magnetic current. That it is also expressible as the curl of a vector is obvious, because it depends upon the velocity of each part of the circuit, and is therefore a line-integral. Examination in detail shows that

$$\mathbf{g} = -\operatorname{curl} \mathrm{V}\mathbf{qB}, \qquad (16)$$

so that we have, by inserting (16) in (15),

$$-\operatorname{curl} (\mathbf{E} - \mathbf{e}) = \mathbf{G}, \qquad (17)$$

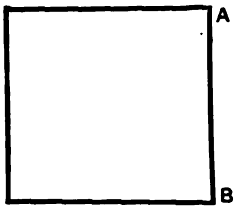
the standard form of the second law of circuitation, when we use (13) to express the impressed force.

The method by which Maxwell deduced (13) is substantially the same in principle; he, however, makes use of an auxiliary function, the vector-potential of the electric current, and this rather complicates the matter, especially as regards the physical meaning of the process. It is always desirable when possible to keep as near as one can to first principles. The above may, without any formal change, be applied to the case of assumed magnetic conductivity, when **G** involves dissipation of energy; the auxiliary **g** in (15), depending merely upon the motion of the circuit across the induction, does not itself involve dissipation.

§ **48.** Perhaps the matter may be put in a somewhat clearer light by converting the case of a moving circuit into that of a circuit at rest, and then employing the law of circuitation in its primitive form. The moving circuit has at any instant a definite position. Imagine it to be momentarily fixed in that position, by stopping the motion of its parts. In order that the relation of the circuit to the induction should be the same as when it was moving, we must now communicate momentarily to the lines of induction the identically opposite motion to the (abolished) motion of the part of the circuit they touch.

We now get equation (15), on the understanding that **g** means the additional magnetic current through a *fixed* circuit due to a given motion of the lines of induction across its boundary, such motion being the negative of the (abolished) motion of the circuit. The matter, is, therefore simplified in treatment. For, in the former way, the process of demonstrating (15) which I have referred to as an "examination in detail," is really considerably complex, involving the translation, rotation, and distortion of an elementary circuit (or equivalently for any circuit). Fixing the circuit does away with this, and we have merely to examine what happens at a single element of the circuit, as induction sweeps across it, in increasing the induction through the circuit, and then apply the resulting formula to every element.

In the consideration of a single element, it is immaterial what the shape of the circuit may be; it may, therefore, be chosen to be




a unit square in the plane of the paper, one of whose sides, AB, is the element of unit length. Now, suppose the induction at AB is perpendicular to the plane of the paper, directed downwards, and that it moves from right to left perpendicularly across AB. Let also from A to B be the positive sense in the circuit. It is evident, without any argumentation, that the directions chosen for **q** and **B** are the most favourable ones possible for increasing the induction through the circuit, and that the rate of its increase, so far as AB alone is concerned, is simply $qB$, the product of the tensors of the velocity **q** of transverse motion of the induction **B**. Further, if the velocity **q** be not wholly transverse to **B** as described, but still be wholly transverse to AB, we must take, instead of $q$, the effective transverse component $q \sin \theta$, if $\theta$ be the angle between **q** and **B**, making our result to be $qB \sin \theta$. Now, this is the tensor of V**qB**, whose direction is from A to B. The motional electric force in the element AB is therefore from B to A, and is V**Bq**, because it is the negative circuitation which measures the magnetic current through a circuit. Lastly, if the motion of **B** be not wholly transverse to AB, we must further multiply by the cosine of the angle between V**Bq** and the element AB.

Digitized by Google

This merely amounts to taking the effective part of **VBq** along the circuit. So, finally, we see that **VBq** fully represents the impressed electric force per unit length in AB when it is fixed, and the induction moves across it, or that its negative

$$\mathbf{e} = \mathbf{VqB}$$

represents the motional electric force when it is the element AB that moves with velocity **q** through the induction **B**. Now, apply the process of circuitation, and we see that **e** is such that its curl represents the rate of increase of induction through the unit circuit due to the motion alone.

This may seem rather laboured, but is perhaps quite as much to the point as a complete analytical demonstration, where one may get lost in the maze of differential coefficients, and have some difficulty in interpreting the analytical steps electromagnetically.

The fictitious motion of the induction above assumed has nothing to do with the real motion of the induction through the medium. If there be any, its effect is fully included in the term **G**, the real magnetic current.

§ 49. The motional magnetic force **h** may be similarly deduced. First we have the primitive form of the first law of circuitation

$$\text{curl } \mathbf{H} = \mathbf{J}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (18)$$

when the unit circuit is at rest, where **J** is the complete electric current-density, and next

$$\text{curl } \mathbf{H} = \mathbf{J} + \mathbf{j}, \quad . \quad . \quad . \quad . \quad . \quad (19)$$

when the circuit moves; where the auxiliary **j** is a fictitious electric current equivalent to the increase of displacement through the circuit by its motion only. Next show that

$$\mathbf{j} = \text{curl } \mathbf{h}, \quad . \quad . \quad . \quad . \quad . \quad . \quad (20)$$

and

$$\mathbf{h} = \mathbf{VDq}, \quad . \quad . \quad . \quad . \quad . \quad . \quad (21)$$

by similar reasoning to that concerning **e**; so that by insertion in (19) the first law of circuitation is reduced to the standard form

$$\text{curl } (\mathbf{H} - \mathbf{h}) = \mathbf{J}, \quad . \quad . \quad . \quad . \quad . \quad (22)$$

with the special form of the impressed force **h** stated.

Comparing the form of **h** with that of **e** we observe that there is a reversal of direction in the vector-products, the flux being before the velocity in one and after it in the other. This arises from the opposite senses of circuitation of the electric and the magnetic force to represent the magnetic and electric currents.

§ 50. The activity of the motional **h** is found by multiplying it by the magnetic current, and is, therefore,

$$\mathbf{hG} = \mathbf{GVDq},$$
$$= \mathbf{qVGD},$$

by the same transformation as from (11) to (12).

We conclude that **VGD** is an impressed mechanical force, per unit volume, and, therefore, that **VDG** is a mechanical force, that is, of the Newtonian type, arising from the electric stress. By analogy with the electromagnetic force it may be termed the magnetoelectric force, acting on dielectrics supporting displacement when the induction varies with the time. Of this more hereafter.

§ 51. So far nothing has been laid down about electrification. But the laws of circuitation cannot be completed without including electrification and its suggested magnetic analogue.

Describe a closed surface in a dielectric, and observe the net amount of displacement leaving it. This, of course, means the excess of the quantity leaving over that entering it. If the net amount be zero, there is no electrification within the region bounded by the surface. If the amount be finite, there is just that amount of electrification in the region. This is independent altogether of its distribution within the region, and of the size and shape of the region.

More formally, the surface-integral of the displacement leaving any closed surface measures the electrification within it.

This being general, if we wish to find the distribution of electrification we must break up the region into smaller regions, and in the same manner determine the electrifications in them. Carrying this on down to the infinitely small unit volume, we, by the same process of surface-integration, find the volume-density of the electrification. It is then called the divergence of the displacement.

That is, in general, the divergence of any flux is the amount of the flux leaving the unit volume.

And in particular, the divergence of the displacement measures the density of electrification.

Similarly, the divergence of the induction measures the "magnetification," if there is any to measure, which is a very doubtful matter indeed. There is no evidence that the flux induction has any divergence; it is purely a circuital flux, so far as is *certainly* known, and this is most intimately connected with the other missing link in a symmetrical electromagnetic scheme, the (unknown) magnetic conductivity.

Divergence is represented by div, thus:—

$$\text{div } \mathbf{D} = \rho, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$
$$\text{div } \mathbf{B} = \sigma, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

if $\rho$ and $\sigma$ are the electrification and magnetification densities, respectively.

In another form, electrification is the source of displacement, and magnetification the source of induction. How these fluxes are distributed after leaving their sources is a perfectly indifferent matter, so far as concerns the measure of the strength of the sources. In an isotropic uniform medium at rest, the fluxes naturally spread out uniformly and radially from point-sources of displacement or of induction. The density of the fluxes then varies as the inverse square of the distance, because the concentric spherical surfaces through which they pass vary in area directly as the square of the distance. Thus

$$D = \frac{\rho}{4\pi r^2}, \qquad B = \frac{\sigma}{4\pi r^2}, \quad . \quad . \quad . \quad . \quad (3)$$

are the tensors of the displacement and induction at distance $r$ from point-sources $\rho$ and $\sigma$.

If the source be spread uniformly over a plane in a uniform isotropic medium to surface-density $\rho$ or $\sigma$, then, by the mere symmetry, we see that half the flux goes one way and half the other, perpendicularly to the plane, so that

$$D = \tfrac{1}{2}\rho, \qquad B = \tfrac{1}{2}\sigma, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

at any distance from the plane. But if we by any means make the source send all the flux one way only, then

$$D = \rho, \qquad B = \sigma, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

at any distance.

§ 52. The above being merely to concisely explain the essential meaning of electrification in relation to displacement, and how it is to be measured, consider a point-source or charge to be in motion through a dielectric at rest. Starting with the charge at rest at one place, the displacement is radial and stationary. When permanently at rest in another place, the displacement is the same with reference to it. In the transition, therefore, the displacement has changed its distribution. There must, therefore, be electric current. Now, the only place where the displacement diverges, however the source may be moving, is at the source itself, and therefore the only place where the displacement current diverges is at the source, because it is the time-variation of the displacement. The displacement current is therefore circuital, with the exception of a missing link at the moving charge. If we suppose that the charge $\rho$ moving with velocity **u** constitutes a current $\mathbf{u}\rho$, that is, in the same sense as the motion, and such that the volume-integral of the current density is $\mathbf{u}\rho$, then the complete system of this "convection" current, and the displacement current together form a circuital flux.

Thus, suppose the charge to be first outside a closed surface and then move across it to its inside. When outside, if the displacement goes through the surface to the inner region, it leaves it again. On the other hand, when the charge is inside, the whole displacement passes outward. Therefore, when the charge is in the very act of crossing the surface, the

Digitized by Google

displacement through it outward changes from 0 to $\rho$, and this is the time-integral of the displacement current outward whilst the charge crosses. This is perfectly and simultaneously compensated by the convection current, making the whole current always circuital.

The electric current is, therefore, made up of three parts, the conduction current, the displacement current, and the convection current; thus,

$$\mathbf{J} = \mathbf{C} + \mathbf{D} + \rho\mathbf{u}, \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

$\rho$ being the volume-density of electrification moving through the stationary medium with the velocity $\mathbf{u}$.

If the medium be also moving at velocity $\mathbf{q}$ referred to fixed space, we must understand by $\mathbf{u}$ above the velocity also referred to fixed space. The velocities $\mathbf{q}$ and $\mathbf{u}$ are only the same when the medium and the charge move together. Thus it will come to the same thing if we stop the motion of the charge altogether, and let the medium have the motion equivalent to the former relative motion.

Similarly, if there should be such a thing as diverging induction, or the "magnetification" denoted by $\sigma$ above, then we shall be obliged to consider a moving magnetic charge as contributing to the magnetic current, making the complete magnetic current be expressed by

$$\mathbf{G} = \mathbf{K} + \dot{\mathbf{B}} + \sigma\mathbf{w} \quad . \quad . \quad . \quad . \quad . \quad (7)$$

if $\mathbf{w}$ be the velocity of the magnetification of density $\sigma$.

(*To be continued.*)

## ELECTRIC AND MAGNETIC SCREENING.*

BY SIR WILLIAM THOMSON.

There are five kinds of screening against electric and magnetic influences, which are quite distinct in our primary knowledge of them, but which must all be seen in connected relation with one another when we know more of electricity than we know at present:—I. Electrostatic screening; II. Magnetostatic screening; III. Variational screening against electromotive force; IV. Variational screening against magnetomotive force; V. Fire-screens and window-blinds or shutters.

### I.

Electrostatic screening is of fundamental significance throughout electric theory. It has also an important place in the history of Natural Philosophy, inasmuch as consideration of it led Faraday from Snow Harris's crudely approximate but most interestingly suggestive doctrine of non-influence of unopposed parts and action in parallel straight lines between the mutually visible parts of mutually attracting conductors, to his own splendid theory of inductive attraction transmitted along curved lines of force by specific action in and of the medium intervening between the conductors.

A continuous metallic surface completely separating enclosed air from the air surrounding it acts as a perfect screen against all electro-static influence between electrified bodies in the portions of air so separated. This proposition, which had been established as a theorem of the mathematical theory of electricity by Green, in the ninth article of his now celebrated essay (see pp. 14 and 48 of the reprint edited by Ferrers), was admirably illustrated by Faraday, by the observations which he made inside the wooden cube covered all around with wire netting and bands of tinfoil, which he insulated within this lecture-room; ("Experimental Researches," 1173—1174). "I went into the cube and lived in it; and, using lighted candles, electrometers, and all other tests of electrical states, I could not find the least influence upon them, or indication of anything particular given by them, though all the time the outside of the cube was powerfully charged, and large sparks and brushes were darting off from every point of its outer surface."

The doctrine of electric images is slightly alluded to, and an illustrative experiment performed, showing the fixing of an electric image. The electroscope used for the experiments is an electrified pith ball, suspended by a varnished double-silk fibre of about 9 or 10 feet long. Figs. 1—4 represent experimental illustrations, in which the pith ball, positively electrified, experiences a force due to electrified bodies, optically screened from it by a thin sheet of tin-plate. In Figs. 1 and 2 the pith ball is attracted round a corner by a stick of rubbed sealing-wax, and in Figs. 3 and 4 repelled round a corner by a stick of rubbed glass. In Fig. 2 the sealing-wax *seems* to repel the pith ball, and in Fig. 4 rubbed glass *seems* to attract it. This

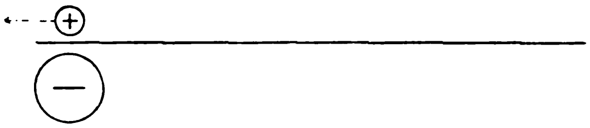


Fig. 1.

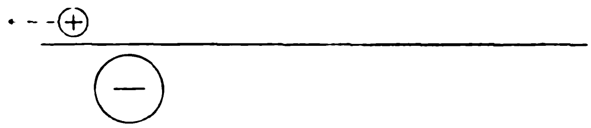


Fig 2.

Fig. 3.

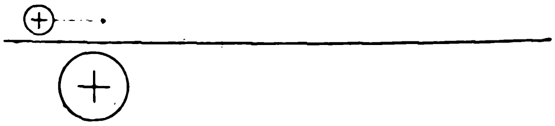


Fig. 4.

experiment constituted a very palpable illustration of Faraday's induction in curved lines of force.

In the present lecture some experimental illustrations were given of electrostatic screening by incomplete plane sheets and curved surfaces of continuous metal, and of imperfectly conducting material, such as paper, slate, wood, and a sheet of vulcanite, moist or dry, window glass at ordinary temperatures in air of ordinary moisture, and by perforated metal screens and screens of network, or gratings of parallel bars.

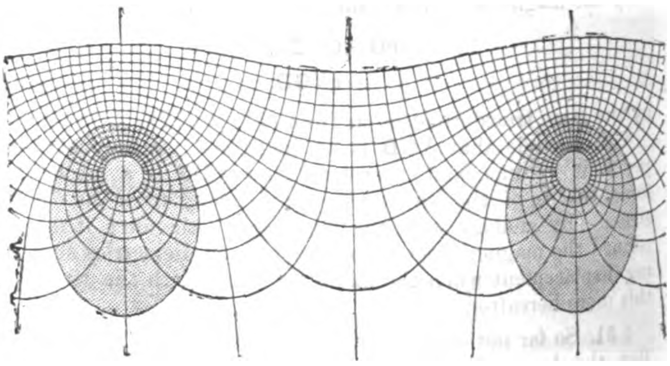


Fig. 5.

The fixing of an electric image is shown in two experiments: (1) the image of a stick of sealing-wax in a thin plane sheet of vulcanite, moistened, warmed, and dried under the electric influence by the application and removal of a spirit-lamp flame; (2) the glass jar of a quadrant electrometer with a rubbed stick of sealing-wax held projecting into it, while the outer surface is moistened, warmed, and dried by the application and removal of a ring of flame produced by cotton wick wrapped on an iron ring and moistened in alcohol.

Fig. 5 is copied from a diagram of Clerk Maxwell's to illustrate screening by a plane grating of parallel bars of approxi-

* Friday Evening Discourse, delivered at the Royal Institution, April 10, 1891.

Digitized by Google

mately circular cross section, with distance from centre to centre 12 times the diameter of each bar. ("Electricity and Magnetism," Vol. I., Art. 203, Fig. XIII.) It represents the lines of force due to equal quantities of opposite electricities on the grating itself, and a parallel plane of continuous metal (not shown in the diagram) at a distance from the grating of not less than one and a-half times the distance from bar to bar. The shading shows the lines of force for the same circumstances, but with oval bars instead of the small circular bars of Maxwell's grating. It is interesting to see how every line of force ends in a bar of the grating, none straying to an infinite distance beyond it, which is necessarily the case when the quantities of electricity on the grating and on the continuous plane are equal and opposite. If an insulated electrified body, with electricity of the same name as that of the grating, for example, is brought up from below, it experiences no electric force differing sensibly from that which would be produced by its own inductive effect on the grating, till it is within a less distance from the grating than the distance from bar to bar, when it experiences repulsion or attraction, according as it is under a bar of the grating or under the middle of a space between two bars. If there be a parallel metal plane below the grating, kept at the same potential as the grating, it takes no sensible proportion of the electricity from the grating, and experiences no sensible force when its distance from the grating exceeds a limit depending on the ratio of the diameter of each bar to the distance from bar to bar. The mathematical theory of this action was partially given by Maxwell (Arts. 203—205), and yesterday I communicated an extension of it to the Royal Society.

II.

Magnetostatic screening by soft iron would follow the same law as electrostatic screening, if the magnetic susceptibility of

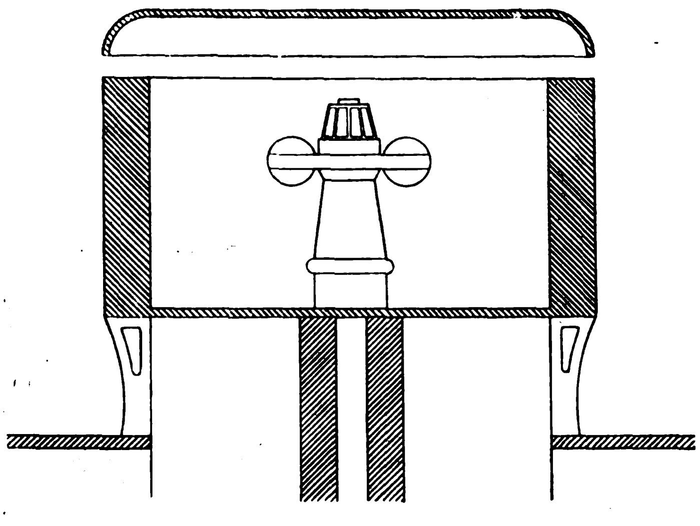


Fig. 6.

the iron were infinitely great. It is not great enough to even approximately fulfil this condition in any practical case. The nearest approach to fulfilment is presented when we have a thick iron shell completely enclosing a hollow space, but the thickness must be a considerable proportion of the smallest diameter, not less than $\frac{1}{10}$, perhaps, for iron of ordinary magnetic susceptibility to produce so much of screening effect that the magnetic force in the interior should be anything less than 5 per cent. of the force at a distance outside, when the shell is placed in a uniform magnetic field. The accompanying diagram, Fig. 6, representing the conning-tower of H.M.S. "Orlando," and the position of the compass within it, has been kindly sent to me by Captain Creak, R.N., for this lecture, by permission of the Controller of the Navy. It gives an interesting illustration of magnetic screening effect by the case of a belt of iron, 1ft. thick, 5ft. high, and 10ft. in internal diameter, with roof and floor of comparatively thin iron. Captain Creak informs me that the average horizontal component of the magnetic directing force on the compass in the centre of this conning-tower is only about one-fifth of that of the undisturbed terrestrial magnetism.

An evil practice, against which careful theoretical and practical warnings were published two or three years ago,* and which is now nearly, though, I believe, not at this moment quite thoroughly, stopped, of what is called single wiring in the electric lighting of ships, has been fallaciously defended by various bad reasons, among them an erroneous argument that the ship's iron produced a sufficient screening effect against disturbance of the ship's compasses, by the electric light currents, when that plan of wiring is adopted. The argument would be good for a ship 50ft. broad and 30ft. deep, if the deck and hull were of iron 3ft. thick. As it is, mathematical calculation shows that the screening effect is quite small in comparison with what the disturbance of the compass would be if the ship and her decks were all of wood. Actual observation, on ships electrically lighted on the single wire system by some of the best electrical engineers in the world, has shown, in many cases, disturbance of the compass of from 3deg. to 7deg., produced by throwing off and on the groups of lights in various parts of the ship, which are thrown on and off habitually in the evenings and nights, in ordinary and necessary practice of sea-going passenger ships. When the facts become known to shipowners, single wiring will never again be admitted at sea unless the alternating current system of electric lighting is again adopted. But, although this system was largely used when electric lighting was first introduced into ships, the economy and other advantages of the direct-current system are so great that no one would think of using the alternate system for the trivial economy, *if any economy there is*, in the single wire, as compared with the double insulated wire system.

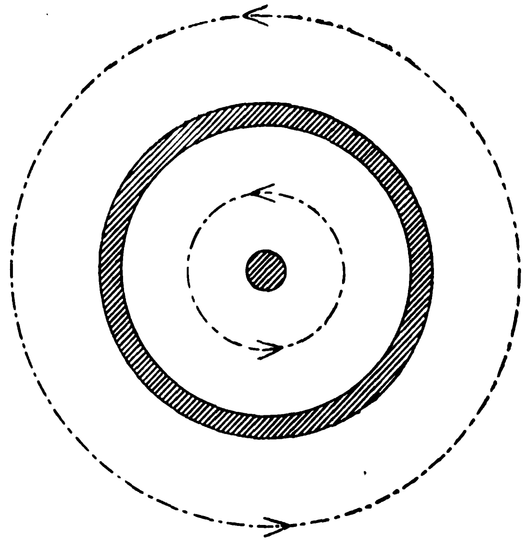


Fig. 7.

An interesting illustration of a case in which iron, of any thickness, however great, produces *no screening effect* on an electric current, steady or alternating, is shown by the accompanying diagram, Fig. 7, which represents in section an electric current along the axis of a circular iron tube, completely surrounding it. Whether the tube be long or short, it exercises no screening effect whatever. A single circular iron ring, supported in the air, with its plane perpendicular to the length of a straight conductor conveying an electric current, produces absolutely no disturbance of the circular endless lines of magnetic force which surround the wire; neither does any piece of iron, wholly bounded by a surface of revolution, with a straight conductor conveying electricity along its axis.

* See *The Electrician*, Vol. XXIII., p. 87. Paper read before the Institution of Electrical Engineers, by Sir William Thomson, "On the Security against Disturbance of Ships' Compasses by Electric Lighting Appliances."

Digitized by Google

## THE MAGNETIC CIRCUIT OF TRANSFORMERS: CLOSED VERSUS OPEN.

BY S. EVERSHED.

(*Continued from page 692.*)

§ 61. In the same volume of *Proceedings* a most interesting Paper by Prof. Ryan is published in which the effect of temperature on core hysteresis is described, and in addition, the observed energy loss from hysteresis when various cores were magnetised by an alternating current is compared with the loss calculated from Ewing's **B-H** curves for slow cycles. One of the most remarkable of these results is here reproduced in Fig. 20,

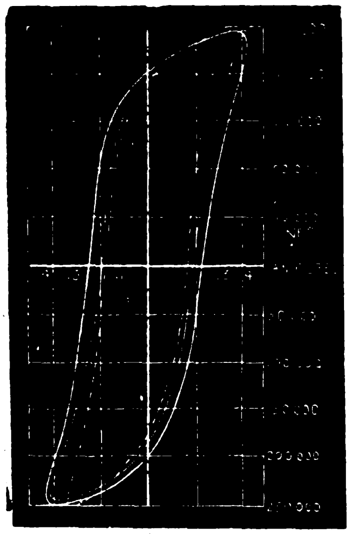


FIG. 20.—Result of Ryan's Experiments. Fine line shows Ewing's Static Hysteresis. Full line shows observed result at 138 ∿ with 10-light Transformer.

where the fine line is the **B-H** curve obtained by Ewing for "static" hysteresis, and the outer thick line is that deduced by Prof. Ryan by working back from the electromotive force and current waves to the induction wave and **B-H** cycle. The observed result includes any eddy currents there may have been in the core of iron plates on which the experiment was made, and is therefore naturally somewhat larger than the static curve, and slightly rounded at the turning-points. As Prof. Ryan well says, "A study of these cards does not reveal that which can be recognised as a trace of viscous hysteresis." Speaking of his method generally, Prof. Ryan remarks with pardonable pride: "This method is found to be fully as accurate, and requires much less time and is more simplified than the analytic method making use of Fourier's theorem." Less

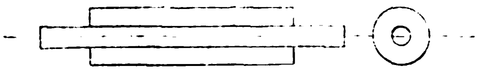


FIG. 21.—Small Open Transformer, one-tenth full size.

time indeed, for our own professors spent years and covered acres of blackboards with the "analytic method," and after all had not discovered that the exciting current was other than a sine function! It takes about 45 minutes to obtain a diagram from a transformer, and everyone can understand it when it is drawn. So far as they go, then, actual diagrams from live transformers agree broadly and substantially with our predicted diagrams. Unfortunately the authors of the Papers we have referred to give no dimensions and details of the transformers, so that we are unable to work out the predicted diagram and so make an accurate comparison between theory and fact.

§ 62. The calculation of the exciting current for open magnetic circuits is of sufficient general interest to warrant a short comparison between the calculated values and actual results. Fig. 21 shows the core and primary coil of a small transformer designed by the writer. The details and dimensions are as follows:—

**Table 16.**—*Open Transformer. Output 200 watts.*
Maximum $B = 8{,}600$ $F = 75$.

| | | |
|---|---|---|
| Iron wire core, total length | = | 40·4 cms. |
| ,, ,, area | = | 4·5 ,, |
| Core projecting outside coil | = | 7·0 ,, |
| Average diameter of primary coil | = | 5·5 ,, |

| | Volts. | Turns. | Resistance. |
|---|---|---|---|
| Primary coil | 2,000 | 15,000 | 470ω |

The usual formula gives 40,500 thoms* as the total induction required to produce 2,000 volts. Since the primary winding occupies so much space outside the core, the whole induction path may be divided in imagination into two parallel portions threading the primary winding, one *viâ* the iron core, the other in the space between the core and the average turns of the coil, to which may be added the small interstices between the wires forming the core. Calculate the magnetic resistance of these two paths separately. The circumference of the core is 8·5 cms, and as 7 cms. project outside the coil at each end, there are 59·5 sq. cms. of cylindrical surface, plus 5·7 cms. on the end, or 65·2 sq. cms. in all. A sphere of this surface has a radius of 2·28 cms., so that the resistance from pole to pole is $\frac{1}{2\pi \times 2{\cdot}28} = {\cdot}07$. The area enclosed by an average turn of the primary coil is 24·5 cms., of which 4·5 is occupied by iron, leaving an air path of 20 cms. area and about 27 cms. in length, the resistance of which is $\frac{27}{20} = 1{\cdot}35$, and if ·07 is added for the external air path, we have a total of 1·42 for that part of the induction path which is composed entirely of air.

Since the core is traversed by something like 40,000 thoms, the density is nearly 9,000 gausses, and we may put **H** at about 10, or $H\,l = 400$, and the ratio of force to induction will be ·01 for the core. This added to ·07 for the external air path gives ·08 as the magnetic resistance *viâ* the core. If ·08 and 1·42 are combined we arrive at the net magnetic resistance of the whole induction path; thus $\frac{{\cdot}08 \times 1{\cdot}42}{{\cdot}08 + 1{\cdot}42} = {\cdot}076$. Since the whole induction is 40,500, we can estimate the exciting current as follows:—

$$\cdot 4\pi \; N \; C' = 40{,}500 \times {\cdot}076 \times 3{,}070,$$

$$\text{and } C = \frac{C'}{\sqrt{2}} = \frac{3{,}070}{1{\cdot}26 \times 15{,}000 \times \sqrt{2}} = {\cdot}115 \text{ ampere.}$$

§ 63. When tested it was found that it required between ·09 and ·1 ampere to excite the transformer to 2,000 volts at a frequency of 75; the volts were measured by an electrometer which had been carefully calibrated and probably read within one, certainly within two, per cent. The current was measured by means of a Cardew voltmeter used as an ammeter, and the reading being very small was somewhat vague, but the current was certainly within the limits named. The method of "equivalent spheres" might be expected to over-estimate the required current, for every assumption made tends to increase the calculated magnetic resistance. The induction is assumed to spread radially from each pole to infinity; it really takes a shorter path curving round from pole to pole. The convention by which the whole induction is supposed to emerge from the core through so much of the ends as project from the core also leads to an over-estimate; obviously a considerable fraction will leave the core a short distance within the coil at each end, and since it threads the greater portion of the whole coil it counts as useful induction. Practically, the calculation by "equivalent spheres" enables us to predict the exciting current required in a coil to produce any given induction in its core with sufficient accuracy for most purposes, and with the certainty that the actual will be rather smaller than the predicted current. A rough method of this sort is frequently of great service in designing electrical apparatus.

§ 64. If the exciting current for a Hedgehog transformer is calculated on precisely the same assumption as to the surface

*One thom = one magnetic line of force.

Digitized by Google

of the equivalent spheres and so on, the resulting value is still somewhat higher than the observed value. Taking Messrs. Swinburne's 10 H.P. Hedgehog as an example, we will calculate the exciting current. The dimensions of the transformer are almost identical in every respect save that of core area, with those of No. 3, as an open transformer (Fig. 7):—

**Table 17.**—*Messrs. Swinburne's 10 H.P. Hedgehog Transformer.*

Maximum $B = 6{,}800$ $F = 100$.

| | | |
|---|---|---|
| Length of core .................. | =73 cms. | |
| Area ,, ,, .................. | 40 ,, | approximately. |
| Volume .................. | 3,000 cub. cms. | approximately. |
| Radius of spherical ends...... | 13 cms. | approximately. |

The core is composed of iron wires, diam. = ·056 cms.

| | Volts. | Turns. | Resistance. |
|---|---|---|---|
| Primary .................. | 2,000 | 1,670 | 3·87 |
| Secondary .................. | 100 | 84 | ·0072 |

It will be noticed that although the primary winding has fewer turns than No. 3 (Fig. 7), the maximum induction is under 7,000, as against 10,000; this is due, of course, to the higher frequency and greater core area. The only other striking difference between the genuine Hedgehog and our imitation is in the resistance of the coils, which are only about one-half the amounts given for (Fig. 7). This merely shows that Mr. Swinburne makes a smaller allowance for insulating space than that adopted by Mr. Ravenshaw, for in designing the coils for No. 3 we made the ratio of the spaces occupied by copper and insulation the same as we found them in the Ravenshaw transformer.

§ 65. The surface over each spherical end of the core will be $2\pi r^2$, and if to this is added the flat surface next the coil cheek, we have $3\pi r^2$ as the surface of the equivalent sphere; and $x$ being the radius of the latter, $3\pi r^2 = 4\pi x^2$. Since $r = 13$ cms. $x$ must be 11·3cms. and the magnetic resistance of the air path is $\frac{1}{2\pi\, 11{\cdot}3} = \frac{1}{71}$. The total induction is $6800 \times 40 = 272{,}000$ thoms, so that [H] required for the air path is $\frac{272{,}000}{71} = 3840$. The maximum H for the core may be safely put at about 7 C.G.S. units, and [H] for the core will be $7 \times 73 = 510$. The total [H] is therefore $3{,}840 + 510 = 4{,}350$, which, divided by $\cdot 4\pi N$, gives the maximum value of the exciting current, or $C' = \frac{4{,}350}{1{\cdot}26 \times 1{,}670} = 2{\cdot}07$ amperes, and the effective value may be taken as $\frac{2{\cdot}07}{\sqrt{2}} = 1{\cdot}46$ amperes. The observed exciting current required to give 2,000 volts on the primary terminals at the frequency of 100 ∿ is 1·35 amperes, or nearly eight per cent. less than the calculated value. This clearly shows that even in the apparently hopelessly complex case of spherical ends formed of radial wires the equivalent sphere, based on the assumption that the spherical end is solid without making deductions for ineffective surface, leads to a sufficiently close approximation to the true exciting current.

§ 66. To return from this digression on the calculation of exciting currents to the subject more immediately concerning us in these Papers; the open transformer is a good thing so far as core waste goes, but there is the large exciting current still weighing like an incubus on our minds. Can it be induced to take some other path than the armature coils of the alternators at the supply station? This is not so difficult a problem as it seems at first sight. Think of electricity flowing along one main from the transformer to the alternator. If before it reaches the alternator it can escape into an elastic reservoir, it will rush into the latter until the pressure from the mains is balanced by the elastic recoil. The reservoir being just so large that the elastic recoil pressure is at each instant equal to the main pressure, when the electric tide sets in in the opposite direction the electricity will be squeezed out again along the main towards the transformer, and not a drop will have been able to get beyond the reservoir to the alternator. Condensers are nothing more or less than elastic reservoirs, and Mr. Swinburne has been experimenting with them with a view to supplying idle current for his transformers. In order to understand their true function when used on alternate current circuits it will be necessary to devote a little space to the theory of condenser currents.

§ 67. The discharge of condensers has been the subject of a great deal of attention for several years, and a recognition of its oscillatory nature under certain conditions (first explained by Sir William Thomson many years ago) has led to brilliant experimental verifications of the electro-magnetic theory of light. It is probable that when once practical men who have to deal with electrical matters on an engineering basis, have had it made clear to them what a condenser will do and why it does it we shall see them taking up this, to them novel, apparatus and turning it to some practical account for electric light and power purposes. It has of course long been an indispensable adjunct in telegraphy.

§ 68. It is usual in discussing the laws of condenser currents to assume that the discharge takes place in a circuit having a resistance R and inductance L, and then determine what values must be given to R and L to make the current oscillatory, and when one is writing a mathematical essay that is no doubt the most interesting course to pursue. When the principal object in view is a clear explanation of the laws governing any complex phenomena, it is perhaps preferable to consider the simplest possible case first, and when that is made clear we may introduce the complicating conditions one at a time, and so arrive by easy and natural steps at the desired end—not necessarily the complete solution of the problem so dear to the heart of the mathematician, but a sufficiently clear conception of the general laws underlying the facts to enable us to make practical applications. That must always be the aim of the practical man who tries to grasp a theory, and he looks to the mathematical physicists to aid him in translating the dry bones of analytics into the flesh and blood of facts. But too often "the hungry sheep look up and are not fed"—hence we see practical men out of their depth in a sea of mathematics—hence these articles!

*(To be continued.)*

## TWISTED TELEPHONE LINES.

While the perfection of talking through the London and Paris Telephone Line is said by Mr. Preece to be due to the fact that he has kept the product of the electrostatic capacity into the resistance as small as possible, and while from theoretical grounds it is thought by some that this theory is not altogether sound, the absence of cross-talk and of the disturbing effects of telegraphic and other electric circuits is undoubtedly due to the method of twisting the lines throughout the whole length of the circuit. But we have on a former occasion remarked that the line from the General Post Office to St. Margaret's Bay is an absolutely silent one, and that as much cannot be said for the longer land line between Sangatte and Paris. Even this section, however, while short of perfection, is far superior to the majority, indeed to almost all of the telephone lines in this country, other than those erected under the supervision of the General Post Office.

There are numerous methods of arranging this twist. The general principle, of course, is to expose each wire in turn to the disturbing influence, and thus to cancel out the induced currents at every complete twist of the wires. When this system was first proposed to the Midland Railway Company, it was objected to on the ground that it would be very difficult for the linesman to detect contacts, since the wires cannot be easily followed by the eye in inspecting them. For this reason some lines were arranged with ordinary parallel wires between post and post. At each post the crossing takes place from insulator to insulator, and the wires proceed to the next post parallel as before. These crossings, as might have been expected, gave rise to more defects than the simple method which has been carried out in numerous instances.

Digitized by Google

Two twists are illustrated in Figs. 1 and 2; in each of these the two pairs of wires are kept distinct, one on each side of the posts. The numbers refer to the wire in each case, the successive diagrams showing the successive posts in the line. The position of the wire may thus be traced from one post to the other. In Fig. 1, will be observed that

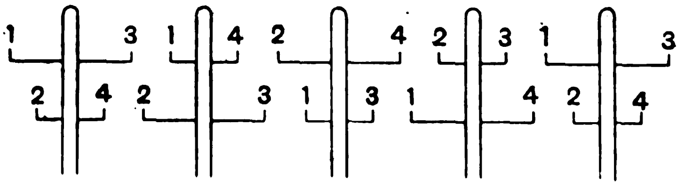



Fig. 1.

1 and 2 rotate about a common axis clockwise, and 3 and 4 rotate in the same direction. This fails to extinguish the induction, but in Fig. 2 it will be noticed that wires 3 and 4 revolve counter-clockwise, and this arrangement acts well. Fig. 3 represents the method of twist adopted in the English land section of the London-Paris Tele-

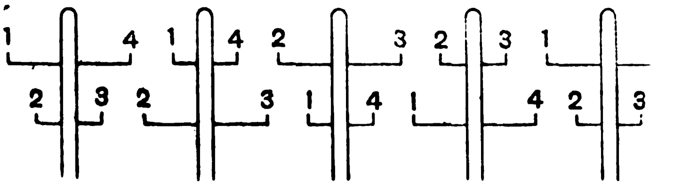



Fig. 2.

phone line. Here the separate conductors are kept at a uniform distance of 14in. apart, and revolve clockwise about a common axis, the whole arrangement being perfectly symmetrical, and the pitch of the twist being four posts' lengths. These wires are conspicuous from the street as they cross from the telegraph building of the General Post Office, passing on

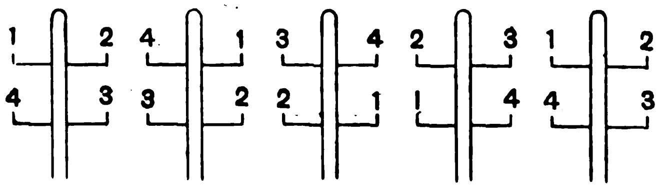



Fig. 3.

to the Stock Exchange and to Cannon-street, and thence on their way to Dover, and the want of parallelism is very noticeable. This square symmetrical twist is like a double wound resistance coil, and is "inductionless." This is Mr. Preece's strong point, for where there is self-induction K.R. is only empirically true within limits, but when L is nothing, he maintains that it is absolutely true.

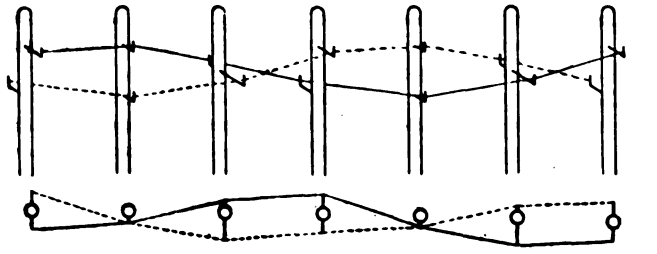


Fig. 4.

It was objected, however, by the French engineers that the wires so disposed might be brought into contact by the wind, and accordingly an arrangement partly shown in Fig. 4 was adopted. The objection was a theoretical one, since such contacts have never been observed in practice, and the device is more ingenious than symmetrical. Only two wires are shown in the two views, one being a plan and the other a perspective diagram. Another pair of wires, revolving in exactly the same manner, is placed below on the same posts. It will be noticed that a complete revolution is made in six posts, and the varying length of the arms keeps the wires at the same distance apart; but the absence of geometrical symmetry entails an absence of electrical balance, and it is found that this portion of the circuit is not altogether free from inductive disturbances caused by neighbouring telegraph and other circuits.

For all ordinary cases these methods of twisting or causing the wires to revolve round each other are probably sufficient to neutralise the effect of extraneous disturbance, but this can only be the case if the disturbing causes extend over a considerable area. If a line conveying a telegraphic or electric lighting current were to run alongside of the telephone line for a portion of its length, considerably less than the pitch of the twist, it would obviously give rise to induced currents. Such a case is very unlikely, but if a disturbing circuit cuts across the telephone circuit obliquely, the resolved component of the surrounding electro-magnetic disturbances might affect the telephone line locally, and thus give rise to induced currents.

## REPLY TO MR. ROBERT SHAND ON "VARIATIONS OF CURRENT IN THE PRIMARY OF OPEN CIRCUIT TRANSFORMERS."*

BY WM. STANLEY, JUN.

The point in question is the accuracy of a statement. In order to clearly state the facts under discussion, I quote the point mentioned:—"In these transformers (open magnetic circuit) the value of the primary current varies comparatively little with the load derived from the secondary circuit, and when such a transformer is gradually loaded, the primary current will remain, roughly speaking, constant, possibly varying 10 to 20 per cent." Mr. Shand questions the accuracy of this statement, furnishing figures from tests made by himself to substantiate his position. Neglecting other results, his conclusion, as shown by Table V. of his article, gives the following data:—

| | |
|---|---|
| Size of transformer | 1,550 watts. |
| Frequency | not given. |
| No. turns in primary | „ „ |
| „ „ „ secondary | „ „ |
| Resistance of coils | „ „ |
| Size of primary and secondary wires | „ „ |

Primary E.M.F., 100 volts; primary current, 3·27 amperes; secondary open. Primary E.M.F., 100 volts; primary current, 16·3 amperes; full load. Drop of secondary potential below normal, 3·5 volts, or 3·5 per cent.

In short, in a transformer of 1,550 watts output with a 3·5 per cent. drop, the variation of primary current was from 16·3 amperes at full load to 3·27 amperes at no load; that is to say, the current fell one-fifth of its full load value when the transformer was not doing useful work. This would certainly seem to conflict with my statement, that the variation was but 20 per cent. But how about the regulation? Certainly no station can use a transformer of 1,500 watts capacity having a drop of 3·5 per cent. Suppose that this transformer was compelled to regulate as well as others of standard make, the permissible drop would then be 1·5 per cent. What, then, would be the "leakage" current at a frequency of 130 periods per second? The resistance of the coils would evidently have to be decreased in the ratio of 3·5 to 1·5, or would be about 43 per cent. of the present value. Maintaining the same size of wire as used in Mr. Shand's experiment would give 43 per cent. of the turns, and with this number of turns the "leakage" current would be about $\left(\frac{100^2}{43^2}=5\right)$ five times as great as he found it—viz., 17·5 amperes. So that if the same fall of potential upon the secondary circuit were allowed for the open as for the closed type of transformer, the current upon the primary circuit when the secondary was open would be as great as when the transformer was doing its full duty.

Of course this reduction of the drop of the transformer cannot be accomplished by simply taking off wire as indicated; the magnetisation of the core given at 6,300 per centimetre gives a hysteresis

* From the *Electrical World* of New York. For Mr. Shand's article, see also *The Electrician*, April 3, 1891, p. 674.

Digitized by Google

loss of about 2·75 watts per pound at a frequency of 133 periods per second. The core is already magnetised too high; reducing the turns to 43 would raise the magnetisation to 14,600 per centimetre, and would give an enormous loss by hysteresis, while the permeability of the core would fall so as to reduce the magnetisation. In short, the transformer made by Mr. Shand cannot be compared with the commercial apparatus; it must be redesigned for 1·5 per cent. drop. In order to compare two types of transformers, it is necessary that they should be designed for the same output; should have the same fall of potential or drop, and the radiating surface per watt lost in the transformer should be the same; they should be subjected to E.M.F's. of the same frequency, and then the "comparison" should be made upon the basis of efficiency and leakage current.

I am now in receipt of a letter from Swinburne and Co. stating that they can make a Hedgehog transformer of 2,000 watts output, having a drop of 2·4 per cent., which will reduce the primary current to about 40 per cent. full load value when the load is taken off. Such a transformer does not regulate sufficiently well for one of 40-light capacity, as it has about 1 per cent. more drop than found in all standard closed circuit transformers of the same size now in use in this country.

## ON THE POTENTIAL DIFFERENCE NEEDED TO PRODUCE A SPARK.*

BY F. PASCHEN.

The author has experimented with spheres of different diameters placed at various distances apart. The gases selected for testing were air, hydrogen, and carbonic acid, and the influence of the pressure under which those gases were examined was also investigated.

With spheres of one centimetre radius the potentials in electrostatic units (300 volts) required for sparking distances of 1, 2, 3, up to 7 millimetres, are found to be 16·1, 27·7, 38·8, 49·4, 60·0, 69·4, and 78·9 respectively, and the sparking potential is slightly less in summer than in winter. The potential required is less the smaller the radius of the balls, except at very short-sparking distances, when a greater voltage is needed. Thus, for a sparking distance of one-tenth of a millimetre the potentials required for balls of 1 cm. and 0·25cm. radius, are respectively 3·35 and 3·67; for a distance of 3mm. the corresponding numbers are 38·8 and 38·7, and for 8 mm. they are 87·8 and 66·8. The diameter of the wires leading to the sparking knobs also exercises an appreciable influence, more especially at long-sparking distances. Thus, with a distance of one centimetre separating balls of one quarter centimetre radius, the sparking potential was 68·9 for leading wires of 0·07cm. diameter, and 73·9 for wires of 0·50 cm. diameter.

The principal result of the experiments is to evidence the following law:—For a given gas at a given temperature the voltage required to produce a spark depends only on the product PD, if the pressure P of the gas, and the sparking distance D are varied, that is to say, the voltage is constant if the product PD is so.

A great number of experiments were made on the three gases for pressures varying from P = 100mm. of mercury to 750mm.; the corresponding values of D varying from 0·75cm to 0.10cm, so that the product PD was in all cases equal to 75. The mean values of the sparking potentials needed under these circumstances for air, hydrogen, and carbonic acid, were found to be respectively 16·65, 9·68, and 17·37. The average divergence of each observation from the mean value was about two per cent. for the first two gases, and three per cent. for the third.

A further set of experiments were made on the gases under various pressures with sparking distances, so arranged that the product PD was 200. Under these circumstances the mean potentials required were 34·64 for air, 19·45 for hydrogen, and 33·37 for carbonic acid. The average divergences of the different observations from each other were about the same as before.

As the density of the gas is proportional to its pressure, we may state the law given above in the following form:—

The difference of potential necessary to produce a spark is a function merely of the product of the density and the sparking distance; or, in other words, this difference of potential depends only on the number of molecules encountered in the path of discharge, and not on the average distance of these molecules from each other.

As M. Cardani has shown that the sparking distance is constant in an atmosphere consisting of a quantity of air kept at constant volume, while its temperature is raised to 300°C., it may also be concluded that the sparking potential does not depend on the relative velocity of the gaseous molecules.

* Abstracted from *Wied. Ann.*, Vol. XXXVII., pp. 69-96.

## BOOKS, &c., RECEIVED.

"The Journal of the Franklin Institute." Vol. CXXXI., No. 784. (Philadelphia: The Franklin Institute.)

"Les Théories Modernes de l'Electricité." By Dr. Oliver Lodge, F.R.S. Translated from the English and Annotated by E. Meylan. (Paris: Gauthier-Villars et Fils.)

## MEETINGS OF SCIENTIFIC SOCIETIES, &c.

**FRIDAY, April 17th** (To-Night).

PHYSICAL SOCIETY.

*5 p.m.* Papers to be read: (1) "On a Property of Magnetic Shunts." By Prof. SILVANUS P. THOMPSON. (2) "An Alternating Current Influence Machine." By JAMES WIMSHURST.

ROYAL INSTITUTION.

*9 p.m.* Evening Discourse. "Magnetic Rocks." By Prof. A. W. RÜCKER, F.R.S.

**SATURDAY, April 18th.**

ROYAL INSTITUTION.

*3 p.m.* Afternoon Lecture. "The Dynamo." By Prof. SILVANUS P. THOMPSON, D.Sc.

**MONDAY, April 20th.**

SOCIETY OF CHEMICAL INDUSTRY.

*8 p.m.* Paper to be read and discussed at Burlington House: "Tanning by the Aid of Electricity." By Dr. S. RIDEAL and A. P. TROTTER.

SOCIETY OF ARTS.

*8 p.m.* Cantor Lecture—II. "The Decorative Treatment of Natural Foliage." By HUGH STANNUS, F.R.I.B.A.

**TUESDAY, April 21st.**

ROYAL INSTITUTION.

*3 p.m.* Afternoon Lecture. "The Geography of Africa." By J. SCOTT KELTIE, F.R.G.S.

SOCIETY OF ARTS.

*4.30 p.m.* Foreign and Colonial Section. Paper to be read: "China." By Sir THOMAS WADE, G.C.M.G.

INSTITUTION OF CIVIL ENGINEERS.

*8 p.m.* Ordinary Meeting. Paper to be further discussed: "The Cost of the Generation and Distribution of Electrical Energy." By R. E. B. CROMPTON, M. Inst. C.E.

**WEDNESDAY, April 22nd.**

SOCIETY OF ARTS

*8 p.m.* Ordinary Meeting. Paper to be read: "Bimetallism." By Sir GUILFORD MOLESWORTH, K.C.I.E.

**THURSDAY, April 23rd.**

ROYAL INSTITUTION.

*3 p.m.* Afternoon Lecture: "Recent Spectroscopic Investigations." By Prof. DEWAR, F.R.S.

INSTITUTION OF ELECTRICAL ENGINEERS.

*8 p.m.* Ordinary General Meeting. Papers to be read: (1) "On Some Effects of Alternating-Current Flow in Conductors having Capacity and Self-Induction." By Dr. J. A. FLEMING, Member. (2) "A Few Calculations on Electrical Shocks from Contact with High-Pressure Conductors." By Major P. CARDEW, R.E., Member.

**FRIDAY, April 24th.**

INSTITUTION OF CIVIL ENGINEERS.

*7.30 p.m.* Students' Meeting. Papers to be read: (1) "A New Type of Water-Motor." By A. SEALY-ALLIN, Stud. Inst. C.E. (2) "Hydraulic Power as applied to Pressing-Machinery." By H. EVINGTON, Stud. Inst. C.E.

ROYAL INSTITUTION.

*9 p.m.* Evening Discourse. "Euphuism—Past and Present." By Rev. CANON AINGER, LL.D.

**SATURDAY, April 25th.**

ROYAL INSTITUTION.

*3 p.m.* Afternoon Lecture. "The Dynamo." By Prof. SILVANUS P. THOMPSON, D.Sc.

*** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

Digitized by Google

# The Electrician.

**Published every Friday, Price Fourpence; Post Free, Fourpence Halfpenny**
**Editorial, Publishing, and Printing Offices:**
**SALISBURY COURT, FLEET ST., LONDON, E.C.**
*Telephone No.* 2714. *Telegrams:* "ELECTRICIAN NEWSPAPER, LONDON."

*All Letters relating to Subscriptions, Advertisements and other business matters should be addressed to the Publisher,* "THE ELECTRICIAN," *Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to* "THE ELECTRICIAN" *Printing and Publishing Company, Limited, and be crossed* "*Coutts and Co.*" *All other letters to be addressed to the Editor.*

*All letters intended for insertion in* "THE ELECTRICIAN," *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

"THE ELECTRICIAN" *is published every Friday morning, in time for the morning mails. Subscribers should receive their copies by the first post on Friday morning.*

"THE ELECTRICIAN" *is on sale at the railway bookstalls throughout the Kingdom on Friday morning, and can be obtained of all Booksellers and Newsvendors; or direct from the Publishing Offices as above.*

*New Volumes of* "THE ELECTRICIAN" *commence in May and November.*

## SUBSCRIPTION RATES.

The rates for Subscriptions to "THE ELECTRICIAN" are as follows:—

| | 3 months s. d. | 6 months. s. d. | 12 months. s. d. |
|---|---|---|---|
| For the United Kingdom | 5 0 | 10 0 | 19 6 |
| For Foreign Parts and Colonies:— Within Postal Union | 6 6 | 12 6 | 24 0 |
| For Aden, Borneo, Ceylon, China, India, Japan, Java, Labuan, Mozambique, New Caledonia, Persia, Philippine Islands, Siam, Transvaal, and Zanzibar | 7 6 | 14 6 | 28 0 |



## TO ADVERTISERS.

"THE ELECTRICIAN" *offers exceptional advantages to Advertisers.* **It has by far the largest circulation of any English Electrical paper, and circulates all over the World.**

*Particulars relating to Advertisements will be promptly forwarded on application to the Offices as above.*

TRADE ADVERTISEMENTS *intended for the current issue must reach the Offices not later than First Post on Thursday morning. Renewals of expiring advertisement orders and alterations to standing advertisements should be in the Publisher's hands by Wednesday at latest. No alteration can be made in Wrapper advertisements after Wednesday evening.*

SMALL PREPAID ADVERTISEMENTS *(for Rates see page xvii.) are accepted up to 4 p.m. on Thursday.*

## TECHNICAL PRINTING.

"THE ELECTRICIAN" PRINTING AND PUBLISHING COMPANY (LIMITED) *inform Electricians, Electric Light Engineers, &c., that they make a specialty of Technical Printing, and have a large Staff thoroughly acquainted with Electro-Technology. They can, therefore, promise Accuracy and Despatch in the Printing of Electro-Technical Literature, &c.*

## "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. (Royal 8vo.)

*Early in each year is issued* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. *The* DIRECTORY *was established in 1883, and the 1891 Edition, published on the 23rd February, 1891, consists of 900 pages of printed matter. The names and addresses of all persons engaged in the Electrical Industries at home and abroad may be relied upon as accurate. Useful Tables and Electrical Formulæ, and information specially compiled for this work are given, together with popularly-written Biographical Notices of the leading Electricians, Electrical Engineers, &c., accompanied in many cases by Portraits.*

*The issue for 1891 is ready, and should be ordered at once. Price 5s., post free 5s. 9d. Abroad postage extra. Full particulars on application.*

## ELECTRICAL BOOKS AND PUBLICATIONS.

*All Books, Newspapers, and other publications, dealing with Electrical and kindred subjects, can be ordered direct of* "THE ELECTRICIAN" *Printing and Publishing Company, who are proprietors of the well-known* "ELECTRICIAN" *Series of Standard Electrical Works, and are agents for all the leading publishing houses at home and abroad.*


## CONTENTS OF THE CURRENT NUMBER.


NOTES .... 715
Electro-magnetic Theory, VIII. By Oliver Heaviside. Contin .... 720
Electric and Magnetic Screening. By Sir W. Thomson. Illus. .... 722
The Magnetic Circuit of Transformers: Closed versus Open. By S. Evershed. Continued. Illustrated .... 724
Twisted Telephone Lines. Illus. .... 725
Reply to Mr. Robert Shand, on "Variations of Current in the Primary of Open Circuit Transformers." By William Stanley, Junr. .... 726
On the Potential Difference Needed to Produce a Spark. By F. Paschen .... 727
REDUCTION OF AUSTRALASIAN CABLE RATES .... 728
The Electric Current and its Laws.—VII. By John T. Sprague. Illus. Concluded. .... 729
Notes on the Design of Multipolar Dynamos. By W. B. Esson. Illustrated. Concluded .... 733
The Measurement of the Power given by any Electric Current to any Circuit. By Prof. W. E. Ayrton, F.R.S., and W. E. Sumpner, D.Sc. Illustrated. .... 736
The London Telephone Rates .... 739
American Notes .... 739
CORRESPONDENCE—
Analysis of Losses in Armature Cores—R. H. Housman. Illustrated .... 740
Control Magnets for Galvanometers—M. Walmsley .... 741
Capacity Measurements on Long Cables—Arthur Dearlove. Illustrated .... 741
Visual Signalling in Foggy Weather—G. Brown .... 742
Legal Intelligence .... 742
Trade Notes and Notices .... 743
PATENT RECORD .... 744
COMPANIES' MEETINGS, &c.—
The Oriental Telephone Company (Limited) .... 744
South of England Telephone Company (Limited) .... 745
Eastern Extension, Australasia and China Telegraph Company (Limited) .... 745
The Indo-European Telegraph Company .... 746
The New York Belting and Packing Co. (Limited) .... 746
New Companies registered .... 747
City Notes, &c. .... 747
Companies' Share List .... 748


## REDUCTION OF AUSTRALASIAN CABLE RATES.

The substantial reduction announced to take place on May 1st in the rates for telegrams over the Australasian Cables, is an event of hardly less importance to the Mother Country than to the Colonies themselves. It is to be regretted that two of the seven Colonial Governments have withheld their assent to the understanding by which this valuable concession has been brought about; but it is not likely that the colonists of Queensland and New Zealand will for any length of time submit to being excluded from such manifest advantages accruing to their neighbours. Meantime the Colonies of South and Western Australia, of Victoria, New South Wales, and Tasmania will, in the course of a few days, begin to enjoy the benefits of a more enlightened policy, resulting in a reduction of their expenditure on cablegrams to the extent of about 60 per cent. On the other hand, the two dissentient Colonies are left to pay what they have paid heretofore, the rates remaining unaltered for those places, the respective Governments claiming, only by way of set-off, exemption from the risk guarantee which the other Colonies have undertaken. Whatever may be the reasons which induced the New Zealand and Tasmanian Colonies to hold aloof, those reasons do not weigh with the people of this country, who are thus compelled to pay higher rates to those places than to the adjacent Colonies, and who consequently will do their utmost to bring the unwilling members into line with the rest.

Apart, however, from this trifling defect in the symmetry of the scheme as a whole, it is one on which the countries interested and the great cable companies of the East are to be heartily congratulated. The negotiations have been somewhat prolonged, and, for a time, were embarrassed by the obtrusive interference of outsiders, whose only object was to advertise

Digitized by Google

themselves as telegraph reformers. Fortunately, the companies on the one hand were not to be terrified into yielding unduly by the clamour for impossible concessions; and, on the other hand, the accredited Colonial Agents were not deceived into pressing their demands to the bounds of positive rejection. There has been give and take on both sides; and, as is usual in purely business transactions between business men when left to themselves, the result is a fair and workmanlike agreement, which has every chance of becoming a lasting one, although, in the first instance, it is an experiment for only twelve months certain. The adhesion of the two Colonies above referred to will probably depend upon the success of the first year's trial; but whether successful or not, it will be watched with extreme interest throughout the telegraph world as a test of the increase of telegraph traffic over very long lines, corresponding to the reduction of charges. To the Colonies the result will be of not less importance; and although we cannot expect customers to use the cables more for the mere purpose of keeping down the rates, it may be confidently expected they will do so from motives of their own, and that the several Colonial Governments will afford every privilege possible to prevent the experiment failing.

That the Colonies are immensely interested in its success will be seen from the nature of the undertaking into which they have entered with the companies. On their side the Eastern Extension, the Eastern, the Indo-European Telegraph Companies, and the Indo-European Telegraph Department of the Indian Government agree conjointly to reduce the rates for South Australia from 9s. 4d. to 4s.; and for Tasmania from 9s. 11d. to 4s. 8d., and for the intermediate Colonies proportionately. Press telegrams are treated with even greater liberality considering that the existing rate is already only one-third of the charge for ordinary messages, the reduction being respectively for the Colonies just named from 2s. 8d. to 1s. 10d. and from 3s. 4d. to 2s. 6d. According to all the calculations of experience, the loss to the companies consequent on reductions of such magnitude, must be very considerable, and will not be overtaken until a long period has been allowed for growth of traffic—a growth which cannot be expected to be very rapid seeing that the data applicable to cheap and popular tariffs do not hold good for tariffs which are necessarily expensive at their cheapest. To protect themselves, partially at least, from this certain loss of revenue, was the chief anxiety of the cable companies whilst frankly desiring to meet the colonists with substantial concessions. At first it was proposed that they should bear three-fourths of the risk, the companies accepting one-fourth, and this for a term of eleven years. Finally, however, the parties agreed to divide the liability equally between them, and to confine the undertaking to a tentative period of one year. If at the end of that time the result is encouraging, a further period of trial may, and probably will, be agreed upon. But should this not prove to be the case, the companies have the right of reverting to the present tariff.

Thus it will be seen that the Colonies have ensured for themselves this large reduction of rates for a period of a year, the companies enjoying the advantage of a much lower tariff meanwhile to enlarge the area and extent of their traffic—an advantage which would no doubt in time repay them their proportion of the first year's loss, as well as that upon the subsequent tariff. It is hoped, however, that it may be possible to sustain the lower rates; for even if the revenue does not tend to rapidly improve in consequence of these great reductions, the fact will demonstrate to the Colonies that the companies have been justified in maintaining their high charges, and will render the argument for Government subsidy unassailable. In other words it will prove that the companies, who have to make a profit out of their business, must either get it out of the traffic or from the Governments who benefit by the service being efficiently maintained. If, however, the traffic increases to the extent anticipated by them, the loss they will have to make good will be proportionately small, and they will be satisfied with the accuracy of their prognostications. The guarantee on the side of the Colonies is distributed over the five who have assented to it, in proportion of their respective populations, and the charge will not be alarmingly heavy on any of them, even should the experiment fail; and will be reduced to extremely small dimensions if it approach anywhere near the point of absolute recovery. This, as we have said, cannot be looked for in the short space of a year; but, whatever happens, the contracting parties will have learnt something very useful by the end of that time to guide them in the course they will then be called upon to adopt. As regards the companies, and perhaps more especially the Chairman of the foremost of them, nothing but praise can be said of the manner in which a critical crisis has been bridged over by firmness, good management, and tact. Some substantial concession had, perhaps, become inevitable; the right moment was seized, and although the experiment is not unattended with risk, it is one that in the end must result in material advantage to all the cable companies concerned, as well as to the Colonial Empire, with which their interests are so closely bound up.

## THE ELECTRIC CURRENT AND ITS LAWS.—VII.

BY JOHN T. SPRAGUE.

(*Concluded from p. 699.*)

§ 59. There are many analogies between electrical transmission and various mechanical modes; but the most perfect and the most easily shown is that of the hydraulic closed circuit transmitting a current of water, which never leaves the system, and energy which is expended in doing work. Fig. 6 is

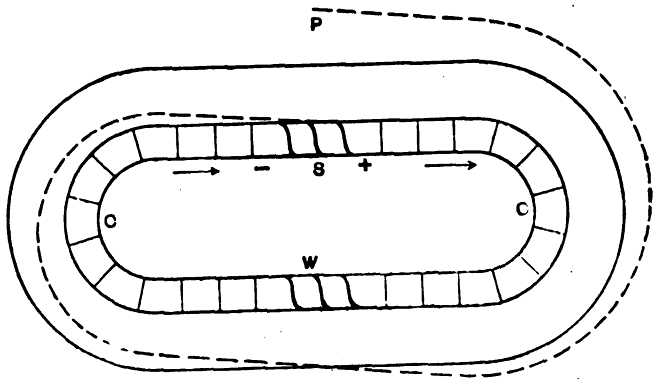



FIG. 6.—Diagram of the Hydraulic Analogue of the Electric Circuit.

intended to show this analogy. C C is the continuous pipe or conductor; S is a turbine, the source of current and energy; W is a similar turbine, doing work when driven by the stream of water.

It will be clearly seen that each revolution of S must drive a fixed (unit) quantity of water (assuming no slip), which corresponds to the amperage equivalence of electric current, and the cross marks in the pipe are intended to show this, as resembling the links of the polar chain. Here, then, we have the material basis, the quantitative element of both currents. It is equal at every section of the circuit; a meter anywhere would read the same, as a galvanometer does in the electric circuit, assuming no leakage. In both cases work done consumes no current; the same quantity enters and leaves the source and every portion of the circuit.

Digitized by Google

§ 60. In the electric circuit we have inductance and magnetance to deal with, but in very different degrees in different circuits, according as they are advantageous or evil. We have just the same, treating them simply as initial absorbed energy, § 32, in the water current. In the practical hydraulic systems this would be an evil, and it is represented only by the elasticity of the pipes and the small compressibility of water. Presently, for theoretical purposes, we may introduce this element into the hydraulic system, but at present we must consider that an initial pressure exists in the conductor which is shown in the external full line, which represents the equal reading of pressure gauges along the circuit, and which corresponds to the zero reading of electrometers on an electric circuit not working.

Directly the source operates we have pressure set up on one side, and suction on the other; that is to say, we have + and − pressure in the circuit, which the pressure gauges will show, precisely as the electrometers would on the electric circuit; the dotted line P shows this, and corresponds in all respects to the line of fall of potential, shown in more full detail than is possible here in Fig. 5, p. 698 (*The Electrician*, April 10th). But here also, according to the nature of the work done, we should find sudden drops due to counter-pressures, and also gradual slopes due to resistance in the circuit.

§ 61. A formula corresponding to Ohm's law could be drawn for hydraulic current, but one element would not be so simple. Electric conductance is a matter purely of sectional area, in any given substance, because the true frictional resistance is equal at every part of that area; it is a function of atomic motions. In the case of a water pipe it is not so; there is the skin friction of the pipe, and there is the friction of the viscosity of water, and neither is related purely to sectional area; but if we once expressed this, for any pipe, in terms of conductance per unit length, its reciprocal would give us the correlative of ohmage in electricity. Here, then, is my answer to questions put me by Professor S. P. Thompson, on p. 375 of *The Electrician* of January 23rd. I consider that Ohm's *formula* applies in its simplest form to constant electric currents; but I hold that Ohm's *law* is the expression of a universal mechanical truth, and can be applied to all cases of mechanical motion and stress; that it does "represent the facts of gravity or of static electricity," whether it professes to do so or not, or whatever may have been in the mind of Ohm himself. It is no uncommon thing for a truth to be far more wide-reaching than the prophet who reveals it, perceives for himself. I do not think that Ohm's law does give us the facts of steady currents; it gives us the current "ordinate" for the conditions of the instant; it, therefore, gives us the constant current practically, because that is one of unchanging conditions of equal ordinates, and consequently a "curve of current," which is a horizontal straight line. But equally the *law* gives us the changing ordinates of the variable period if we put the varying conditions into the formula which applies the law. I shall come to this subject again.

§ 62. To return to Fig. 6, + and − pressure, that is pressure and suction, push and pull can equally transmit energy, do work and generate current. The hydraulic circuit, like the electric, can be subdivided into branches (multiple arc, derived, or shunt circuits) of various sizes and lengths, and the same laws will govern them as control the corresponding electric subdivisions of circuit. Work can be done in series or in arc, the machines being placed on an outgoing conductor and the conductance adapted to let the current pass at once to the return circuit. In fact, the distribution of energy by a water current, under pressure in a closed pipe, goes on under conditions absolutely identical with those of the electric current. If, in this latter, the wire is a mere waste-pipe and the energy goes by an outside medium, there is no escape from the conclusion that the energy of a hydraulic engine is taken to the motors, not by the water, but by some mysterious outer agent having the properties of a dielectric. I doubt whether any hydraulic engineer will swallow that, whatever educated electricians may do.

§ 63. Now let us bring the phenomena of the variable period into the hydraulic main. To do this we must provide a dielectric. That is, something possessing elastance, permittance, reluctance, and so on. In other words, the conductor must first expend energy upon something external to the current, which must be first satisfied, and will, therefore, *retard* the real current. This is easy when we need only to manufacture abstract ideas, and need not call for capital expenditure. We have only to make the conductor elastic, and this is merely the same thing as using an electric circuit with large "inductance and magnetance;" instead of a rigid steel pipe, let us lay down a strong india-rubber one, and put it under pressure till it fills the external full line in Fig. 6.

§ 64. Directly the source acts, the + and − pressures will convert this cylinder into a long conical pipe, having the outline of line P. In electrical phrase, the first effort of the source will be all engaged in producing external stresses; none the less, the energy of the source will travel inside the conductor. Why should we say it does not do so in the electric case? The conditions are the same. Let us now reproduce Fig. 4 as Fig. 7, which was drawn for this use, and see what happens in this initial variable period.

This shows the earliest effect of + pressure. The water, shown by arrows entering the pipe, meets an obstacle,—the inertia of the water in the pipe, shown in the shaded lines I. The elastic pipe yields to the pressure and expands. The energy of the source is first employed in setting up stresses, and actual "current" is limited to a superficial skin, and is itself employed, not in propagating true current in the conductor, but purely in setting up external stresses. The same conditions, but reversed, are set up on the opposite side of the source by suction, or − pressure. The actual current of the source is local; does not appear in the distant parts of the conductor until the full limit of stress, corresponding to the

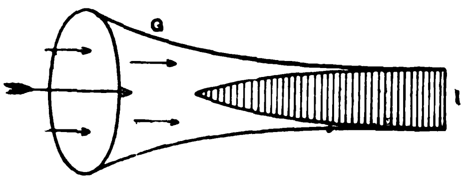



FIG. 7.

pressure of the source, is charged upon the external "inductive" field, and is propagated along the conductor in a wave of impulse. Let the source cease to act; this stored energy returns to the conductor, and produces an "extra current," equalising the pressures along the whole circuit, even though that circuit is broken; that is, no passage is open through the source. In what way do the conditions differ from those of an electric circuit?

§ 65. Oscillations? Frequency? Separate induced circuit and current? Yes, we will have them all—*theoretically*. I do not advise practical applications.

Let us lay down two such elastic circuits as that of § 60, and enclose them in a rigid casing so as to create a field of force. Let the primary circuit, with its source, correspond to C C, Fig. 6, made elastic; let the secondary circuit be an identical one placed upon and pressed to the other. Now let the source work, and convert the primary into the conical form resulting from pressure. The secondary, which forms part of the external field—that is, the dielectric field of the primary—receives a transmitted stress which converts it also into a conical tube, but in a reverse direction; the corresponding stresses are set up in it, by the energy of the source, which is in no way in its circuit, and a momentary current is induced which will work its turbine.

A reverse action and current will come into existence as soon as the pressure of the source ceases; but just so long as the source maintains its action, neither the stresses in its own conductor, nor the stresses in the secondary, will have any influence whatever upon the current in the primary.

Set up oscillations, reversals, or intermittent action of the source, and you will have alternating currents following each other in the secondary. A little ingenuity, and we could so "commutate" the motor in the secondary as to get a suc-

Digitized by Google

cession of direct impulses through it, out of the alternating impulses in the conductor, just as we do in the H armature type of dynamo machines; and we could do work in the motor as we do with the dynamo; or we could convert the to-and-fro motion of the motor itself into a direct rotary motion.

Again, I ask, in what way do the conditions differ from those of the electric circuit? Why need we seek some hypothetical mode for the transfer of energy, when our common-sense shows us the simple truth in natural actions, which we can test practically, instead of groping among abstract ideas and inexplicable symbols?

§ 66. Let us examine these corresponding conditions in the primary and secondary electric circuits, and settle Prof. S. P. Thompson's Fifth Proposition, p. 464 (*The Electrician*, February 13th). Let Fig. 8 represent two circuits, the primary one *a a*—from which energy is in some way transmitted through the insulating medium, to the separate secondary, or induced circuit, *b b*, closed through the galvanometer G. I show them wound side by side upon a magnetisable core; in fact, as a crude transformer or induction coil.

Before we ask how the energy gets to the secondary, let us inquire how it gets to the primary? We have Mr. Heaviside telling us, p. 388, § 15 (*The Electrician*, January 30th), "the source of energy must, therefore, first supply the dielectric surrounding the wire (primary) before the substance of the wire itself can be influenced, that is the dielectric must be the real primary agent;" again, p. 389, § 16, "the battery acts upon the dielectric primarily—electrical conductors act, as regards internal propagation, not as conductors, but rather as obstructors." Very well, only I wish someone would answer my question, § 18, p, 576 (*The Electrician*, March 13th), how does the current which cannot exist till energy is supplied, control this external energy, and so create itself?

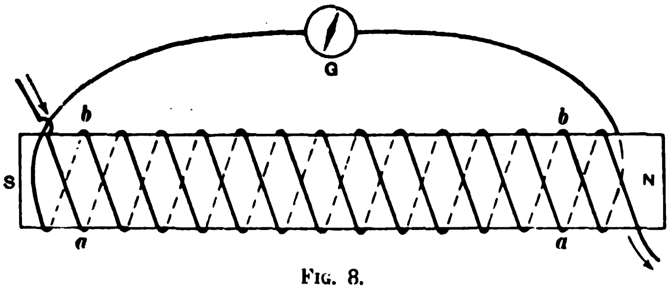



Fig. 8.

However, this theory means clearly that the energy of the source forms a sheath surrounding the coils in Fig. 8, whether it goes round and round, led by the wire, or whether it flows across the wires, I do not see; but it seems to me the latter is the meaning of "lateral transmission."

§ 67. The conductor is an obstructor and a waste-pipe. Very good; but here are *two waste-pipes.* What is the principle of selection? Both are closed, both are equally capable of dissipating energy; *both have currents in them,* and it may even happen that the current in the secondary may be earlier in phase than the retarded current in the primary. I want to know why the actual initial current in the secondary stops at once? Why does it not draw upon the obliging energy in the "medium" and keep itself going? It does not; it acts just like our secondary hydraulic current; the energy of the source traversing the dielectric at the speed of light, first sets up stresses in the medium, with an incidental current in the secondary, magnetises the core, taking its time to do this thoroughly, and then, "like a bird that seeketh its mother's nest," coolly gets into its own conductor and patiently expends itself wholly in maintaining a current in that conductor. Now, why *does* it select only that waste-pipe which is connected to the source?

Why should it not? it never was out of it. If there were the smallest break in that primary conductor no energy would go into the dielectric, no magnetism be set up in the core, and no energy issue from the source at all, except what is needed to charge the small inductive circuit between its terminals, and possibly, set up some small static charge in the dielectric. A break in the other waste-pipe available, the secondary circuit would have no effect except to reduce the initial absorption of energy.

§ 68. Now let us examine the relations of the two-wire coil in the light of common-sense theory, treating the wire connected to the source as the sole outlet of energy from, and the conduit of current from the source, on the principles of current already discussed. First, let us note that although we do get "current" with all its phenomena of amperage equivalence in the secondary, this current is not derived from the source at all; the whole of the amperage generated in the source is retained in the primary wire. That is to say, the secondary current is a new and independent evolution. But its energy is derived from the source.

If we wind our two hydraulic circuits into a similar coil instead of treating them as in § 65, the result will be precisely the same, and will correspond with the electric facts. And why? Because our elastic pipes are the true correlatives and analogues of inductance in electricity, fields of force, absorbing energy from the source, and delivering it up as conditions permit.

The first effort of the source is to charge these fields, to set up the static stresses of inductance, and to charge the magnetic field. Make two exactly similar systems as regards wires, but giving one a higher inductance by using insulation of higher capacity, and higher magnetance by putting iron in one of the cores. The currents in primary and secondary will be wholly different in the two. Higher inductance and magnetance will retard current in the primary, because more energy is absorbed in the charges. They will give increased current in the secondary, because it is there that the stored energy goes.

§ 69. I have already shown that the momentary current on closing circuit is due to the secondary wire forming part of the

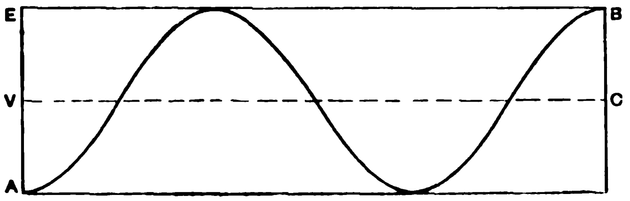



Fig. 9.

static inductive field, and also of the magnetic field, and having to range its atoms in the corresponding order, just as the current is produced in the dynamo. And it must be remembered that this polar order is no hypothesis. Polarised light reveals the structural change which occurs whenever a substance is made to form part of the lines of force. The experiments, new and old, mentioned in Dr. Fleming's excellent Paper on "Electromagnetic Repulsion" (see *The Electrician*, March 13th, *et seq.*), prove it to demonstration; for they all depend on something happening in the interior of bodies, proved to be motions, because they produce heat, these bodies being forced into lines of force.

The current at break is produced by the stored energy, the inductance and magnetance; it is a result similar to the extra current in a single wire. Why does it appear in the secondary wire, instead of the primary, from which it issued? Because the circuit of the primary is broken, and, therefore, resists the evolution of current in it. As a matter of fact, current does form in both wires, but chiefly in that which favours its evolution. We must regard the field of force as a momentary source, with a "voltance" due to the contained energy, and, therefore, with a rapidly vanishing voltage. It is this energy, this voltance, which acts as an E.M.F. upon any outlet available to it, and so generates a current in the secondary wire entirely independent of the current of the original source, excepting in so far as that current originally controlled, by its amperage, the manner in which the energy was stored and the kind of stress set up.*

§ 70. It is necessary now to consider some other facts of the variable periods. Let Fig. 9 represent a succession of current impulses; they may be either intermittent direct currents, or

* A charged condenser acts in the same way as a temporary source, and secondary batteries work on the same principles.

Digitized by Google

they may be alternating currents, and these may be either commutated into one direction, or left alternating, except where employed in electrolysis; but if alternating we must consider that suitable instruments are used.

Prof. S. P. Thompson asked, p. 375 (*The Electrician*, January 23rd), if I held that Ohm's law applies to alternating currents, and if an alternating E.M.F. of 100 volts as measured by a Cardew's voltmeter acting in an ohmage of 5, would give a current = 20 amperes. Now, that does not admit an answer, yes or no; it involves some very serious points of theory and practice. Cardew's voltmeter, while a most valuable instrument, does not measure volts, nor does any voltmeter which is not an electrometer. It measures the last of a series of transformations of energy, viz., the expansion of a wire, resulting from heat generated by a current in a derived circuit (the wire) under the voltage it has to estimate.

But let us go to the root of the matter; an alternating current has *no* definite voltage, no true definite current which can be expressed as one value. Granted we can get at something, the average voltage and current, the square root of the mean of the squares of all the ordinates of the curves, which may be of great practical use, but which, when we examine it, is merely a convenient fiction. Precisely the same thing is true of the new unit of inductance, the Henry. It will express the inductance in terms of an average; it will be very useful; but in the light of truth it is nothing but a "dodge." Inductance may be called a "length," and measured in secohms or quadrants; but nothing of the kind really exists in nature. If it takes a minute to bore a hole an inch deep, would there be any fact in the statement that the average depth during that minute was half an inch? Of course it would be a true statement in a column of statistics, and possibly in mathematics.

§ 71. The case is identical with that so clearly stated by Mr. Evershed, §§ 35-6, p. 597, "the mathematical clothiers calmly cut down the infinite series to one solitary term." Now let us study Fig. 9.

Where is *the* voltage or *the* current in these curves. You can integrate them. Yes, for some purposes; but only as a dodge. Nature will not integrate them. The actual voltages and currents are incessantly varying in portions of the ordinate, or line A E, and the true current is varying on the curve A C. Let A V be the voltage read on a Cardew's voltmeter, and let us imagine that by Ohm's formula we can get the curve into the line V C. Pass your current into a suitable galvanometer with a needle which will remain fairly steady, and into a recording meter, and let us find that these instruments record an average current agreeing with the voltmeter (we may suppose proper corrections applied to Ohm's formula). Pass your current, if made direct, into a copper depositing cell, and admit that it also agrees, and that we have the same result in an incandescent lamp. Surely we have got a truth; the measure of voltage and current prove it. Not a bit of it. They only prove the utility of the dodge for some practical purposes.

§ 72. But now pass your current into an electrolytic cell, the re-voltage of which is equal to the Cardew voltage; let us call these both volt 1·5 for the purpose of illustration. Now, according to formula

$$\frac{1\cdot5 - 1\cdot5}{R} = 0,$$

we ought to have no current at all. But what does happen is that we get a considerable current. All the current below the line V C in the curve A C is extinguished; but all the curve above the line is effective, and that is a very considerable part of it, because, of course, it is not the linear curve, but its height above zero A, which measures the current; in this part of the current time, therefore, we have a + voltage ranging from 1·5 to 3, with a − re-voltage of 1·5 to generate current according to Ohm's law.

I will make a prediction of great practical importance, based on this. If we have incandescent lamps giving a life of, say, 1,000 hours at a fixed voltage, when worked from a battery, they will have a much shorter life when worked by an alternating current under the same voltage, shown by Cardew's or other voltmeter.

§ 73. I have not said much about the process of conduction in wires, except in regard to the formation of polar chains; but it is evident that modern physicists are tending to the belief that it is of the same nature as conduction in electrolytes; and as Mr. Heaviside evidently looks with some favour upon the idea, § 40, p. 633 (*The Electrician*, March 27th), it may not be long before it has a suitable mathematical outfit. Well, I taught and published that conception over 23 years ago, and have consistently held it, as part of my theory of electricity, as now afresh laid out in these articles; so it appears that "modern views" are coming up to the line I have held for a quarter of a century and more.

Many think that there is some specific entity, which they call "electricity," which forms a part of the molecules of matter, and by its transfer effects changes in matter and energy. I see no need for such an entity, and even if it exists, as part of matter, and cause of its functions, then it is included in my "concept" of matter! If we recognise that the ultimate atoms, or, rather, equivalents of matter, are, in fact, "polar" bodies, we need not hypothesize about the cause of the polarity, any more than about the essence of matter. It is simply the extension to all matter of the idea of atomic magnetism which Prof. Ewing has made prominent of late, as regards specially magnetic substances. We can see that certain consequences follow, which bear upon the structure of matter. The union of two atoms by their opposite polarities constitutes a monad molecule, while three or many would build up the more complex molecules.

The formation of a polar chain means simply the opening out of these molecules into atomic order, by an impressed force, itself of a polar nature. Then, as I long ago pointed out, the internal attractions, which constitute the actual molecule, are necessarily weakened, and partly diverted to external atoms, thus constituting the chain. All this we can easily reproduce

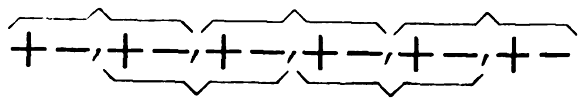


Fig. 10.

(I did it for myself more than 30 years ago) by means of small magnetic needles, with which we can form an actual polar chain, such as I drew on p. 332 of my "Electricity."

A step further and a general interchange occurs along the lines, and a semi-rotation of each new formed molecule, each such action being the accompaniment and consequence of one ultimate equivalent of zinc dissolving and sending its energy or voltance into the polar chain, acting as an impressed force. It is easily pictured (Fig. 10), each + − being one polar atom, the freed end ones at once uniting with those of other chains to reform molecules, and the whole row turning over to range themselves afresh in rank with the polar order of the source.

§ 74. A few words now about the velocity of electricity. A chief reason for the invention of etherial electricity is that matter is said to be not capable of such motions. We know nothing abou the capacity for *atomic* motions, and have not right to argue from mechanical or mass motions of matter. The evidence of the spectroscope is that atoms do really make these motions. Neither do we know anything of the actual velocity of electric transmission, and we have good reason to believe that pure vacuum, our nearest approach to ether, does not transmit electric action at all.

But we have long known that the so-called velocity of electricity in wires is much the same as that of light in the ether, and we are told that Mr. Lecher has recently shown this again experimentally. But if we had a perfectly rigid and frictionless wire, without inertia, 1,000 miles long, and pulled one end through, say, three inches, that motion would be transmitted the 1,000 miles with, say, the velocity of light, and would do work. But the real motion at any point would only be three inches, and the actual velocity in the 1,000 miles a mere trifle. Well, an electric conductor acts as a nearly frictionless and rigid transmitter. The actual motion is rotation of molecules, and we have no evidence that any sal transfer or linear motion occurs at all.

Digitized by Google

Now I have finished, and listen to hear the other side. I only ask them to give us something to be understood; and, as far as I am concerned, to accept my plain meaning, and to use my allegories and illustrations within my own limits. No allegory or illustration will endure over-driving. Like hobbies, they are serviceable while kept in hand, but just as the tiger, pleasant enough to hunt, is inconvenient when it takes its turn at hunting, allegories and hobbies, when they bolt, are apt to end their journey in a ditch.

## NOTES ON THE DESIGN OF MULTIPOLAR DYNAMOS.*

BY W. B. ESSON.

*(Concluded from page 705.)*

### 7. *Dimensions of the Field Magnets.*

It will be apparent, from the foregoing considerations, that the employment of two, or more than two, poles for direct-current machines of moderate dimensions resolves itself mainly into a deliberation regarding the most economical shape to give to the field magnets. As regards the armature, considered by itself, we may say that the choice of dimensions is mostly a matter of convenience, seeing that the amount of copper required and efficiency are for a given output practically unaltered by variations in this respect, while the reduction in the weight of the core due to an increased

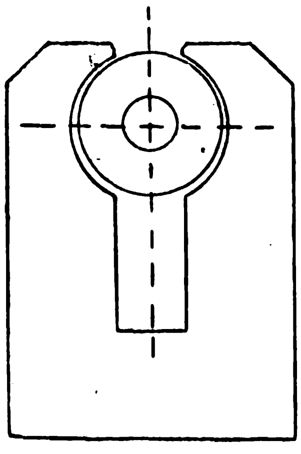


FIG. 3.

number of poles is to some extent compensated by the extra expense of larger plates and increased weight of the armature supports. Again, the cost of labour is increased by the larger diameter; but, everything being taken into account, considerations respecting the armature do not influence the design to a very great extent. One thing in favour of increasing the poles, as far as the armature is concerned, must, however, be remembered, and that is the reduction, consequent on a smaller conductor being used, of the losses arising from parasitic currents. We now turn our attention to the magnets.

I have said that for the prevention of sparking it is necessary that, the induction per square centimetre remaining the same, the air-gap increases proportionally to the diameter, whether the space is necessary for conductors and clearance or not, but that the coefficient by which the diameter has to be multiplied to give the length of the gap necessary to prevent sparking, diminishes directly as the pole angle. In comparing the magnetic system of a four or six-pole machine with that of a two-pole one, it is necessary to adopt dimensions for the armature in accordance with the considerations already mentioned; hence, if the two-pole armature had a length of core equal to one and a-half times its diameter, in a four-pole one the length should be about half the diameter. The diagrams (Figs. 3 and 4) show the cross sections of two such machines. The diameter of the four-pole armature is 1·4, and its length ·5 times that of the two-pole one, consequently both machines give the same output. The weight of the two horse-shoe magnets in the four-pole machine comes to 56 per cent. of the weight of the single horse-shoe magnet, which indicates in this particular case a considerable saving in wrought iron. In taking the copper weight it is necessary to bear in mind that this does not vary simply as the length of the wire if the machines are of the some efficiency, but as the square of the length; so in this particular comparison the copper on the two horse-shoes would be, roughly, 30 per cent. more than on the single horse-shoe, assuming the length of the air-gaps to be the same. Now, if it were possible to reduce the gaps by 12 per cent. or so, the copper weight would be similar in both machines, and we should have credit for a certain amount of iron saved in the construction of the four-pole one, which could be balanced against the increased expenditure for labour. If the gap can be reduced by more than 12 per cent.—always retaining the depth of the winding the same—there is a saving of copper as well as iron, and it is simply the comparison between the value of the copper and other materials used and the cost of the labour in the two cases which determines, at least in machines of moderate size, whether two or more poles should be adopted.

In getting out the best relation of L to $d$ in the different types of armatures, it is assumed, of course, that, the volume being proportional to the diameter, the depth of the winding remains unaltered, as that is the condition which gives uniform rise in temperature. Accordingly, for a given output, the layer of copper on the armature will be of the same depth whether the machine has two poles and an armature having a length of one and a-half times its diameter, or four poles and an armature having a length of only half the diameter. But whether it is possible to reduce the gap to an extent which, with an increased number of poles, will lead to a less costly construction, is a question which for machines of moderate dimensions must receive careful consideration in each individual case. The answer depends upon how much larger the gap has to be to prevent sparking in the case of two poles only, than is requisite to accommodate the conductors and allow the necessary clearance. If the difference is considerable, it may pay better to add poles, and reduce the gaps that way, than to do the same thing by diminishing the pole angle or increasing the induction, or both. The question, it appears, is answered in different ways by different people. It is somewhat interesting to note, for instance, that one engineer, distinguished for the past six years as an ardent advocate of multipolar machines, has, after reducing from six poles to four, lately arrived at two, while another has jumped straight away from two to six without a halt at the intermediate number.

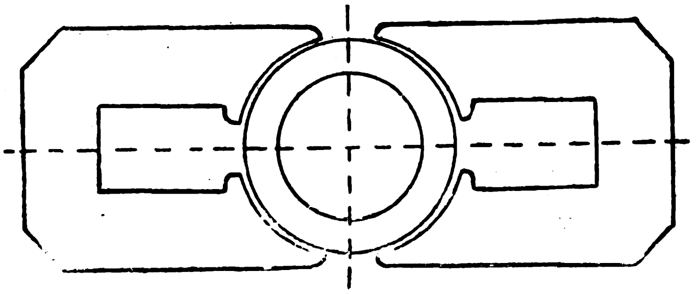


FIG. 4.

But when we come to machines of a certain size there is undoubtedly a gain in employing more than two poles, while very large machines become impossible of construction with two poles only. Consider the case of a two-pole armature of 60 centimetres diameter. Assuming the induction in the gap to be 5,000 C.G.S. lines per square centimetre, and the pole angle 130 deg., our calculations show that the length of air-gap would require to be 3·24 centimetres. This is some 40 per cent. in excess of the requirements of conductors and clearance; so, if the gap is reduced until it just allows of the requisite clearance, the induction must be increased from 5,000 to 7,000. Keeping the output of the machine the same, however, we can reduce the diameter of the armature to 54 centimetres, and work with an induction in the gap of 6,500. Observe, the magnetising force spent in the gap has now been reduced by about 7 per cent., but the total field through the armature has been increased by 15 per cent., and the induction in the armature per square centimetre by more than 25 per cent. If we retain the same section of iron in the fields, it may be assumed then that about the same total magnetising force is required, whether the machine has an armature 60 centimetres diameter, with a gap induction of 5,000 C.G.S. units, or one 54 centimetres diameter, with a gap induction of 6,500. The latter might turn out to be impossible owing to the greater heating of the armature core; any way, what I am attempting to show now is, that by pressing up the induction with a view of reducing the gap, little, if any, advantage is obtained. But by increasing the number of poles, and reducing the gap in that way, we effect, without increasing the gap induction, a marked economy. As it is unnecessary to go into a mass of figures to prove what each can readily prove for himself from the data already before you, I will just give here the results. If we substitute for the two-pole armature of 60 or 54 centimetres diameter and 90 centimetres long a four-pole one of 84 centimetres

* Paper read before the Institution of Electrical Engineers, April 9, 1891.

Digitized by Google

diameter and 45 centimetres long, with a gap induction of 5,000, we require for the magnetising coils while working at the same sparking limit, and with the same efficiency, rather under 70 per cent. of the copper on the two-pole field. When to the saving in copper there is added the saving in iron, there will be, after the extra labour is debited against the four-pole machine, a considerable balance in its favour. But to go beyond four poles in this case would be a mistake.

Having discussed the design of multipolar machines as influenced by both theory and practice, it remains to conclude this communication by calling attention to some of the ordinary forms of multipolar fields. The double wrought-iron horse-shoe (Fig. 4) is not very frequently used, being rather costly; but a similar machine with magnets of cast iron, lately made by my firm for the National Line s.s. "America," is shown in Fig. 5. The

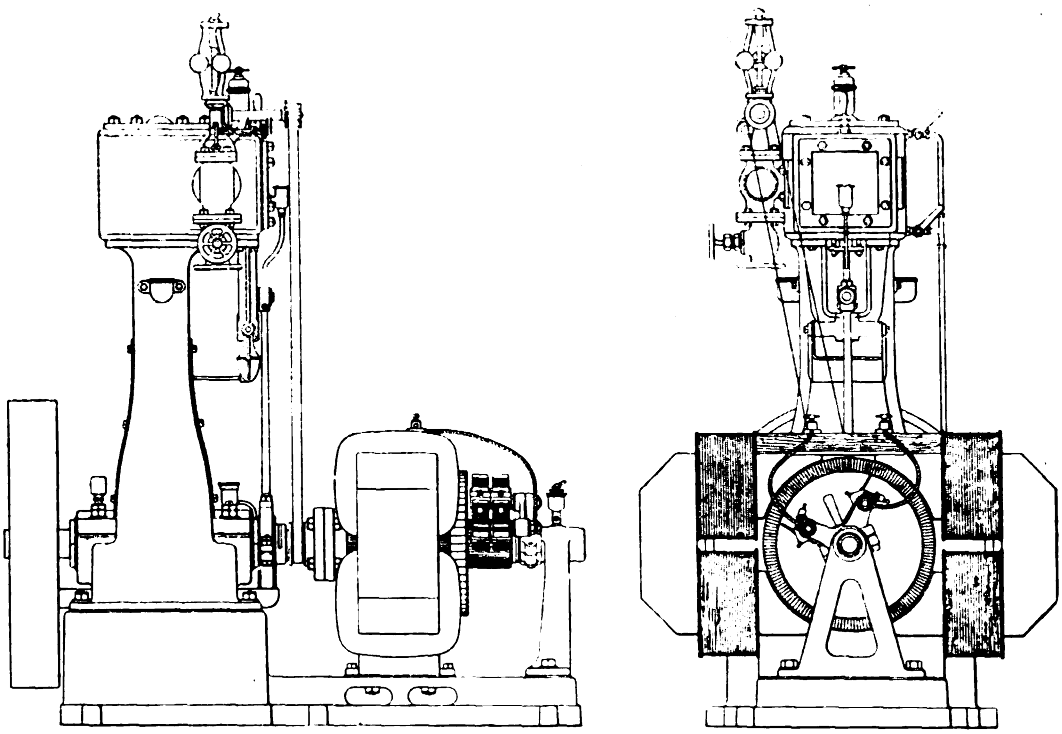


Fig. 5.—Engine and Dynamo for ss. "America.'

Increasing the poles always results in an actual increase of copper, unless at the same time the power spent in the gap is reduced, and this latter must be effected without reducing the thickness of the armature winding. The economy shown above is simply due to the fact that in a two-pole machine of the dimensions specified the gap necessary for the prevention of sparking must be much larger than the conductors require unless pressed up to a high induction. If

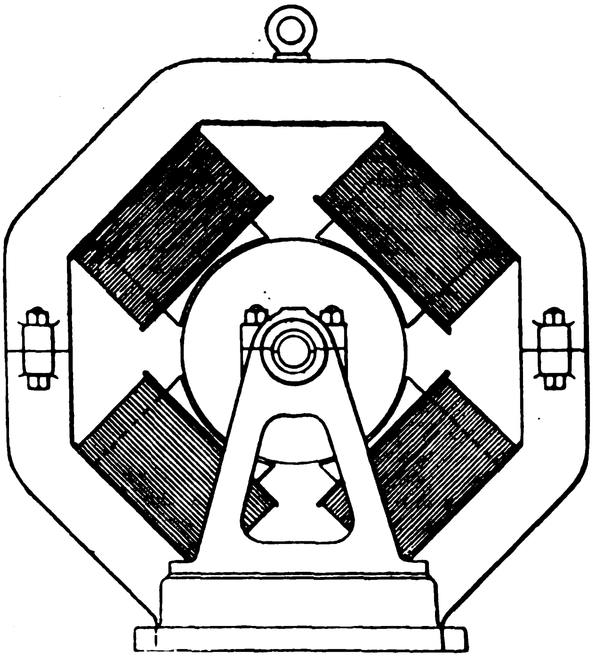


Fig. 6.

with four poles the gap is still larger than necessary, we go to six poles, and so on. But when we arrive at a point where increasing the number admits of no reduction in the gap, we go no farther. It may be mentioned, however, that even in sizes where a four-pole construction showed no actual economy in first cost, it might still be preferable to the two-pole on account of its symmetrical field and the absence of magnetic pull.

armature core in this case was formed by winding square annealed-iron wires on a gun-metal flanged cylinder. The winding was of the Gramme type, and the machine was coupled direct to an inverted engine, as shown in the figure. This design, introduced by Gramme in 1869, generally gives place to the arrangement shown in Fig. 6, a form designed by the same inventor in 1885, and since adopted for cylinder-wound armatures

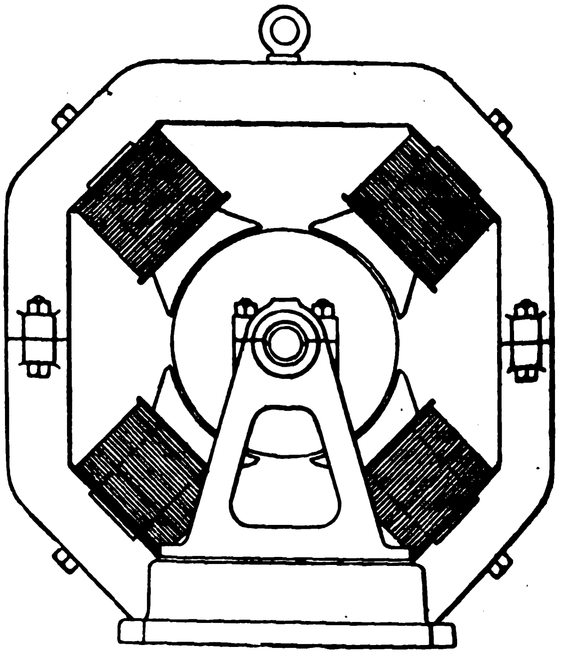


Fig. 7.

by many makers, including Mr. Jasper, in Belgium; Mr. Brown, of the Œrlikon Works, in Switzerland; and Messrs. Paterson and Cooper, in England. Lately Mr. Kapp has used the same form for six and eight-pole machines with drum armatures. The magnets and octagonal yoke in Fig. 6 are of cast iron, in two pieces, the lower limbs, the bottom half of the yoke-ring, and bed-plate being one casting, and the top limbs and upper part of the yoke being

Digitized by Google

another. Fig. 7 represents a similar field in which the magnet cores are of wrought iron, fitted with cast iron pole-pieces, as used by Mr. Kapp in the machines above-mentioned. The decision as to whether cast iron or wrought iron should be used is arrived at in a very simple manner—by comparing the excess of copper required on one hand with the extra machining required on the other.

It will be observed that in the designs Figs. 6 and 7 the yokes are considerably longer than those shown in Fig. 4 ; and the weight of the former, if made of the same material, would be, roughly, twice that of the latter, though even then the complete magnet system would be but 75 per cent. of the weight of Fig. 3.

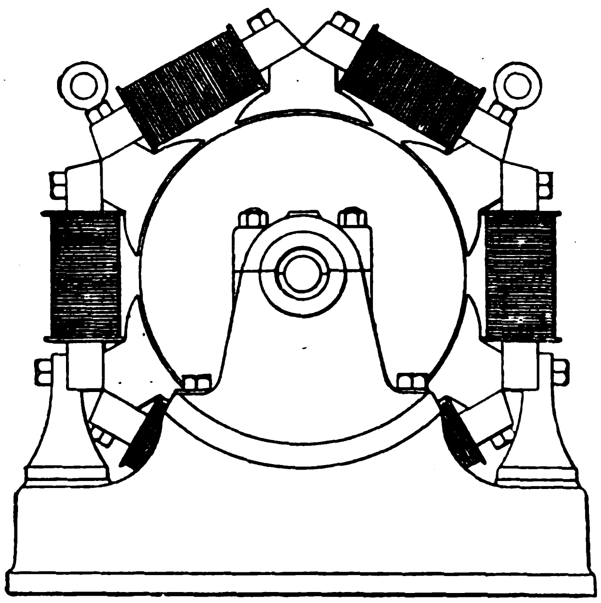


Fig. 8.

The yokes being of cast iron, however, the system really comes about 20 per cent. heavier than Fig. 3 ; the less expensive character of the material compensating, of course, for the increased weight.

All these are examples of single magnetic circuits, where the lines of force from each pole remain undivided in their paths through the magnetising coils ; but in Figs. 8 and 9 are shown examples of double magnetic circuits, in which the lines from each pole take two paths through separate coils. Fig. 8 is a type of magnet used by Sautter-Lemmonier, of Paris, for Gramme-wound armatures, and by Cuenod-Sautter, of Geneva, for armatures having a Siemens winding as modified by Thury. The magnetising coils are wound upon the parts of the system constituting in Fig. 7 the yokes, and a greater amount of copper is in consequence required. It looks at first sight as if the weight of copper were not very different in the two types, but in this respect appearances are deceptive, for, as a matter of fact, the field of a four-pole machine made to Fig. 8 would require about 125 per cent. more copper than if made according to Fig. 7. It will be observed, however, that the magnet cores and pole-pieces, which are made throughout of the softest wrought iron, are very light. In Fig. 9 the magnets are a series of wrought-iron bars lying parallel to the armature, each fitted with a cast pole-piece in the middle of its length, and having two magnetising coils, one on each side of this piece. It is a structure which may be frequently met with, though not precisely in the form shown, and the observations regarding the copper made with reference to Fig. 8 apply equally here.

The cost of a four-pole machine is approximately represented by the cost of a couple of two-pole machines of the same efficiency

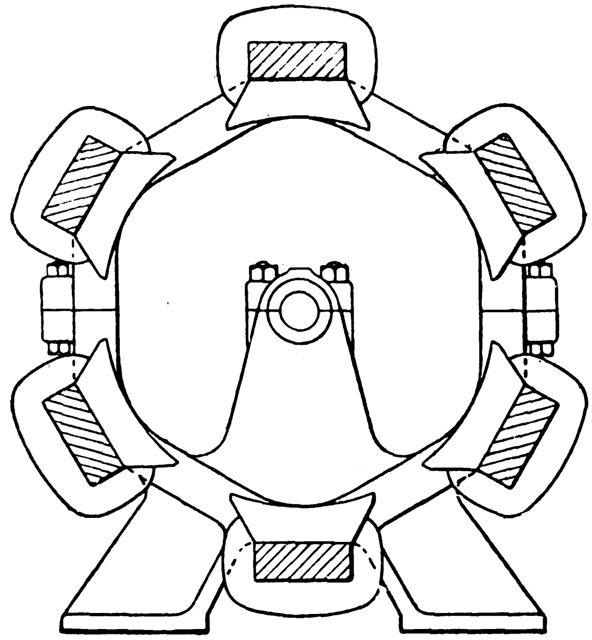


Fig. 9.

which give each half the output at twice the speed ; the cost of a six-pole by that of three two-pole machines which give one-third of the output at three times the speed ; and so on. For comparison, the fields must be in both the multipolar machines and two-pole machines of the same character—that is, with single or double magnetic circuits.

The fields of alternators may be similarly divided into those having single and those having double magnetic circuits ; the former requiring, as in the fields of direct-current machines, much less copper than the latter. Amongst those having single magnetic circuits are the machines of Siemens, Ferranti, Mordey, Westinghouse, Elwell-Parker, and Paterson and Cooper. Mr. Kapp possesses the distinction of having the only alternator with double magnetic circuits. The "Phœnix" alternator, shown in Fig. 10, possesses some features which may be of interest as illustrating the way in which the commercial aspect of designing has to be considered. The yoke-ring is of cast iron, but the magnets are of tooled wrought iron, shaped as shown. If the magnets had a breadth equal all the way up to the length of the armature core, they might as well have been of cast iron, for the little advan-

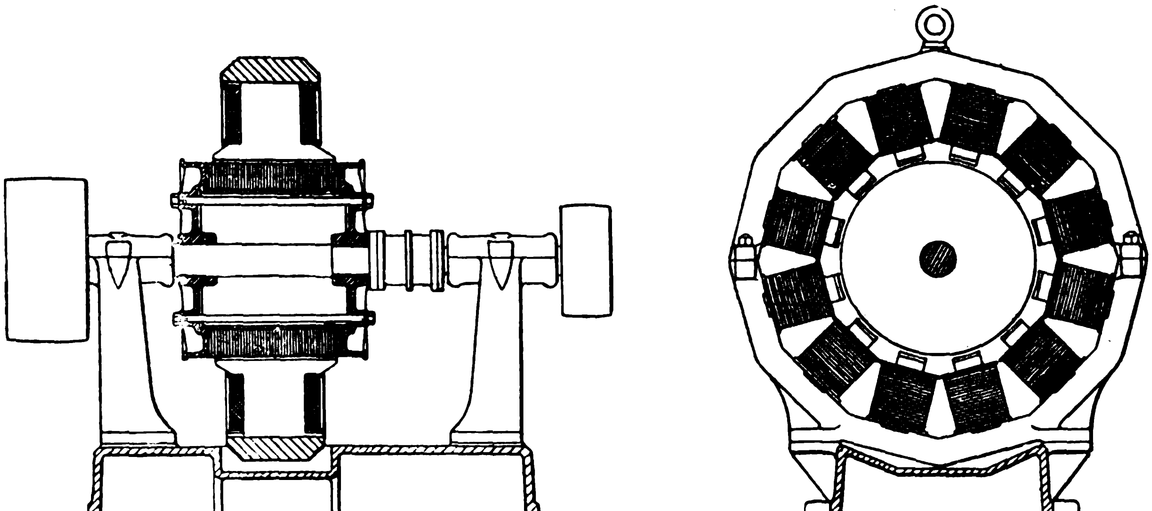


Fig. 10.

Digitized by Google

tage consequent on the reduction of copper obtained by narrowing them would not have paid for the extra work in tooling wrought iron. But when we reduce the breadth where the magnetising coils are, as shown, we at once diminish the copper on the fields by 60 per cent., greatly reduce the leakage area, and get a good balance after paying for extra tooling. The machine, as will be seen, has 12 radial magnets, and there are on the armature six flat coils, each equal to three times the width of the magnet cores, and laid on the periphery with a space equal to the core between them.

The length of the Paper prohibits me from dealing with many special types of machine, to which, however, all the reasoning here used may be applied without difficulty.

## THE MEASUREMENT OF THE POWER GIVEN BY ANY ELECTRIC CURRENT TO ANY CIRCUIT.*

BY PROF. W. E. AYRTON, F.R.S., AND W. E. SUMPNER, D.SC.

### I.

There are three well-known methods of measuring the electrical power supplied by alternating currents. The first of these is the electrometer method† the accuracy of which is entirely independent of the way in which the currents vary with time, or of the nature of the circuit the power given to which it is desired to measure. As the method is unique in this respect, it might have been expected that its use would have been extensive. Unfortunately, however, the application of the method is restricted by the fact that Sir W. Thomson's quadrant electrometers do not generally obey the law given for these instruments in the text books. A method of an entirely different kind was published by Mr. Blakesley in 1888, and consists of an ingenious use of three dynamometers. The original proof given by the inventor was based on several hypotheses, many of which have since been shown to be unnecessary. There, however, still remain two grave objections to the method. It is only applicable to the case of a transformer, and it moreover assumes that in the transformer tested there is no magnetic leakage, *i.e.*, every line of force is supposed to go through each convolution of both primary

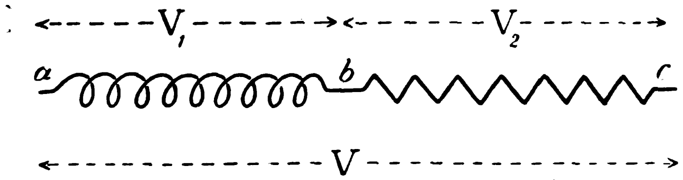



FIG. 1.

and secondary coils. The remaining method, that of the electromagnetic wattmeter, is perhaps the commonest of all, but here errors are introduced in consequence of the self-induction of the fine wire coil, and several investigators have devoted their attention to the discovery of devices by means of which these errors may be reduced to a minimum.

Several months ago, however, while working at alternate current interference, we noticed that it was possible to employ an extremely simple method, based on the difference of phase of the P.D. and the current for measuring the power by *any* current to *any* circuit. This method, which has since been in regular use in the laboratories of the Central Institution, is quite independent of any assumptions as to the nature of the current, or of the circuit, the power given to which it is desired to measure, and it has the further great advantage that the only measuring instrument required is the ordinary alternate-current voltmeter of commerce.

In series with the circuit *ab* (Fig. 1) the power given to which we desire to measure, connect a non-inductive resistance *bc* of *r* ohms.

Let $V_1$, $V_2$, and V be the readings of the voltmeter when applied between *a* and *b*, *b* and *c*, and *a* and *c* respectively; then, if W be the mean watts supplied to the circuit *ab*, we have in all cases, whatever the nature of the current, or of the circuit *ab*—

$$W = \frac{1}{2r}(V^2 - V_1^2 - V_2^2) \quad . \quad . \quad . \quad . \quad . \quad (1).$$

For, let $v_1$, $v_2$, and $v$ be the instantaneous values of the P.D. between *a* and *b*, *b* and *c*, and *a* and *c* at some moment *t*,

then $$v = v_1 + v_2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2).$$

If *a* be the current in amperes flowing through the circuit at time *t*, then $a\,v_1$ equals the watts *w* given to *ab* at that time. But

$$a = \frac{v_2}{r},$$

since the resistance *b c* is non-inductive:

$$\therefore w = \frac{v_1 v_2}{r}.$$

Then, squaring (2) we have

$$v^2 = v_1^2 + 2\,v_1\,v_2 + v_2^2$$

$$\therefore w = \frac{1}{2r}(v^2 - v_1^2 - v_2^2).$$

Consequently $$\int_0^T w\,d\,t = \frac{1}{2r}\left(\int_0^T v^2\,d\,t - \int_0^T v_1^2\,d\,t - \int_0^T v_2^2\,d\,t\right),$$

or $$W = \frac{1}{2r}(V^2 - V_1^2 - V_2^2),$$

the equation given above.

If the resistance of *b c* be not known, or if there be any fear that it may be changed by the passage of the current, then an ammeter (an alternate current ammeter, of course, if alternate currents be employed) can be inserted in the circuit. Let A be the reading of this ammeter, and which represents the square root of the mean square of the current, then, for *r* in (1) we may substitute $V_2/A$, or

$$W = \frac{A}{2\,V_2}(V^2 - V_1^2 - V_2^2) \quad . \quad . \quad . \quad . \quad . \quad (3).$$

When employing this last formula, the non-inductive resistance *bc* may be that offered by incandescent lamps, since there is no objection to the resistance varying with different mean strengths of the current employed.

This voltmeter method of measuring power was arrived at quite independently of the electrometer method referred to above, but an examination of the electrometer method shows that it is practically equivalent to simultaneous measurements of three P.D's.

### II.

The method which we have described for measuring the power given by *any* current to *any* circuit may be conveniently employed for measuring the power given to an alternating-current arc, or to an alternating-current arc lamp. It is known that an alternating-current arc requires a greater current than a direct-current arc to produce the same light with similar carbons; for example, a 10-ampere direct-current lamp requires 12½ amperes, or 25 per cent. larger current, when used with an alternating current. In a masterly Paper on "The Theory of Alternating Currents," read before the Society of Telegraph Engineers on November 13, 1884, Dr. Hopkinson refers to a law given by Joubert, that the difference of potentials between the carbons in an alternating arc is of approximately constant numerical value throughout the period, and that it reverses sign discontinuously at each reversal of the current. Using this law as his basis, he works out mathematically some very curious relationships between the variations of current and P.D. time.

Three of our senior students, Messrs. Kolkhorst, Thornton, and Weekes, have been making a number of experiments on the power supplied to alternating-current arcs by using the method of measuring power described above. From these experiments it would appear that the quality of the carbon employed affects materially the difference in phase between the currents passing through the arc and the P.D. between the carbons. If the arc be quite steady and only give out the rhythmic hum that accompanies a good arc, such as can be obtained with cored carbons of proper quality, the arc appears to act practically as a simple resistance, and M. Joubert's law does not hold. But if the arc be maintained between uncored carbons of poor quality, and be hissing, there is considerable difference in phase between the current and the P.D. between the terminals; further, the experiments show that the current is very far from being a sine function of the time, although produced by a dynamo whose E.M.F. normally follows a harmonic law.

We do not purpose, in this communication, to enter at length into these experiments on alternate-current arcs, but a few examples of the experimental results that have been obtained will be interesting as illustrating the ready applicability of this new method of measuring power to such investigations.

In addition to the difference of phase of P.D. and current that may be produced in the arc itself, there is the electro-magnet to be considered by which the distance between the carbons is usually regulated in arc lamps. This electro-magnet will introduce lag between the P.D. at the terminals of the lamp and the current passing through the electro-magnet and the arc in series; and hence, even although the arc be perfectly steady, we find, even in the case of a Brush lamp especially intended for alternate currents, that the true power supplied to the electro-magnet and arc is 20 per cent.

* Abstract of Paper read before the Royal Society, April 9, 1891.

† Suggested simultaneously by Profs. Ayrton and Fitzgerald, at the Paris Congress, in 1881.

Digitized by Google

less than the product of the readings of the ammeter and the voltmeter attached to the lamp terminals, and which gives the square root of the mean product of the squares of the current and P.D.

If, however, the arc be between common carbons and be hissing, the difference, we find, is much greater. With cored carbons this Brush lamp requires a P.D. of about 35 volts to be maintained between its terminals, but if these cored carbons be replaced by common carbons and the arc be hissing, the P.D. between the terminals of the lamp at once rises to 45 or even 50 volts, although the current passing through the lamp and the amount of light given out remain practically as before. And then we find that the true power supplied to the lamp may be only one-half of the square root of the mean product of the squares of the current and P.D., so that the readings of the ammeter and voltmeter alone make the apparent power twice as great as the true power.

For the purpose of easily estimating the ratio of the true to the apparent power supplied, formula (3) may be thus written,

$$W = AV_1\left\{1 - \frac{(V_1+V_2-V)(V_1+V_2+V)}{2V_1V_2}\right\} \quad . \quad . \quad (4),$$

from which we see that the expression in the brackets represents the ratio of the true to the apparent power supplied to the lamp or other circuit *a b* (Fig. 1). Hence the percentage error made in assuming that the power supplied to any circuit was the product of the ammeter and voltmeter readings would be in all cases, whatever the nature of the current or of the circuit,

$$100\frac{(V_1+V_2-V)(V_1+V_2+V)}{2V_1V_2} \quad . \quad . \quad . \quad (5).$$

The following are samples of the results obtained with a hand-regulated lamp, there being no electromagnet at all in series with

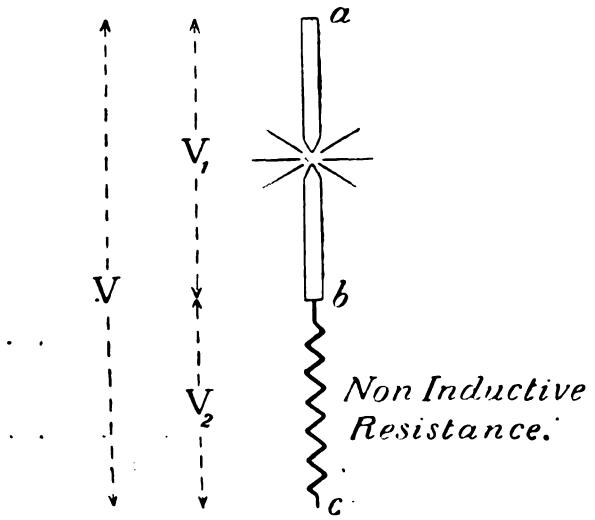



FIG. 2.

the arc (Fig. 2). The carbons were not cored and the arc was hissing. The frequency was maintained at 200 periods per second.

**Table I.**

| Square root of mean square. | | | | Percentage error in estimating power formula (5). |
|---|---|---|---|---|
| Of P.D. in volts between. | | | Of current in amperes. | |
| *a* and *b*. $V_1$. | *b* and *c*. $V_2$. | *a* and *c*. V. | A. | |
| 55·0 | 60·0 | 108·0 | 12·3 | 24·0 |
| 45·4 | 75·4 | 107·3 | 11·8 | 45·8 |

For the purpose of obtaining an idea of $\phi$, the angle of phase difference produced by the hissing arc, between the current and the P.D., we may assume that the P.D. and current are sine functions of the time; then, as may be easily proved,

$$\cos\phi = \frac{V^2 - V_1^2 - V_2^2}{2V_1V_2} \quad . \quad . \quad . \quad . \quad . \quad . \quad (6),$$

and the values of $\phi$ for the two tests given above come out as 40° 20′ and 57° 10′. It will, of course, be observed that this assumption of a harmonic law for the P.D. and current for the purpose of obtaining some idea of the value of $\phi$ in no way affects the generality of the method for the measurement of the power, since this is based on no such assumption.

The following are samples of the results obtained with a Brush alternate-current lamp regulated by an electro-magnet (Fig. 3), the carbons not being cored, and the arc hissing. The frequency was maintained at 200 periods per second.

**Table II.**

| Square root of the mean square. | | | | Percentage error in estimating power formula (5). | Lag between current and P.D. |
|---|---|---|---|---|---|
| Of P.D. in volts between | | | Of current in amperes. | | |
| *a* and *b*. $V_1$. | *b* and *c*. $V_2$. | *a* and *c*. V. | | | $\phi$. |
| 64·8 | 58·0 | 108·4 | 13·0 | 44·0 | 56° 0′ |
| 59·8 | 64·2 | 107·4 | 12·0 | 50·5 | 60° 20′ |
| 55·0 | 67·3 | 107·4 | 10·6 | 47·0 | 58° 30′ |

The experiments already described tell us that a hissing arc may cause a considerable phase difference between the P.D. and the

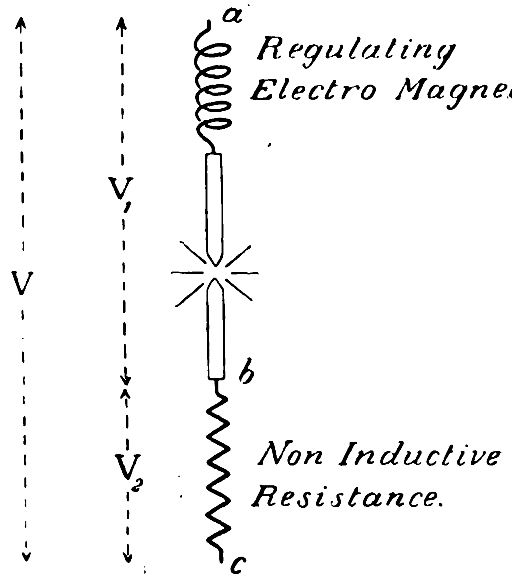



FIG. 3.

current, but they do not enable us to decide whether such an arc causes the current to lag behind the P.D., or to lead in front of it. To decide this point, that is, to decide whether a hissing arc acts like an inductive coil, or a condenser, a variety of experiments were

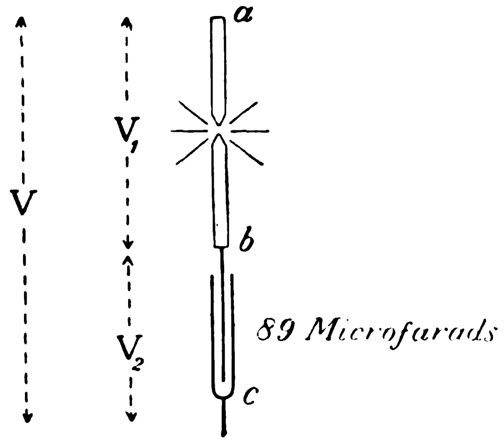



FIG. 4.

made by putting induction or capacity in series with the arc. The following gives the result of one such experiment:—In series with a hand-regulated lamp (and, therefore, containing no electromagnet), was placed a condenser of 80 microfarads (Fig. 4). Uncored carbons were used, and they were adjusted so that the arc was very short at first; the carbons were then not touched, and, as they burnt away, the arc grew longer and longer until it finally went out. The frequency was maintained at 200 periods per second.

Digitized by Google

**Table III.**

| E.M.F. of dynamo in volts. | Square root of mean square. Of P.D. in volts between a and b. $V_1$. | b and c. $V_2$. | a and c. V. | Of current in amperes. A. | Sum of $V_1+V_2$. | Lag between current and P.D. $\phi$ |
|---|---|---|---|---|---|---|
| 59 | 35·4 | 89·0 | 72·3 | 12·0 | 124·4 | 129° |
| | 38·0 | 92·0 | 73·3 | 12·5 | 130·0 | 133° |
| | 51·2 | 104·5 | 74·3 | 14·0 | 155·7 | 135° |
| | 69·2 | 86·5 | 67·5 | 13·4 | 155·7 | 131° |

Comparing V with the E.M.F. of the dynamo, we see that the arc and the condenser together acted as a condenser on the whole; but comparing V with $V_1 + V_2$, we see that the arc acted as an induction and not as a capacity.

It having been conclusively proved that a hissing arc with uncored carbons acts as an induction, it was interesting to compare the impedance it produces with the impedance produced by the ordinary regulating electro-magnet of the lamp. The arc itself seen in Fig. 3 was, therefore, short-circuited, and the following measurements made, $V_1$ now being the square root of the mean square of the P.D. between the terminals of the regulating electro-magnet, $V_2$ as before that between the terminals of the non-inductive resistance, and V that between *a* and *c*, the arc, as already explained, being short-circuited. The frequency was maintained at 200 periods per second.

**Table IV.**

| $V_1$. | $V_2$. | V. | A. |
|---|---|---|---|
| 35·4 | 69·2 | 82·0 | 11·3 |
| 35·4 | 65·6 | 80·0 | 11·4 |

We have, then, P.D. measurements giving the phase difference of current and P.D. with the arc alone (Table I. and Fig. 2); with the arc and regulating electro-magnet (Table II. and Fig. 3); and with the electro-magnet alone (Table IV.). Defining impedance in the usual way as the ratio of the square root of mean square of P.D. to the square root of mean square of current, we find from the two sets of results given on Table I., that

the impedance of the arc alone equals .................... $\begin{cases}4{\cdot}47\\3{\cdot}78\end{cases}$;

from the three sets of results given in Table II., that

the impedance of the arc and electro-magnet equals ... $\begin{cases}5{\cdot}87\\5{\cdot}15\\5{\cdot}14\end{cases}$;

and from the two sets of results given in Table IV., that

the impedance of the electro-magnetic alone equals ... $\begin{cases}3{\cdot}14\\3{\cdot}16\end{cases}$

In order to test whether the current follows a harmonic law, let us assume that it does, then find what result this assumption leads to, and, lastly, see whether the experiments confirm this result or not. Let, therefore, the instantaneous current at any moment be of the form

$$\frac{V_0}{\sqrt{(r^2+L^2p^2)}}\sin(pt-q),$$

where *r* is the effective resistance in each case, viz., the ratio of the *true* watts given to the circuit divided by the mean square of the current in amperes, and where *p* equals $2\pi n$, *n* being the number of periods per second. In each of the seven experiments referred to in Tables I., II., and IV., *n* was 200.

The seven values of *r* in ohms corresponding with the seven values of the impedance given above are for the

Arc alone ............................ $\begin{cases}3{\cdot}42\\2{\cdot}07.\end{cases}$

Arc and electro-magnet ......... $\begin{cases}2{\cdot}65\\2{\cdot}66\\2{\cdot}71.\end{cases}$

Electro-magnet alone ............ $\begin{cases}0{\cdot}44\\0{\cdot}54\end{cases}$;

and, since the impedance equals $\sqrt{(r^2+L^2p^2)}$, if the harmonic law be true, the corresponding values of L *p* are, for

Arc alone ............................ $\begin{cases}2{\cdot}88\\3{\cdot}16.\end{cases}$

Arc and electro-magnet ......... $\begin{cases}4{\cdot}08\\4{\cdot}41\\4{\cdot}37.\end{cases}$

Electro-magnet alone ............ $\begin{cases}3{\cdot}12\\3{\cdot}11.\end{cases}$

But if the harmonic law hold for the current, the sum of L *p* for the arc alone, plus the L *p* for the electro-magnet alone, must equal the L *p* for the arc and electro-magnet, since *p* has the same value in each case. Now it is obvious that the condition is far from being fulfilled with the numbers just given. Hence the current does not follow a harmonic law.

It is interesting to notice that the L *p* for the hissing arc alone is actually greater than the L *p* for the regulating electro-magnet.

The values given above for *r*, being obtained by dividing the *true* watts by the mean square of the current in amperes, are the effective resistances in ohms—whether the current follows a harmonic law or not. Hence, by comparing the value of *r* for the regulating electro-magnet alone with its resistance in ohms, measured with a steady current, we have a true measure of the waste of energy in the iron core of the electro-magnet due to hysteresis and Foucault currents. Now the resistance of this electro-magnet for a steady current is only 0·065 ohm; hence 90 per cent. of the energy given to the regulating electro-magnet of this Brush lamp is wasted in heating its iron core when the frequency is 200. Here again we have a further illustration of the importance of being able to measure, by means of the simple method we have described, the power given by any current to any circuit.

III.

*The Best Conditions for Use of the Method.*

In cases where great accuracy is required in the measurement of the power, it is important to consider what value should be given to the non-inductive resistance (Fig. 1), in order to reduce to a minimum any error that may arise from inaccurate reading of the voltmeter or on the graduation of its scale.

Since
$$W=\frac{1}{2r}(V^2-V_1^2-V_2^2),$$
$$dW=\frac{1}{r}(V\,dV-V_1\,dV_1-V_2\,dV_2),$$

where $dV$, $dV_1$, $dV_2$ are the errors made in the estimation of the three P.D.'s.

Let $dV=\pm eV$; $dV_1=\pm eV_1$; $dV=\pm eV_2$,

where *e* is a small fraction, *i.e.*, let the errors be each the same small fraction of the correct value, then the probable value of $(dW)^2$ is

$$\frac{1}{r^2}(V^2e^2V^2+V_1^2e^2V_1^2+V_2^2e^2V_2^2),$$

so that
$$\left(\frac{dW}{W}\right)^2=4e^2\frac{V^4+V_1^4+V_2^4}{(V^2-V_1^2-V_2)^2}\quad\ldots\quad(7).$$

Let the non-inductive resistance have such a value that

$$V_2=xV_1\quad\ldots\ldots\ldots\quad(8).$$

We then want to find the value of *x* for which $\frac{dW}{W}$ will be a minimum.

Now suppose for simplicity that the currents follow a sine law, and that $\phi$ is the angle of lag between $V_1$ and $V_2$.

Then
$$V^2=V_1^2+V_2^2+2V_1V_2\cos\phi\quad\ldots\quad(9),$$

and from this equation together with (7) and (8) we get

$$\left(\frac{dW}{W}\right)^2=4e^2\frac{(1+x^2+2x\cos\phi)^2+1+x^4}{4x^2\cos^2\phi}$$

Now $\cos\phi$ depends on the circuit, the power given to which we desire to measure, and is independent of *x*. Hence differentiating with respect to *x* and equating to nought in the usual manner, we find that *x* equal to unity makes $\frac{dW}{W}$ a minimum.

Hence, inaccuracies in the three readings of the voltmeter, or in the graduation of its scale, produce the least effect in this method of measuring power when the P.D. between the terminals of the non-inductive resistance is equal to the P.D. at the terminals of the circuit under test.

The next point to consider is, what is the percentage error made in measuring the power by this method compared with the percentage error made in reading one of the P.D.'s.

Let *x* equal unity, then we find

$$\frac{dW}{We}=\frac{\sqrt{2+4(1+\cos\phi)^2}}{\cos\phi}$$

Now, $dW/We$ is the ratio of the percentage error made in measuring the power to the percentage error made in one of the P.D.'s, and the right-hand side of the last equation we find equals from 4 to 5 for the values of the lag angle $\phi$ that occur in ordinary practice. An error of one per cent. in each of the mea-

Digitized by Google

surements of V, $V_1$ and $V_2$ would therefore introduce a probable error of from 4 to 5 per cent. in the measurement of the power. The error would be reduced to half its amount if the voltmeters were graduated to read directly the mean square of the volts instead of the square root of the mean square.

It is, of course, clear that these errors to which we have been referring are not errors in any way essential to the method proposed for measuring power, since by the employment of an accurately graduated voltmeter, by exercising care in taking the readings, and if necessary, by repeating the measurements two or three times and taking the means of the observations, the power can be measured to any degree of accuracy desired.

As in practice, the sum of the potentials $V_1$ and $V_2$ will not, as a rule, be much in excess of V, we may very conveniently express the true power W in terms of the excess in question.

Let
$$y = \frac{V_1 + V_2 - V}{V_1}.$$

Then the true power W is
$$W = V_1 A \cos\phi,$$

where
$$\cos\phi = \frac{V^2 - V_1^2 - V_2^2}{2 V_1 V_2},$$

and A is the current through $ab$ (Fig. 1) as read by an alternate current ammeter.

Now if $V_1 = V_2$ it is easy to show that
$$\cos\phi = 1 - 2y + \frac{y^2}{2},$$

or, as $y$ is very small, generally
$$W = V_1 A (1 - 2y).$$

For example, if $V_1$ and $V_2$ were 50 volts each, and V were 98 volts, so that $y = 2/50$, or 4 per cent., the true power would be 8 per cent. less than the apparent power $V_1 A$ obtained by multiplying the volts by the amperes. The same expression shows that if due to any uncertainty about the graduation, or reading of the instrument, the value of the number $y$ is uncertain to ·01, the error one is liable to in the measurement of the power W is twice this, or 2 per cent.

## THE LONDON TELEPHONE RATES.

A meeting convened by circular, dated the 8th inst., signed "Hasties," and emanating from 65, Lincoln's Inn-fields, was held at the Cannon-street Hotel, on Wednesday, "for the purpose of taking such steps as may then appear advisable in the interests of the subscribers to the telephone." In a previous circular, similarly signed, and dated last month, subscribers to the telephone were invited to join an association so that their interests might be secured "especially by lowering the rate and obtaining a double-wire system, by which alone the voice can clearly be heard in London."

Mr. HASTIES, on taking the chair, read the notice convening the meeting, as above referred to. He had, he said, been a subscriber to the telephone for several years, not only at his offices, but also at his private house. There were a great many complaints with regard to the inconveniences and inefficiency of the service afforded by the Telephone Company. Personally, he was very well served, but at a very high price. What had brought him to take action was that he had happened to come across in *The Times* the report of the last meeting of the National Telephone Company, and he then saw that the Chairman at that meeting ventured to tell his shareholders that the Company had no occasion to reduce their price in London, as the subscribers were prepared to pay what the Company asked them for the service which they rendered. He himself paid £20 a year for the telephone at his office, and for the one at his house he paid £12. He felt sure that the Telephone Company lost nothing in connection with this second telephone, and he believed that they could afford to supply telephones at £12 a year in London. It was to this price as a maximum that he proposed they should insist on the Company reducing their charges. He would like to say at once, as it might remove some misapprehension, that he had no wish to promote a new company. His desire in calling that meeting was that the subscribers might be induced by sticking together to have the same power towards the Company in regard to the charges as the Company had towards the subscribers. He had received contributions—all in sums of 5s., in accordance with the invitation contained in his first circular — amounting together to £98, representing, as nearly as possible, 400 members; and he had since found that there would be no difficulty whatever in getting one-half of the subscribers to the Telephone Company to join in the movement which he had initiated. It would be a question for them that day to decide whether they should establish a permanent Association to which complaints could be addressed, and which would permanently keep the Telephone Company in order, or whether they would limit their action to an endeavour to reduce the Company's rates, and insisting on the double wire, and then disbanding. In the latter event he thought that only those who had joined the Association should have the benefit of the reduction in the rates which the Company might consent to, but if they were to maintain their Association the more subscribers they got the better. He had communicated with the Postmaster-General on the subject, and had received a reply; but at the present juncture he did not think it would be advisable to read the whole of the answer which had been forwarded to him. He thought if he read the following part of it it would suffice:—"As to any action which the Post Office itself might be prepared to take, I am to say that the Postmaster-General could not be indifferent to a clearly expressed demand for the establishment of a telephonic service in London, but he regards it as premature at present to state what the charge for such service would be." This showed, he thought, that the Postmaster-General was ready to undertake the work required by the public if the Telephone Company was not ready to meet the demands of their subscribers.

Mr. LEAGE (City Road) said he thought they were all indebted to the Chairman and his firm for having called the meeting together. For some time past the subscribers to the Telephone Company had regarded the charges as excessive and unjust. The service given by the Company was very imperfect, and they had frequently to wait a long time before they could get a reply. He thought that £12 a year was a full and sufficient amount to pay for the service which was rendered by the Company. If the rate were reduced to the amount mentioned, he had no doubt that the Company themselves would be benefited by the increase of business which the reduction would induce. He moved a resolution to the effect that an Association should be formed for the protection of the subscribers to the National Telephone Company in England.

Mr. GODDARD CLARKE (of Messrs. Potter and Clarke) stated that his firm, on receiving the circular from Messrs. Hasties, determined to co-operate with them as much as possible, and they sent round to their friends a letter drawing attention to the circular and requesting their co-operation. They had further communicated with friends of theirs who were connected with provincial exchanges, asking to be informed of the amount of the annual subscription charged for connection with the Telephone Exchange of their towns. In this circular they also said: "If in addition to your Exchange connection you have the facility of communicating with any other towns, be good enough to mention these, and whether such facility involves any extra charge." He held in his hand the replies which he had received, mainly from wholesale druggists in England and Scotland, and the bulk of them stated that within very recent times their rates had been reduced some £20 to £15, others from £15 to £10, and some from £10 to £5; and he maintained that if this could be done in the country, London subscribers ought to have a similar advantage. All the replies he had received showed that the charges imposed upon the London subscribers were much higher than those prevailing in country towns.

The CHAIRMAN put the resolution and it was carried.

Mr. LEAGE then proposed, and Mr. CHARLES R. HAIG seconded, a resolution for the formation of a committee.

Mr. JACKSON thought that before the committee took any active steps they should confer together as to the best mode of approaching the Company in order that the strong weapon of defence which that meeting showed that the telephone subscribers possessed should be used with the most effect. He thought that the committee should not attempt to deal with the Telephone Company until the Association had a large additional number of subscribers. They had many grievances against the Company. To his mind, as a professional man, the point that touched them most was not so much the subscription which they had to pay to the Company, although, no doubt, that was very high, but the dissatisfaction which was caused to them by the inefficiency of the Company's service.

Mr. RAWSON thought that the committee should be a provisional one.

The following gentlemen were then appointed to act on the committee:—Messrs. Hastie, C. R. Haig, Clarke, Jackson, Tyrer, Leage, Collins, Copeman (Provision Exchange), Rawson, and J. J. Ball.

Mr. RAWSON said that comparisons were drawn between the services rendered in London and in provincial towns, but the position in the metropolis was different. Many of the difficulties which existed were not owing to any fault on the part of the Telephone Company. He felt, in fact, that they were not there in opposition to the Telephone Company, but really to appoint a committee which could see that the interests both of the subscribers to and the shareholders of the Telephone Company were protected as far as possible. He afterwards spoke of the importance of communicating with Paris by telephone, and proposed a resolution expressing the opinion of the meeting that the committee should do what they could to further the establishment of direct communication between subscribers' offices in London and Paris.

The resolution was seconded and agreed to.

A vote of thanks to the Chairman brought the meeting to a close.

## AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *April* 3, 1891.

**The Bell Telephone Company.**—The annual report of the Bell Telephone Company for the year ending December 31, 1890, shows that the total earnings of the Company for the year were $4,375,290. Of this amount, $2,913,368 were received from rental of telephones; from dividends, $1,256,274; from extra territorial and branch lines, $89,478; from telegraph commission, $26,491; from interest, $77,447; and from miscellaneous sources, $12,230. The total expenses of the Company were $1,505,872, divided as follows: operation, $311,437; legal, $123,359; interest and taxes, $257,174; commission, $575,221; royalty, $10,000; concession, $228,573; mis-

Digitized by Google

cellaneous, $105. The net earnings were therefore $2,869,418. The report shows that at Dec. 31, 1890, there were total miles of wire, 240,412; increase, 47,199; total circuits, 173,665; increase, 16,885; total employés, 7,845; increase, 1,087; total stations, 202,931; increase, 17,928; of which 2,746 are toll stations, not at fixed annual rates, not heretofore classed with subscribers' stations; total instruments in hand of licensees under rental December 20, 1890, 483,790—increase, 38,929. The estimated number of exchange connections daily in the United States is 1,438,294, or a total per year of over 450,000,000. The average daily number of extra territorial connections is 9,701, or a total per year of about 3,200,000. Extra territorial earnings for the year amounted to $1,116,975.18, of which the Bell Telephone Company's share is $92,261.17, an increase of $7,027.99 over 1889. A material increase in mileage of underground wire was made, equal to 27,573, which gain is more than the total mileage a year ago. Twenty-one places now have underground wires, against thirteen a year ago. The long-distance Company added 4,682 miles of wire to its total, and is earning a moderate rate on the investments above its expenses. The net earnings last year amounted to $120,665, which were invested in extension of the plant. The total capital stock of the Company is given as $32,740,580, and the dividends paid during the year on outstanding stock at 18 per cent. amounted to $2,213,913.

**Slow-Speed Gearless Motors.**—During the past week two of the large companies doing street railway business in this country have published descriptions of new motors, the principal feature of which is the entire absence of all gears, in both cases the armature being placed directly upon the car axle. One of these is the Short Electric Railway Company's motor (see *The Electrician*, April 10th, p. 708). The second motor is that of the Westinghouse Company. This motor is practically an ironclad one. The armature is of the drum type, and is built directly upon the car axle, the armature core being keyed directly to it. The armature is but 16in. in diameter, and the total depth of the motor being but 20in., a clearance of 5in. is obtained between the motor and the rail when car wheels of 30in. diameter are used. Provision is made in the gears of both motors for rapidly dismounting them from the car axle for necessary repairs. Sheet-iron cases are provided for protecting the motors from injury.

**Overhead Wire Raid in New York.**—The official axe has been at work in New York City during the past week removing electric light poles from the streets in certain sections of the metropolis. An order was issued early in the week by Major Grant directing the superintendent of the Bureau of Encumbrances to remove the poles and wires of the United States Electric Lighting Company, on Broadway, between two specified points; and the order also included the removal of housetop wires in a considerable section of the city. In accordance with this order a gang of men began chopping down poles and removing the wires, but upon the promise of the general manager of the Company owning most of the wires, that he would put a force of men at work and remove the obstructions himself at once, the city's force of men ceased work in that particular direction, but the removal of the housetop wires still goes on by the city's employés. The electric light companies are removing, as far as possible, the poles and wires that come under the mayor's order. No injunctions were obtained to prevent the city from removing the poles, and the mayor positively refuses to delay the matter any longer.

## CORRESPONDENCE.

### ANALYSIS OF LOSSES IN ARMATURE CORES.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I enclose a few notes on the practical use of my method, together with curves showing the experimental points. There is very little doubt that in practice the greater part of the curve is straight. This is no assumption, three or four points being *always* taken and not two only. There is, however, a slight tendency in the curve to turn up at very slow speeds, but this seems merely a question of lubrication.

It will be seen from the diagram plotted below that, at any rate for 90 per cent. of their length, the curves are for all practical purposes straight lines, any apparent curvature being accidental.

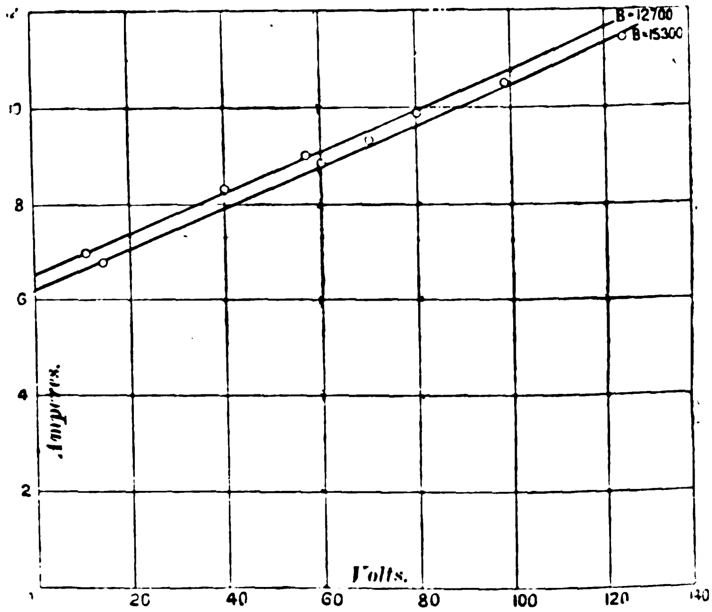
There are, however, some precautions to be taken. Voltmeters are often subject to considerable errors in the lower part of the scale, consequently it is better to use a low reading instrument for the lower readings, or else trust to the volts being proportional to the speed, and only measure the latter.

Variations of friction are often very troublesome, and should always be checked by repeating the readings in inverse order. Friction is generally lower after changing from a high speed to a slow one, and will take some minutes to settle, while the opposite occurs on changing from a slow speed to a high one. It is hardly necessary to add that the bearings should be run down into good condition before these experiments are made.

The brush-friction may easily be determined by raising the brushes in pairs and noting the fall of current.

When cells are not available for supplying the current, it is generally necessary to have a considerable resistance, or, better still, inductance, in the armature circuit, otherwise accurate current-readings are impossible.

When a second machine is available for driving the machine to be tested, friction may be entirely eliminated from the diagram by coupling the two shafts together, driving the one as a motor, and noting the change of current through its armature




when the field of the other is on and off, taking care that the speed is the same. The diagram obtained by plotting the volts and *change of current* in the motor will give the losses by Foucault currents and hysteresis in the other. The efficiency of the motor does not come in appreciably if it is not too small.

This method of analysis may also be applied for separating the losses in transformers, by measuring the waste power with a wattmeter at different frequencies, keeping the maximum induction in the iron constant. The diagram in this case would have Joules per cycle and cycles per second co-ordinated.
—Yours, &c., R. H. Housman.

### CONTROL MAGNETS FOR GALVANOMETERS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: With reference to Dr. Obach's letter on the above subject in your last issue (p. 680), I must crave your indulgence for a few words of explanation.

In working with a ballistic galvanometer recently supplied to me by Messrs. Nalder Brothers and Co., I certainly experienced the inconveniences mentioned in your article of March 20th (p. 610), as well as some others. These I overcame by devices which would occur to anyone engaged in testing, and with which, therefore, I need not trouble you.

Digitized by Google

But as my instrument was one of the earliest of this particular pattern sent out by the makers, they requested me to point out any small details in which it might be improved. After mentioning these inconveniences I therefore made two or three suggestions, and, amongst other things, pointed out that the usual position of the control magnet in *astatic* reflecting galvanometers is not the best that theory would indicate. The almost universal custom is to place the magnet in question *above* the suspended astatic magnetic system. Now, the magnets of the latter are usually some distance apart, and the controlling magnet is therefore nearer to the upper magnets of the system than it is to the lower. Thus the portion of the controlling field due to this magnet, especially if the magnet be low down, may be much greater at the upper needles than at the lower. But this is contrary to the principles on which astatic working is based, for, assuming the whole suspended system to be very nearly astatic, the two astaticising systems, upper and lower, should be placed in controlling fields of the same strength, and therefore the proper position for the controlling magnet is in the horizontal plane bisecting the distance between the suspended astaticised magnets. Thus, *if the magnet be kept horizontal*, the combined controlling field due to it and the earth at the positions of the upper and lower magnets will always be of the same strength. Moreover, by altering the orientation of this magnet in its horizontal plane, the position of the zero can be adjusted. For this purpose the magnet would require to be mounted differently to what it is in fig. 1, p. 610, but the necessary mounting, though more elaborate, is not difficult to devise.

The above argument does not so strictly apply to the particular astatic system in "Nalder's Ballistic Galvanometer," where the suspended magnets may be regarded as being in *three* different horizontal planes. But, even then, I think that the proper position for the controlling magnet is in the central plane of these three.

It may be interesting to note how my suggestion has been modified, and its object to some extent frustrated by the employment of the small and weak top magnet A (fig. 1, p. 610). But after reading the above I hope that Dr. Obach will acquit me of any intention of appropriating his well-known and ingenious device for altering the sensitiveness of tangent (or single needle) galvanometers. His object is "to adjust the constant of the galvanometer to a certain value;" mine is to more nearly fulfil the conditions of *astatic* working, and for this purpose the east and west position, so important for his object, is not absolutely necessary so long as the controlling magnet lies in the proper horizontal plane. For some time when working with astatic reflecting galvanometers I have used this position for the controlling magnet.

In conclusion, I may add that on reading the article under discussion my first impulse was to write to you and point out the modifications made in my suggestion, but on reflection it seemed to me that the point involved was too simple a one to occupy your valuable space with it. The same considerations have probably occurred to other users of astatic galvanometers, though I have never seen an instrument fitted with the control magnet in the position indicated. Dr. Obach's letter must be my apology for troubling you now.—Yours, &c.,

R. Mullineux Walmsley.

Heriot Watt College, Edinburgh, April 9, 1891.

## CAPACITY MEASUREMENTS ON LONG CABLES.

TO THE EDITOR OF THE ELECTRICIAN.

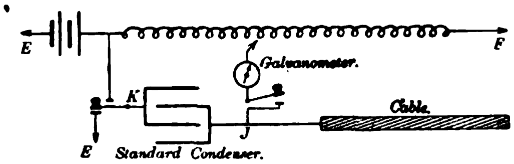
Sir: In their letter *The Electrician* of the 27th of March, Messrs. Ansell and Young refer to a Paper of mine on the above subject, published in your issue of March 6th.

They say they fail to see how the method of correction in question applies to a submarine cable in respect to leakage; with your permission I can, I believe, make this plain.

For purposes of reference I enclose a diagram.

The condenser and cable being arranged as shown in the above diagram, suppose the + pole of the battery to be applied to the armature, K, of the condenser, the potential of that armature will be raised from O to V say, and simultaneously or nearly so the potential of the junction, J, will be raised from O to $p$.

Were there no leakage or absorption, the junction would remain at potential $p$ during the whole of the period of the application of the battery, but owing to leakage the potential of the junction actually falls, during the time requisite for obtaining balance on the slides, from $p$ to $p^1$, $p^1$ being the observed slide reading when balance is obtained.




Now let the armature K be "earthed" and the discharge from the junction observed on the galvanometer.

Just as the junction was raised in potential by $p$ units when the armature K was raised from O to V by the battery, *so will it be reduced in potential by $p$ units*, when the armature is brought from V to O by earthing.

Hence, when the discharge is taken, the potential of the junction is $p^1 - p$ and the discharge is $(p^1 - p)$ $K^1$, where $K^1$ is the total capacity in circuit.

By the third operation described in my Paper, a slide reading is found, say $V^1$, so that $V^1 K^1 = -(p^1 - p) K^1$, which in this case is to be added to the observed slide reading $p^1$.

So that we have the corrected S.R. $= p^1 + p - p^1 = p$, and, as has been shown, $p$ is the required true instantaneous potential of the junction.

The following experiments were made on the 6th April on a length of Muirhead's "artificial line" or cable. The fall of potential when a leak of a Megohm was inserted was exceedingly rapid, and it was difficult to obtain the correct S.R. Each test was, however, repeated several times, to make quite certain that the true reading was obtained:—

| Time of charge in seconds. | Leak in megohms. | S.R. when balance is obtained. | Earthing period in seconds. | Discharge from junction in scale divisions. | Equivalent value of scale divs. in S.R.'s. | Corrected S.R. | Apparent capacity by observed S.R. | True and corrected capacity microfarads. |
|---|---|---|---|---|---|---|---|---|
| *Experiment I.—Standard Condenser = 20 microfarads versus one box artificial line = 60 knots cable.* | | | | | | | | |
| 10 | Infinity | 5133 | 2 | negligible | ... | ... | 18·96 | 18·96 |
| 10 | 1 | 3971 | 2 | 225 | +1162 | 5133 | 30·36 | 18·96 |
| *Experiment II.—20 mfds. v. 2 boxes, equivalent to 150 knots cable (approx.)* | | | | | | | | |
| 5 | Infinity | 2893 | 2 | negligible | ... | ... | 49·14 | 49·14 |
| 5 | 1 | 2680 | 2 | 168 | +207 | 2887 | 54·62 | 49·28 |
| *Experiment III.—20 mfds. v. 3 boxes, equivalent to 240 knots cable (approx.)* | | | | | | | | |
| 5 | Infinity | 2010 | 2 | negligible | ... | ... | 79·50 | 79·50 |
| 5 | 1 | 1900 | 2 | 232 | +108 | 2008 | 85·26 | 79·60 |
| 5 | 1 | 1900 corrected by Messrs. Ansell and Young's formula = 80·06 | | | | | | |

To the last example given I have applied the formula suggested by Messrs. Ansell and Young, and arrived at the value of 80·06 microfarads, which is 0·4 per cent. in excess of the correct value, and not nearly so close an approach to the true capacity as that given by the method of correction under consideration.

The above comparison was made with condensers, all of which had practically the same rate of absorption, and the correction as shown answers perfectly when leakage alone exists. When difference of absorption occurs as well as leakage, the correction as proved by the figures given in my Paper of March 6th is equally valuable.

Messrs. Ansell and Young's suggested correction simply corrects for leakage, and is inapplicable when absorption also exists, as is almost invariably the case when comparing the capacities of a paraffin condenser and a submarine cable.—Yours, &c.,

Arthur Dearlove.

4, Great Winchester-street, E.C., April 8, 1891.

Digitized by Google

## VISUAL SIGNALLING IN FOGGY WEATHER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your last issue you discuss the subject of visual signalling between lighthouse and shore in a fog.

In a light fog and to a short distance this was found possible by our Royal Navy twelve years ago. Ships a mile or so apart directed their projector beam vertically, and a few degrees from vertical made dots, down to about 40° made dashes. In looking upward you have generally very little to obscure partial vision.

I have often thought that in light fogs or misty weather any powerful beam of light would have a better chance of being noticed if flashed vertically over ship or lighthouse.—Yours, &c.,

G. BROWN, ex-Signal Master, Gibraltar.

40, Llanover-road, Woolwich, April 12, 1891.

## LEGAL INTELLIGENCE

### The Jablochkoff Patent.

The Judicial Committee of the Privy Council, represented on the occasion by Lord Hobhouse, Lord Shand, Lord Morris, Lord Watson, and Sir Richard Couch, had under consideration on Wednesday the petition of the Electrical Engineering Corporation (Limited) for the prolongation of the Jablochkoff patent.

Mr. MOULTON, Q.C., and Mr. ROGER WALLACE appeared for the promoters, while Mr. SUTTON represented the Government. Opposition to the petition was alluded to by the counsel for the promoters, but no official reference was made to the opposing parties.

Mr. MOULTON, Q.C., opening the case, wished to preface his remarks by a few words upon the nature of the patent. It was a patent for the division of the electric light by means of what are now known as "transformers." The date of the patent was 14 years ago (No. 1,996, of 1877), at the time that the electric light was in its very infancy. The problem then before the world was a problem that was admitted to be of the greatest possible practical importance, namely, to make the electric light useable in a subdivided form. Now, at that date in 1877, many persons believed that that was practically an insoluble problem. Their lordships would be aware that a solution of that problem had been found by the invention of the incandescent lamp, which did not at the time referred to exist. But the earliest inventor who produced a practical solution of this problem to any amount might, he thought, fairly be said to be the patentee then before the Court, Mr. Jablochkoff, who, early in 1877, invented the Jablochkoff candle. In working out the question with regard to the sub-division of the light, Mr. Jablochkoff had to face the problem of dividing the electricity. It was in investigating this problem that the patentee came on the invention which was the subject of the petition then before the Court. Of course, he would have to enter upon the novelty of the invention, and he would have no difficulty in establishing, first, the enormous practical importance of the invention; and secondly, that this idea of utilising induction for the purpose of secondary generation was a great surprise to the electrical engineers of the time. Having, as he believed established its importance, Mr. Moulton stated also that the patent had been unremunerative, though not by any fault. The chief difficulty in his way he had only learned within about 24 hours. There were originally opponents to the patent's prolongation, with regard to which he felt no difficulty. But late on Monday his clients received a letter from the solicitors of other opponents, stating that they were going to bring before their lordships proof of a certain prior publication, which anticipated the patent of his (Mr. Moulton's) client. On examining the statements of this alleged prior publication he found on examination a Paper was read at a meeting of the Society of Telegraph Engineers on May 9, 1877. Many licenses had been granted for Jablochkoff's patent, and the whole question was looked into very carefully in the litigation before the House of Lords. On referring to the *Journal* of the Telegraphic Engineers his client found, to his great astonishment, that the patent of Mr. Jablochkoff was dated May 22, 1877, while, by a strange accident, the cover of it was, and always had been, dated May 2, 1877. On examining the Paper referred to it was discovered for the first time that Mr. Jablochkoff's invention—as being his invention, without question of there being another inventor—was first communicated on May 9th to the Society of Engineers by some person unknown to Mr. Jablochkoff, and without his having had anything to do with it. The consequence was that, so far as the validity of the patent was concerned, and reasonable and prior publication, he was obliged to admit that this prior publication rendered his client's patent invalid, unless and until there could be a prolongation of the patent under their lordship's order. Their lordships would remember that under the law of 1877, on petition to their lordships, a confirmation might be obtained of a patent of which the patentee believed himself to be the first and true inventor, and who found it was not so. The Statute was 5 and 6 Vic., ch. 83, sec. 2, and applied to patents then existing on January 1, 1884. The Act said:—"If such a patentee on the other side shall discover that some other person had, unknown to such patentee, invented or used the same, or some part thereof, before the date of such patent, it shall and may be lawful for such patentee to petition Her Majesty in Council to confirm the patent, the matter of which petition shall be urged before the Judicial Committee of the Privy Council, and such Committee, on examining the said matter, and being satisfied that such patentee believed himself to be the first and original inventor, and being satisfied that such invention or part thereof had not been publicly or generally used before the date of the first patent, may report to Her Majesty that the purport of such prayer may be granted," &c. Mr. Moulton was obliged to admit that without confirmation the patent was invalid. He would, therefore, be obliged to ask their lordships the favour of being allowed to amend the petition, by adding thereto a prayer for confirmation, and if their lordships thought proper to prolong the petition without that, he would be able to present the petition for confirmation.

A considerable discussion was hereupon gone into relative to the technical notice which Mr. Jablochkoff should have given before the hearing of the petition.

Mr. MOULTON urged that the case should proceed, but

Lord SHAND said the Council could not proceed except in accordance with the statute.

Lord MORRIS thought the only practical way was that the petition should stand over till the technicalities had been complied with, and then a start should again be made *de novo*.

Lord SHAND said his attention had been called to the first of the rules laid down, viz., that the parties intending to apply by petition under Section 2 should give public notice by advertisement in the *London Gazette* three times, in three London papers, and three times in some country paper published in the town where the applicant carried on his manufacture. His lordship said the Committee could no more alter that rule than they could alter the statute.

After the Committee had conferred it was agreed to adjourn the case till Wednesday, May 20th, the necessary formalities of giving notice, &c, to be observed meantime.

Mr. MOULTON then explained to the Committee that Mr. Jablochkoff was in attendance prepared to give evidence, that he was anxious to go to Russia, and therefore he requested that the evidence might be given at once, or be allowed to be presented on affidavit.

The Committee pointed out that Mr. Jablochkoff's evidence without cross-examination would not be very valuable, and that if there was ultimately no opposition then Jablochkoff would have a quiet walk over.

### Savory and Moore v. The London Electric Supply Corporation (Limited).

The above action came before Mr. Justice Kekewich on Tuesday and Wednesday last in the Chancery Division of the High Court of Justice, the plaintiffs, who are the well-known chemists and druggists of Bond-street, being represented by Mr. C. M. Warmington, Q.C., M.P., and Mr. Vernon Smith: while the defendant Corporation had for their counsel Mr. Fletcher Moulton, Q.C., and Mr. Hamilton.

Mr. WARMINGTON, Q.C., in his opening remarks, explained that the action was one to restrain a nuisance, the nuisance in question being that of increased danger from fire caused by the proximity of the defendants' works to the plaintiffs' premises. The plaintiffs' property was in Bond-street, and the defendants were the owners of large buildings adjoining in Bloomfield-place and Grosvenor-mews.

His LORDSHIP: The nuisance is not noise or vibration then?

Mr. WARMINGTON: No. It is the increased danger from fire. This action was one which was almost on all fours with an action which his Lordship had tried some time ago, and where an injunction had been granted. The case he (Mr. Warmington) was referring to was that of McMurray *v.* Caldwell. There the plaintiff was the proprietor of a paper mill at Wandsworth, and he sought an injunction to restrain the defendant, who was the manufacturer of articles called amorces, or toy percussion caps, from so carrying on his business as to be a nuisance, and running the risk of causing explosions in consequence of the dangerous character of his trade. As he had said, the injunction was granted as asked, and in the Court of Appeal the defendant was only allowed to carry on his business on his undertaking to take extra special precautions against explosions, which might cause damage to the plaintiff's paper mill. Up to the autumn of 1890, the London Electric Supply Corporation had used the premises now in question as an electric light generating station, but at that time, in consequence of certain steps taken by Messrs. Savory and Moore, they ceased to do this, and removed their generating plant to a site at Deptford, where they erected very large works, and employed a large number of hands. Having generated their electricity at Deptford, they transmitted it to the Bond-street centre. Well, what the defendants had been doing was to send along their electricity from Deptford to Bond-street at a pressure of as much as 10,000 volts. This the plaintiffs considered highly dangerous, and, as a fact, they had a good reason for thinking so, because several accidents had happened on the premises, and there had been more than one fire of a serious description, one which occurred in November, 1890, almost gutting the defendants' works. Excuses would be made for this fire, and it would be contended that the man who was in charge of the machinery lost his head, and might have prevented the catastrophe. Be that as it might, however, the fire did occur, and the plaintiffs were anxious that there should be no repetition of the accident. With this view the present action was brought, and he (Mr. Warmington) thought the evidence he should call would prove that the defendants' works as they at present existed were a source of considerable danger to the plaintiffs' property.

Witnesses were then called whose evidence went to show that accidents had happened on the defendant Corporation's premises, and that fires had occurred which had only been put out with considerable difficulty.

On the suggestion of his Lordship, Mr. Moulton, Q.C., reserved the speech which he was entitled to deliver in opening the defendants' case, until after he had called his witnesses.

Mr. S. Ferranti, Dr. John Hopkinson, and other experts were then called, and they stated that now, at all events, there was no danger what-

Digitized by Google

ever of any fire arising from the distributing room used by the defendants. That room had been made thoroughly fireproof, and, as a fact, there was nothing whatever in it that could burn. The "converters" themselves could not possibly take fire, whatever happened.

The evidence having been concluded,

His LORDSHIP said he should direct that the action should stand over for three months, to give the defendants an opportunity of seeing whether they could take extra precautions to prevent any danger from fire arising from their works. He thought that something might be done to the floors above the basement, in which, he was informed, the converters were placed. He should adjourn the further hearing of the case in order that the defendants might take such steps as would render the upper stories of their building fireproof.

### The Attorney-General v. the Boy Messengers Company (Limited); the Attorney-General v. the District Messenger Service and News Company (Limited).

These cases, which were heard on Tuesday before Mr. Justice A. L. Smith and Mr. Justice Grantham, raised the question, on informations by the Attorney-General on behalf of the Crown, whether the business of these Companies was carried on in contravention of the exclusive rights of the Postmaster-General under the Post Office Acts. The information alleged that the Boy Messengers (Limited) was a joint-stock company, the objects of which, as registered, are to carry on the business of messengers and carriers in the metropolis and other places in the United Kingdom. Further, the information charged that in July, 1890, the Company instituted a system of telegraphs. The solicitor to the Post Office had written to the Company that their delivery of letters was a contravention of the exclusive privileges of the Postmaster-General, and a correspondence ensued. It was then stated that the Company had had interviews with the solicitor to the Postmaster-General with respect to an intention on the part of the Company to introduce, as a new feature in their business, a system of electric calls, and in July last the Postmaster-General offered to grant a licence to the Company to work the system of calls provided that a stringent clause was inserted in the licence to the effect that the Company should not undertake the delivery of letters. But the Company refused to accept any licence containing such a clause. In March last the solicitor to the Postmaster-General wrote to the Company that he could not entertain their proposals; that if not assured that they would abstain from violating the law he was instructed to commence proceedings against them, and this information was accordingly filed. The Attorney-General waived penalties but asked that "it may be declared that any message or communication, written or printed, sent by one person addressed or directed to another, for the purpose of being sent and delivered by post or other means, is a letter within the meaning of the Post Office Acts, and that the receiving of letters to be so sent is the collecting of letters within those Acts and an infringement of the exclusive rights of the Postmaster-General;" and he prayed that the Company should be restrained from continuing these acts, and that an account be taken of all moneys received by them for so sending letters, &c.

Mr. Finlay, Q.C., and Mr. Ernest Pollock appeared for the Boy Messengers Company: and Mr. Bremner appeared for the District Messengers Company.

When the case first came on it was by consent postponed, as the parties were negotiating, and it was more than once so postponed. It came on again on Tuesday morning, but was once more put off until later in the day, when

The SOLICITOR-GENERAL stated that terms had been arrived at which, in the judgment of the Postmaster-General, gave sufficient security for the public interest, and at the same time also secured the proper maintenance of the exclusive right of the Postmaster-General, and, though an injunction was to be agreed to against any breach of that exclusive right, he hoped there would be no occasion to apply to the Court to enforce it. The terms agreed upon were not stated, but from what followed it may be inferred that the Companies are to take out licences from the Postmaster-General.

Mr. BREMNER, who appeared for the District Messengers Company, said that under the arrangement which had been entered into, the Company would be able to carry on their business as widely as they had hitherto done with the consent of the Postmaster-General.

Mr. E. POLLOCK, who appeared for the Boy Messengers Company, desired to say as much on their behalf. They had, he said, licences from the Postmaster-General under the Telegraph Acts, which would enable them to extend their telegraph business, as well as licences to carry on their previous business.

Accordingly a decree for an injunction will be entered against any infringement of the exclusive rights of the Postmaster-General (whatever they may be), and the business of the Companies will be carried on under licences from the Postmaster-General.

### B. Verity and Sons v. Terry.

This was an action, heard before Mr. Justice Charles on Monday last, to recover £593. 0s. 6d., for work done by the plaintiffs as electric lighting engineers. Mr. J. F. Moulton, Q.C., and Mr. S. O. Buckmaster appeared for the plaintiffs; and Mr. Cyril Dodd, Q.C., and Mr. T. J. Bullen for the defendant.

The plaintiffs' claim was for the installation of the electric light in the theatre, and various other sums for goods supplied in connection with the work. The defendant pleaded that the plaintiffs had agreed to improve and repair the existing electric lighting at his theatre, and supply the whole of the materials for the sum of £125, and to supply 15 additional lights in the defendant's offices, and an electrolier in the saloon bar of the theatre for the sum of £22. 15s. The defendent alleged, further, that any work done or goods supplied other than the 15 additional lights and the electrolier was done or were supplied without his authority or knowledge, and paid £27. 15s. into court (having already paid plaintiffs the sum of £120) as sufficient to answer the plaintiffs' claim.

Mr. G. H. VERITY, one of the plaintiff firm, in his evidence, said all the orders came from Mr. Bricknell, the defendant's agent. He went over the place and pointed out where all lights were to be put. They worked night and day to have the installation ready before a piece called *New Lamps for Old* was produced. Nothing had been done without orders from Mr. Bricknell.

Mr. CUNNINGTON, Mr. Verity's engineer, corroborated this evidence.

Mr. EDWARD O'CONNOR TERRY stated that he was the proprietor of Terry's Theatre. He let his theatre at the time in question to somebody on behalf of Miss Graham (who was bringing out "New Lamps for Old"). He left London for India in January, 1890. Up to this time he had spent some hundreds of pounds in electric lighting at his theatre with satisfactory results. When he let the theatre he communicated with the plaintiffs about improving the electric lighting. The plaintiffs' estimate or report was brought to him before he left England, and he accepted it. He never gave Mr. Bricknell any authority to vary this estimate in any way.

At this stage of the case, by suggestion of the learned Judge, the counsel engaged conferred with him in his private room, and his Lordship, on their return, intimated that he was pleased to say that the parties had come to an arrangement, whereby the defendant was to pay to the plaintiffs £375 (including the amount paid into court and paid to plaintiffs already).

The learned JUDGE said he thought the plaintiffs were not to blame in any way for what had occurred; but as the work had been done while Mr. Terry was absent his surprise at the amount of the bill was natural. The work had been well done and the prices were fair, and under all the circumstances the learned Judge thought the defendant ought to pay the costs of the action.

Judgment accordingly.

## TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

"THE ELECTRICIAN"

**ELECTRICAL TRADES' DIRECTORY & HANDBOOK for 1891.**

The new edition of our well-known Directory and Handbook is now ready, price 5s., postage extra. The book consists of over 900 pages, and has entailed this year a heavy amount of work. The HANDBOOK DIVISION contains a mass of most useful information. The DIRECTORY DIVISION consists of 430 pages, and contains a very carefully compiled Alphabetical and Classified List of Firms and Persons engaged in the Electrical and Allied Trades in all parts of the world. This Division has been corrected up to date, and the book is thoroughly reliable, the very numerous changes which take place at the beginning of the year being incorporated. By the aid of this Directory, makers of Electrical Machinery, Apparatus, Instruments, Fittings, Sundries, Novelties, and other goods, may safely communicate direct with probable customers without the annoyance and great expense consequent upon using books which are mere lists of Members of Scientific Societies repeated again and again. The Colonial and Foreign Division of this Directory will be found extensive and reliable. *Orders should be forwarded at once.*

ACCEPTED TENDER.—Mr. G. Jennings, the well-known sanitary engineer of Lambeth, has secured the contract for providing and fixing patent electro-mechanical apparatus for indicating and recording in pumping station the level of water in reservoir, for the Sutton-in-Ashfield Local Board.

MESSRS. MERRYWEATHER AND SONS.—This firm send us their illustrated price list, and particulars of their improved patent sphincter grip armoured india-rubber hose, and notify that they have materially improved both the materials employed and the process of manufacturing same. Messrs. Merryweather and Sons refer with pardonable pride to the numerous awards which have been received for this hose, and caution purchasers against buying inferior makes. Amongst the list of users will be found quite a number of electrical and engineering firms. The list also includes prices and particulars of several other manufactures of the firm.

MESSRS. WOODHOUSE AND RAWSON UNITED (LIMITED).—We are informed that this Company have now opened their show-rooms at 34, Cannon-street, facing the Mansion House Station, and invite inspection. The Company intend exhibiting in these rooms samples of all the appliances and fittings in connection with electric lighting, telephone, bell, and other electrical installations, and will keep a stock ready for immediate delivery. Apart from the Company's own manufactures, a great number of appliances of other makers will be kept, including Silvertown, Henley, and okonite wires, and cables. Messrs. Woodhouse and Rawson United (Limited) also announce that in view of the large number of orders

Digitized by Google

in hand for steam and electric launches, tugs, &c., they have resolved to extend their riverside premises, and have purchased a piece of ground, situated close to Kew Railway Bridge, on the Surrey side, with a frontage to the river of between 600ft. and 700ft., where the Company will also have good dock accommodation. The new works will be nearly opposite the two existing yards of the Company, and will, it is expected, be in working order in the course of the next two months.

MESSRS. CATHCART AND PETO.—Messrs. Cathcart and Peto notify us that they have taken into partnership Mr. F. W. A. Radford, and the firm will in future be known under the title of Cathcart, Peto, and Radford. The premises occupied by the firm at 57B, Hatton-garden, E.C., will shortly be greatly enlarged to admit increased business.

MESSRS. CUTTRISS AND CO.—We are able to announce that the business of Messrs. Cuttriss and Co., electrical engineers and manufacturing electricians, of Elmwood Electrical Works, Camp-road, Leeds, is about to be transferred to a limited company, which will be registered in a few days.

BOULT'S COMPREHENSIVE WIRING TABLE.—We have received from Mr. Boult some copies of figures calculated from Mr. Kennelly's well-known formula, showing the current allowable in insulated wires laid in wood casings. The sheet is issued as a supplement to the book, and is accompanied by a number of very flattering testimonials. Purchasers of Mr. Boult's book from *The Electrician* Company can obtain a copy of these calculations post free on application to the Publisher.

ELECTRIC LIGHT INSTALLATION AT DUNSTON FLOUR MILL.—The Co-operative Wholesale Society's flour mill at Dunston-on-Tyne has just been lighted throughout by Messrs. Ernest Scott and Mountain, The Close Works, Newcastle-on-Tyne. This installation is the largest in a flour mill in the United Kingdom, and consists of about 600 16-c.p. incandescent lamps. A very complete system of electric bells has also been fitted by the same firm.

# PATENT RECORD.

## APPLICATIONS FOR PATENTS.

**NOTE.**—***The undermentioned applications are not open to pub inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.***

March 16, 1891.

4,643. P. H. WILLIAMS. Egham. Improvements in and connected with chains, cables, and couplings for electrical mains and other purposes, or for insulating, protecting, carrying or conveying electrical mains and other elements, and in preliminary preparation or insulation of such mains for being so carried, conveyed, and protected.

4,669. V. HIRBEC. London. Apparatus on the principle of utilising heat as a source of electricity.

4,678. J. PILKIN. London. Improvements in terminals for electrical purposes.

4,682. S. Z. DE FERRANTI. London. Improved means for securing safety in electrical supply systems.

4,684. W. MAYES. London. Improvements in instruments for measuring and adjusting magnetic force.

4,689. C. E. CHALLIS. London. Electric switches.

March 17, 1891.

4,715. N. S. AMSTUTZ. London. Improvements in a process of and apparatus for electrically reproducing uneven, irregular, or undulating surfaces.

4,840. G. F. ATTREE. London. Improvements in and connected with electric signalling for railways.

4,751. O. IMRAY. London. Improvements in electrical transportation systems (S. S. Wheeler, and C. S. Bradley, United States).

4,757. T. L. WILLSON. London. Improvements in the electric reduction of aluminium and other metals, and in the production of alloys thereof.

4,758. A. M. CLARK. London. Improvements in electric railways (the Waddell-Entz Electric Company, United States).

4,767. P. M. TURQUAND. London. New or improved wall fittings or plugs for portable electric lamps, also applicable to suspended electric lamps and other electric apparatus.

4,781. W. J. ENGLEDUE. London. A new or improved solution or electrolytic fluid for galvanic batteries.

4,792. E. J. SILKMAN. London. Electric type-writers.

4,794. J. E. KINGSBURY. London. Improvements in signalling and telephonic systems (the Western Electric Company, United States).

March 18, 1891.

4,812. H. A. MILLER. Forest Hill. Improvements in the construction of incandescent lamps.

4,831. W. McGEOCH, Jun., and A. J. McGEOCH. Glasgow. Improvements in holders for incandescent lamps.

4,838. M. BAILEY and J. WARNER. London. Improvements in incandescent electric lamps.

## SPECIFICATIONS PUBLISHED.

1890.

3,900. PYKE AND BARNETT. Electrical inductoria. (Price 6d.)

5,409. CAPPILLERI AND OTHERS. Electric arc lamps. (Price 8d.)

5,562. EMMOTT AND RIDER. Dynamo-electric machines. (Price 8d.)

6,802. WALLER AND MANVILLE. Electrical traction. (Price 1s. 1d.)

6,223. ANCIZAR (Zerda-Bayon). Galvanic batteries. (Price 6d.)

6,623. WARDEN AND SMITH. Electric switches. (Price 6d.)

6,924. EAGER AND MILBURN. Electric batteries. (Price 4d.)

7,422. BRYAN. Electric circuit regulator. (Price 6d.)

7,520. JOHNSON AND PHILLIPS. Signalling on electric circuits. (Price 4d.

7,624. KINGDON. Electrical transformers. (Price 8d.)

7,725. CHALLIS AND GRAHAM. Electric switches. (Price 6d.)

14,844. APPLETON AND JOSEPH. Electrical connector. (Price 8d.)

19,272A. CARPENTER. Electric soldering irons. (Price 8d.)

1891.

657. LAKE (Lord). Electric conductors. (Price 6d.)

2,297. HAZELTINE. Electric arc lamps. (Price 8d.)

# COMPANIES' MEETINGS & REPORTS.

## Oriental Telephone Company (Limited).

The eleventh ordinary annual general meeting of this Company was held on Wednesday at the City Terminus Hotel, Cannon-street, under the presidency of Mr. William Addison.

The SECRETARY (Mr. Alex. B. Chalmers) having read the notice calling the meeting, the report of the Directors was taken as read.

The CHAIRMAN then said:—In moving the adoption of the report and balance-sheet, it is again my pleasure to announce a continued progress in the business of the Company. It is true such progress is not so rapid as could be wished, owing to the difficulties we have to contend with in extending our operations. This is especially the case in India, the telegraph department of the Indian Government being most unwilling to allow the facilities which are necessary to the success of our subsidiary companies in that country. However, notwithstanding the restrictions against which those companies have to contend, I am glad that we are able to report an increase in their dividends this year, amounting to ½ per cent. on the Bengal Company's shares, and to 1 per cent. on the Bombay shares. This result is attributable in some measure to economy in management. Our exchanges in Singapore and Rangoon also show an improvement in their revenues, as, in a smaller degree, do those also at Colombo, Madras, and Mauritius. The Directors of the Telephone Company of Egypt, after paying the interest on their Debentures, amounting to £345, have declared a dividend of 6 per cent. The amount of the dividend has been brought into our balance-sheet, which you have in your hands. It is with great regret I have to announce to you the loss we have sustained since the issue of the report, by the death of our colleague, the Right Hon. G. Cavendish Bentinck, who has sat with us on your Board for five or six years. To comply with the Articles of Association, Mr. Lloyd retires in the place of Mr Bentinck, and offers himself for re-election. You will no doubt expect me to refer to the alteration in the mode of distributing the dividend. As you are aware, we have been in negotiation with a large holder of vendors' shares, with the view of some arrangement being come to for placing all the Capital on a common footing. In the course of this negotiation, an actuary, who was called in to advise upon the relative positions of the shareholders, raised an important question as to the mode in which the profits were divisible—whether or not, in fact, the deficiency of dividend due to the holders of ordinary shares for the first five years should be made up by application of the entire subsequent profits, or solely by means of the dividends upon the vendors' shares. Counsel's opinion was taken upon the point. I think it undesirable to state the nature of the opinions obtained further than to say that after due consideration of them the Directors have decided to prepare the accounts in the form in which they are now laid before you, and under which, as you will see, it is proposed that the deficiency referred to should be made up solely by the application of the dividends upon the vendors' shares. Since the issue of the report, proceedings have been taken by a holder of vendors' shares which our solicitor will explain to you.

The SOLICITOR (Mr. Joseph Addison): Before the report is considered you may like to know exactly what has been the object of the alteration in the mode of declaring the dividend. Until this question was raised, and until, as happened last year, some new ordinary shares—although only a small amount—were issued which were not entitled to the benefit of the vendors' guarantee, the question did not become of importance; but when, with the view of putting the capital of the Company on a satisfactory basis to all parties, an opinion was obtained that possibly it was only the dividend upon the vendors' shares which should go to make up this deficiency, then that fact, coupled with the issue of these new shares, has made it absolutely necessary, in the judgment of the Directors, that they should declare a dividend upon all the shares, and that they should intimate plainly the opinion which they had obtained, that it was only the dividends on the vendors' shares that should go to make up the

Digitized by Google

deficiency in the first five years to the ordinary shareholders. You quite see that if that contention is upheld it will make a very large difference in favour of the holders of the ordinary shares as against the holders of the vendors' shares, because that deficiency, which is of considerable amount, would in that view have to be made up solely out of the dividend declared upon the Vendors' shares, instead of by the adding together of the dividends on the ordinary shares with the dividends on the vendors' shares, Then, with respect to these legal proceedings, naturally the view which is taken is not one that is very agreeable to the holders of the vendors' shares, and a gentleman who is a very large holder of vendors' shares has thought fit to challenge this construction which the Board have put on the agreement, and he is now taking proceedings in one of the Courts which will come on on Friday, not with the view of stopping the payment of the dividends, but with the view, if he can, of getting the Court to decide at once which is the right construction—that is, whether the holders of the ordinary shares are to bring into account in making up the deficiency of dividends on their own shares as well as on the vendors' shares. Nothing will be done which will stop the payment of the dividend. The notices will be sent out in the ordinary way, and it will be seen whether the Court on Friday morning will give directions that the sending them out be without prejudice to the question raised by the vendors, which is a very important one. The Directors will not express any opinion on this question, although they have adopted this course. They feel that they represent the whole of the Company. The question will be duly and properly considered, and the rights of the holders of the vendors' and the ordinary shares will be fully protected.

The CHAIRMAN: I now beg to move the adoption of the report, and if any gentleman has any questions to ask before it is put to the meeting I shall be happy to answer them.

Mr. W. S. CUFF asked if there was any reason why the Directors should not tell the meeting the amount of the deficiency referred to which had to be made up. He was still not clear about the question between the holders of the ordinary and the vendors' shares. It seemed to him that by what was proposed the Directors gave the dividend to the vendors' shares, but took it back with the same hand. He did not, however, see how the position of the vendors was altered.

The SOLICITOR: I do not know that there is any objection to say that the deficiency existing at February 4, 1886, at which the five years came to an end, was £20,000. I think I had better refer shortly to the clause in the agreement. The agreement, which the vendors signed stated that "during the five years from February 4, 1881, the holders of the vendors' shares would not participate in the profits of these years until the ordinary shares received 6 per cent. in each year," which they did not do. Then the agreement went on to say, "and if in any such five years the dividend at the rate of 6 per cent. per annum upon the amount paid up, or credited as paid up, on the ordinary shares shall not be paid to the holders, the deficiency shall be made up to the holders of the ordinary shares out of the profits of the Oriental Company applicable to the payment of dividends in future years in priority to the rights of the holders of vendors' shares to participate." You see the question raised there is whether the holders of the ordinary shares are entitled to receive their share of the profits of subsequent years without counting these profits towards the £20,000.

Mr. CUFF stated that the matter was perfectly clear now.

Mr. W. M. HIBBERT thought a whole year was a long time to elapse before the shareholders heard anything with regard to the progress of the Company. Their shares, therefore, remained neglected by investors. They now paid 3½ per cent. on the shares, but when they considered that the shares were quoted at 7s. or 7s. 6d. each, this dividend really represented about 5½ per cent. Including, however, the amount written off in reduction of capital expenditure, the sum added to reserve fund and carried forward, they were earning a dividend of 10 per cent. on the present price of the shares.

Mr. CHESTON stated that he had no idea of embarrassing their proceedings that day, but as a holder of vendors' shares he could not allow the dividends to be declared in the way proposed by the Board without a protest.

The CHAIRMAN then proposed the resolution as follows:—

"*That the Directors' report, together with the balance-sheet to December* 31, 1890, *be approved and adopted, and that a dividend at the rate of* 2½ *per cent., free of income tax, for the year ended December* 31, 1890, *be declared on the paid-up capital of the Company.*"

Mr. B. ST. JOHN ACKERS seconded the resolution, which was carried unanimously.

On the motion of the Chairman, seconded by Mr. Henry Grewing, Mr. Ackers was re-elected a Director, as was also Mr. Thomas Lloyd, on the motion of the Chairman, seconded by Mr. G. B. Frost.

Mr. HICKS then proposed and Mr. Cuff seconded the following resolution, which was carried unanimously:—

"*That Messrs. Deloitte, Devers, Griffiths, and Co. be re-elected Auditors of the Company for the current year, and that their remuneration as such Auditors be the sum of fifty guineas.*"

The CHAIRMAN then said: I have now to bring before you the question of altering the Memorandum of Association of the Company, which, under a recent Act, can now be done at a moderate expense, provided such enlargement has some relation to the kind of business at present carried on. Your Directors propose taking advantage of these facilities to enable them to supply such electric apparatus or force as they may have application for.

They have no intention of departing from the business which they now carry on, but they have been asked to supply electric lighting apparatus, &c., from their different agencies, which they have been obliged to decline owing to the Company's Memorandum of Association not including such business.

Of course it will be for you gentlemen to sanction or decline such enlargement of the objects of the Company, but your Board considers it to the advantage of the Company that they should be able to execute orders for electrical apparatus other than telephones that might be offered to its agencies abroad.

Mr. FROST, in seconding the motion, stated that from time to time they received applications from the agents of the Company abroad for the supply of electrical apparatus—not that the Company was required to work it, but that they should supply it; and he thought it was quite necessary that they should take the powers in question, even if they did not use them.

The SOLICITOR then explained the nature of the alteration, after which

The CHAIRMAN proposed the following resolution:—

"*That the Company's Memorandum of Association be altered as follows: —By adding at the end of paragraph (b) of clause 3 the words 'or generation, employment or utilisation of electricity or magnetism.' By inserting after the said paragraph (b) the following additional paragraph (b 1.)— 'To carry on any business or manufacture relating to the generation, employment or utilisation of electricity or magnetism or the apparatus connected therewith.'*"

Mr. GREWING seconded the motion.

Mr. HIBBERT inquired whether any more capital would be needed in connection with what was now proposed, as they were really opening out a new business entirely.

The CHAIRMAN: We have no idea of raising any fresh capital.

Mr. HIBBERT: There is no necessity for it.

The CHAIRMAN: Not at all.

The SOLICITOR stated that the alteration proposed by the resolution would enable the Directors to do what they could not do now. Some time ago the question was raised whether the Company could take shares in companies abroad if the objects of those companies included objects beyond those contained in the Memorandum of Association of the Oriental Company. It was, therefore, very important, when the Company might be desirous of supporting the formation of companies abroad, that they should have the power of doing so, even though the Memorandum in the case of those companies might be wider than that of their own Company. In reply to a question, the Solicitor added that the alteration would not necessitate the re-registration of the Company.

The CHAIRMAN then put the motion, which was carried unanimously.

The SOLICITOR then stated that it would be necessary for the resolution to be confirmed at a subsequent meeting, of which due notice would be given.

A vote of thanks to the Chairman and the Directors was then proposed, seconded, and carried unanimously.

The CHAIRMAN briefly acknowledged the compliment, and the proceedings then terminated.

## South of England Telephone Company (Limited).

An extraordinary general meeting of this Company was held at Winchester House, Old Broad-street, on the 13th inst., Mr. D. O. Bateson in the chair, when the resolutions passed at the meeting on the 16th ult., as reported in *The Electrician* of the 20th ult., were confirmed. They were for approving an agreement expressed to be made between the Company and the National Telephone Company for amalgamating the two companies by transferring the business of the former to the latter Company.

The CHAIRMAN afterwards proposed and Mr. J. F. BROWN seconded a resolution (which was unanimously agreed to) fixing the remuneration of the Directors for the past year at £200.

On the motion of the CHAIRMAN, seconded by Mr. BILLETT, the following resolution was afterwards passed unanimously:—

"*That the purchase consideration to be received by the Liquidator under the above agreement be distributed among the members as follows;*—

"(a) *As to the cash portion of such consideration, (1) in repayment of* £2,992, *the amount of money paid in advance of calls on the Preference Shares, (2) of interest on the same sum at the rate of* 5 *per cent. per annum, from November* 1, 1890, *to the time of such repayment, and (3) the balance in payment of a sum equal to* 6 *per cent. per annum on the amount paid up on the Preference Shares from November* 1, 1890, *to the date when the Debenture Stock hereinafter mentioned commences to carry interest.*

"(b) *As to* £70,000 *Four and a-Half per Cent. Debenture Stock of the National Company by distributing the same among the holders of the Preference Shares, according to the amounts paid up on such shares otherwise than in advance of calls.*

"(c) *As to the* 12,000 *fully paid Ordinary Shares of the National Company, by distributing the same among the holders of the Ordinary Shares of this Company, according to the number of shares held by them respectively.*"

## The Eastern Extension, Australasia, and China Telegraph Company.

The following is the report of the Directors for the half-year ended 31st December last, to be submitted to the thirty-fifth ordinary general meeting of the Company, to be held at Winchester House, E.C., on Wednesday, the 22nd inst., at 2 o'clock:—

The gross receipts, including Government subsidies, have amounted during that period to £279,095. 1s. 0d., against £264,103. 12s. 11d. for the corresponding half-year of 1889. The working and other expenses, including £23,118. 6s. 6d. for cost of repairs to cables and expenses of ships, absorb £74,090. 3s. 2d. against £73,498. 19s. 3d for the corresponding

Digitized by Google

period of 1889, leaving a balance of £205,004. 17s. 10d. From this is deducted £2 915. 9s. 1d. for Income Tax, and £35,281. 9s. 10d. for interest on debentures, debenture stock, and contribution to sinking fund, leaving as the net profit for the half-year £166,807. 18s. 11d. Against this £1,120. 19s. 6d. has been charged for cost of new land line at Banjoewangie, and additions to staff quarters, and £100,000 on account of the cost of duplicating the Madras-Penang Cable, which is referred to below, leaving a balance of £65,686. 19s. 5d., which with £71,820. 7s. 5d. brought forward, shows an available balance of £137,507. 6s. 10d.

One quarterly interim dividend of 1¼ per cent. has been paid for the half-year, and it is now proposed to distribute another of like amount, making, with the interim dividends paid for the first half-year, a total dividend of 5 per cent. It is also proposed to pay a bonus of 4s. per share or 2 per cent., making a total distribution of 7 per cent. for the year 1890. The balance of £25,007. 6s. 10d. has been carried to the general reserve fund, which, after being credited with interest and profit on sale of investments, and debited with £10,722. 13s. 1d. on account of the cable renewals, &c., now stands at £495,239. 6s. 7d.

Your Directors have the satisfaction to report that, notwithstanding the financial depression existing at the time, the recent conversion of the Company's 6 per cent. debentures into 4 per cent. mortgage debenture stock, was attended with marked success, the whole of the issue having been subscribed by the shareholders at par. By this operation a saving in revenue of £6,400 per annum has been effected. Since the close of the year, nearly the whole of the 6 per cent. debentures have been paid off.

In accordance with the provisions of the trust deed, dated May 15, 1879, 320 of the Company's 5 per cent. Australian Government subsidy debentures were drawn by lot on the 7th inst. for payment at par on the 1st July next.

The negotiations with the Governments of Australasia, referred to in the last report, have resulted in an agreement being concluded between the Company and the Governments of New South Wales, Victoria, South Australia, Tasmania and Western Australia, for reduction of the tariffs to those Colonies from the 1st May proximo, as follows :—

| | | | |
|---|---|---|---|
| From 9s. 4d. | to 4s. 0d. | per word for | public telegrams. |
| „ 7s. 1d. | „ 3s. 6d. | „ | Government telegrams. |
| „ 2s. 8d. | „ 1s. 10d. | „ | press telegrams, |

for a tentative period of one year, to be extended if found to work satisfactorily. The contracting Colonies guarantee the Company against one-half the risk of any loss should the receipts at the reduced rates fall short of the present earnings from the Australasian traffic, and the Company takes the other half. It was hoped that Queensland and New Zealand would have agreed to take part in the experiment, but after considerable negotiations between the various Governments, those Colonies declined to join in the guarantee ; consequently the tariffs to Queensland and New Zealand will remain unchanged.

The Contract with the Telegraph Construction and Maintenance Company for the manufacture and laying of the Madras-Penang duplicate cable has been satisfactorily carried out, and the service is now in a thoroughly efficient condition to meet any requirements that may arise in connection with the reduced rates to Australia

The Company's maintenance ships have, as usual, been employed on various repairs, but with the exception of the interruption of the Saigon-Tonquin cable from the 20th to the 27th October, and of the cables between Java and Australia referred to in the last report, there have been no interruptions materially affecting the Company's revenue during the half-year under review.

In accordance with the Articles of Association the Right Honorable Viscount Monck and George Garden Nicol, Esq., retire by rotation, and being eligible, offer themselves for re-election. The retiring auditors, Mr. Henry Dever and Messrs. Welton, Jones and Co., also offer themselves for re-election.

## The Indo-European Telegraph Company (Limited).

The following is the Directors' report for the year 1890 :—

The Directors have to regret the death of one of the foreign members of the Board, Mr. A. Delbrück, Banker, of Berlin.

The Company's revenue from all sources for 1890 amounted to £113,807. 3s. 11d., as compared with £108,288. 15s. 5d. for 1889, showing an increase of £5,518. 8s. 6d. The expenses were: on commercial and general account, £29,728. 18s. 1d. ; on maintenance account, £28,173. 1s. 6d. ; total, £57,901. 19s. 7d., as against £59,240. 6s. 9d. for 1889, a decrease of £1,338. 7s. 2d. Deducting the above expenses, taking credit for £2,035. 10s. 3d. brought over from 1889, and debiting income tax, there remains the sum of £56,668. 16s. 7d. From this amount, £10,000 has been placed to reserve ; and that sum, together with £10,625, amount of interim dividend, have to be deducted, leaving a balance of £36,043. 16s. 7d.

The Directors now propose the declaration of a dividend for the six months ending December 31st, of 17s. 6d. per share, making, with the dividend already paid, 6 per cent. for the year and a bonus of 20s. per share, both free of income tax, making in all 10 per cent., carrying forward £4,168. 16. 7d. to the credit of 1891.

As the shareholders are aware, the Telegraph Conference was held last year in Paris ; nothing occurred to materially affect the interests of this Company. The Directors in association with some of the Australian Colonies and the Eastern Extension Telegraph Company, as well as the Indian Government and the Eastern Telegraph Company, subject to the consent of certain Governments interested, have arranged as an experiment to introduce a 4s. per word rate, for messages exchanged with the Australian Colonies. This is made practicable owing to the guarantee of the Colonies to bear half of the loss sustained by the application of the reduced rates. Queensland and New Zealand, which have declined to join in the above guarantee, will not participate in the benefit of the reduction. Should the trial thus proposed to be given to very low rates prove a failure, the tariffs will be again raised. Duplex apparatus have been applied, and are working very satisfactorily, upon both of the Company's land and cable wires, between London and Germany.

It will be observed that notice is given of a special resolution which the Board consider advisable in the interests of the Company.

The following Directors retire by rotation, and offer themselves for re-election :—J. Herbert Tritton, Esq., and Major-General Tremenheere, R.E. The transfer books will be closed from the 14th to the 28th instants, both inclusive. The auditors, Messrs. C. F. Kemp, Ford and Co., public accountants, retire, and offer themselves for re-election.

## New York Belting and Packing Company (Limited).

The adjourned statutory general meeting of this Company was held on Tuesday, at the offices, 98 and 100, Queen Victoria-street, under the presidency of Mr. H. B. Henyon.

The SECRETARY (Mr. J. C. Wylde) having read the minutes of the meeting held on the 7th inst.,

The CHAIRMAN said : Our first duty is to put before you, "That the adjournment from the Cannon-street Hotel to this office be acknowledged."

Mr. J. H. TOD said : I saw Mr. Stevens on Saturday. He had just come back from America, and unfortunately, through a domestic bereavement happening since his departure from this country, and through business in Liverpool, he had to go off at once. We have, therefore, no written statement, but only his verbal statement to Mr. Pope, which was very satisfactory. Mr. Stevens is perfectly satisfied as to the nature and extent of the business. One question I put to him was to be perfectly certain when in America that the valuation of the machinery, which is always a ticklish matter, was absolutely cor-

PATENT

SILICIUM BRONZE AND SILICIUM COPPER WIRE.

The best for overhead Telephone and Telegraph Lines,

AND ALL ELECTRICAL PURPOSES.

Hard Drawn High Conductivity Copper Wire.

ROLLED AND DRAWN PHOSPHOR BRONZE.

PHOSPHOR BRONZE VULCAN PHOSPHOR DURO METAL

PHOSPHOR BRONZE BEARINGS, BUSHES, AND OTHER PARTS OF ELECTRICAL MACHINERY

*SOLE PROPRIETORS of the British, Indian and Colonial Patents,*

THE PHOSPHOR BRONZE COMPANY (Limited),

*87, Sumner Street, Southwark, London, S.E.*

WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

Digitized by Google

rect. He is fully satisfied himself that it is under-estimated. Some changes have been made there, and I think Mr. Pope told you of that last week. Mr. Belmont has joined the Board. The business is going on thoroughly well, and Mr. Stevens is satisfied that we shall be able to increase it very materially within the next year or two. There will be a meeting somewhat later on, on account of some verbal alterations being required in the Articles of Association for Stock Exchange purposes.

After a few remarks from shareholders present, the meeting, which was purely formal, terminated.

## NEW COMPANIES REGISTERED.

**BRITISH HYDRAULIC FOUNDRY COMPANY (LIMITED).**—This Company has been registered in Edinburgh with a capital of £200,000, in £10 shares, to acquire patents relating to machine-moulding and metal-casting granted to Stephen Alley and John Alex. MacLellan, Glasgow; to carry out an agreement with Alley and MacLellan, engineers, Polmadie, Glasgow; to carry on the business of metal founders, engineers, steelmakers, iron-masters, &c.

**BROWN'S METALLIC PACKING COMPANY (LIMITED).**—This Company has been registered in Edinburgh with a capital of £11,000, in £10 shares, to purchase from Alex. Francis Garden Brown, Swindrigemuir, Dalry, his invention for metallic packing applicable to bearings and the patent applied for, and to carry on the business of mechanical engineers, iron-founders, &c. The registered office is at 51, West Regent-street, Glasgow.

**A. EARNSHAW AND SONS (LIMITED).**—Registered with a capital of £30,000 in £10 shares, to acquire the business of A. Earnshaw and Sons, Crown Works, Booth Town, near Halifax, Yorkshire, and to carry on generally the business of iron-founders, machine and tool makers.

**ROBERT HINDLE AND CO. (LIMITED).**—Registered with a capital of £15,000, in £50 shares, to (*inter alia*) acquire, construct, and maintain tramways, railways, manufactories, electric works, &c. Office, Sabden, Lancashire.

**JOHNSON, MATTHEY AND COMPANY (LIMITED).**—Messrs. Johnson, Matthey and Company, the well-known assayers, announce that on the occasion of admitting to partnership three of the sons of their seniors, they have considered it advisable for family reasons, and with the view of assuring to the business for the future a normal capital, to register it as a Joint Stock Company under the title of "Johnson, Matthey and Company, Limited," incorporated under the Companies' Acts. The nominal capital (ordinary and preference shares in equal moieties) is £900,000, of which £750,000 is now issued, and £600,000 paid up, leaving an uncalled liability on the ordinary shares of £150,000. The whole of the issued capital is taken up by the members of the firm, who will continue to manage the business as Directors, and no change is contemplated in the character of its operations. The Company acquires the business as from January 1st last.

**MOSS BAY HEMATITE IRON AND STEEL COMPANY (LIMITED).**—Registered with a capital of £308,196, in 17,122 6 per cent. Preference shares of £8 each, and 17,122 ordinary shares of £10 each. Objects: To carry on the business of ironmasters, miners, mechanical engineers, metal workers, tool makers, electricians, suppliers of electricity, boiler makers, and manufacturing chemists, to buy and sell, manufacture and repair machinery, electrical implements, tools, and utensils.

**STAFFORDSHIRE CHEMICAL COMPANY (LIMITED).**—Registered with a capital of £50,000, in £10 shares, to carry on the business of manufacturers of chemicals, or any business connected therewith.

**UNION ENGINEERING COMPANY (LIMITED).**—Registered with a capital of £19,000, in 1,000 Preference Shares of £10 each and 300 Ordinary Shares of £30 each. Object:—To acquire the business of the Union Engineering Company, carried on at Holt Town, and 2, Clarence-buildings, Booth-street, Manchester, and to develop and extend the same.

## CITY NOTES, &c.

**ANGLO-AMERICAN TELEGRAPH COMPANY.**—At a meeting of the Board of Directors of this Company on Friday last, it was resolved to declare an interim dividend for the quarter ended March 31st last of 12s. per cent on the ordinary Stock, and 24s. per cent. on the Preferred Stock, less income-tax, payable on the 1st May to the stockholders registered on the books of the Company on the 7th inst.

**BRAZILIAN SUBMARINE TELEGRAPH COMPANY.**—The receipts of this Company for the past week amounted to £5,918.

**CITY AND SOUTH LONDON RAILWAY COMPANY.**—The traffic receipts of this Company for the week ended April 12th amounted to £827.

**DIRECT UNITED STATES CABLE COMPANY.**—The Board of this Company have resolved upon the payment of an interim dividend of 3s. 6d. per share, free of income-tax, being at the rate of 3½ per cent. per annum for the quarter ended March 31, 1891, such dividend to be payable on and after the 24th inst.

**GREAT NORTHERN TELEGRAPH COMPANY OF COPENHAGEN.**—The accounts of this Company for the year 1890 have just been issued, from which it appears that, after providing for the interim dividend of 5 per cent. per annum, and an extra dividend of 7s. 2d. per share, and adding £66,666 to the reserve fund, a balance of £48,216 will remain to be carried forward.

**INDIA RUBBER ESTATES COMPANY (LIMITED).**—On a petition of Martin's Bank (Limited), judgment creditors on a dishonoured acceptance, but who have not issued execution, Mr. Justice Chitty on Saturday made an order for winding up the Company.

**NEW SHANGHAI ELECTRIC COMPANY (LIMITED).**—The report of the Directors of this Company states that after paying all expenses, the working account for the 14 months (from October 31, 1889, to December 31, 1890), shows a total profit of Tls. 7,705.22, which the Directors recommend should be dealt with as follows:—Plant account for depreciation, Tls. 3,690.08; dividend of 7 per cent. to all shareholders for the period ended December 31, 1890, Tls. 3,339.00; carrying forward, Tls.676.14; total, Tls.7,705.22. The Company have contracted to light the China Merchants' Kinlee-yuen Wharves, with six lamps for three years from April 1st next, at the same rate per lamp now charged to the municipality. Owing to the delay caused by strikes, &c. in England, the incandescent lighting plant was not ready until May 1, 1890, and its actual working only covers eight months, and not at full power during that time. With this short period of probation, the Directors are not yet prepared to give any definite opinion as to the future prospects of this branch. The increase in the price of coal during 1890 has further added to the expenditure, as was the case in 1889. Mr. R. M. Campbell having resigned on leaving Shanghai, Dr. Neil Macleod was invited to join the Board. Mr. F. E. Haskell, on his return to Shanghai, was also asked to re-join. These appointments require confirmation by the shareholders. In accordance with the deed of settlement, Mr. J. Beattie retires from the Board, but offers himself for re-election. The auditor, Mr. C. J. Dudgeon, resigned on leaving Shanghai, and Mr. R. F. Eastlack was temporarily appointed in his place. The latter now retires, but offers himself for re-election.

**PETZOLD AND CO., ENGINEERS (LIMITED).**—The transfer books of this Company will be closed from April 15th to May 1st, inclusive.

**REUTER'S TELEGRAM COMPANY (LIMITED).**—Mr. Justice Chitty on Saturday confirmed a special resolution of this Company to alter the Articles of Association by adding to the objects of the Company the telephoning of news, the construction and purchase of telephones, and the business of advertising agents, and contractors in all its branches in all parts of the world.——The twenty-seventh ordinary general meeting of the Company will be held at the Company's offices, 24, Old Jewry, London, E.C., on Wednesday, the 29th inst., at noon, and the transfer books will be closed from the 14th until the 28th inst., inclusive.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY.**—The traffic receipts of this Company for the week ended April 10, 1891, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £4,777.


# THE NON-CONDUCTOR OF ELECTRICITY.

**VULCANISED FIBRE,**
PATENTED.

WAREHOUSE.

This new material is supplied in two qualities, Flexible and Hard.

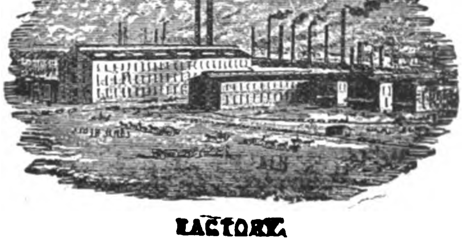
The FLEXIBLE is a substitute for Leather, Rubber, Gutta Percha, &c., and is extensively used by Brass Founders, Axle Makers, Hydraulic, Sanitary, and other Engineers, Pump Makers, Carriage Builders, &c.

It makes the best Hot and Cold Water Packings, and for Axle Washers of all kinds it is unequalled.

The HARD is a substitute for Metals, Hard Wood, Ivory, Vulcanite, Ebonite, &c., and is a good Insulator.

Sold in sheets, 5ft. 6in. by 3ft. 6in., varying in thickness from 1-50in. to 1in.

FLEXIBLE, 2/- per lb.; HARD, 2/3 per lb.


FACTORY.

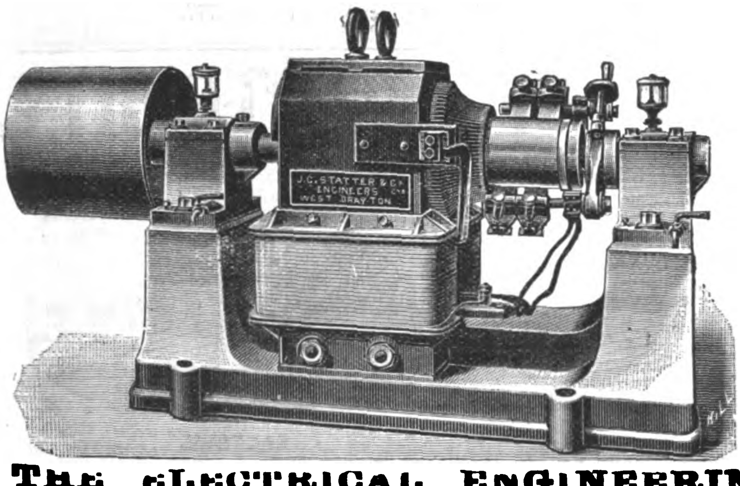
**MOSSES & MITCHELL, 70, Chiswell-st., London, E.C.**


Digitized by Google

# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name. | Previous Week's Price, April 8. | | Price Wednesday, April 15. | | Rate per Cent. Yielded | Dividend Due. | Business Done During Week Ending April 15. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **TELEGRAPHS.** | | | | | £ s. d. | | | |
| £1,381,380 | Stock | 15/0 | Anglo-American | 46½ | 47½ | 46½ | 46¾ | 5 18 3 | Jan., Apr., July, Oct. | 46⅞ | .. |
| £2,809,310 | Stock | 30/0 | Do. Preferred | 84½ | 85½ | 84½ | 85½ | 6 14 6 | ,, ,, | 85½ | 84½ |
| £2,809,310 | Stock | .. | Do. Deferred | 11 | 11½ | 11 | 11½ | .. | | 11⅝ | .. |
| £250,000 | 100 | 4% | African Direct, Telegraph 4% Debentures | 99 | 102 | 99 | 102 | 3 18 5 | January and July .. | .. | .. |
| 130,000 | £10 | 3/0 | Brazilian Submarine | 11½ | 12 | 11½ | 12 | 6 5 0 | Mar., June, Oct., Dec. | 11⅞ | 11⅝ |
| £84,500 | £100 | 5% | Do. 5 per Cent. Bonds | 100 | 103 | 100 | 103 | 4 17 1 | January and July .. | .. | .. |
| £75,000 | £100 | 5% | Do. 5 per Cent. Bonds (2nd Series, 1906) | 103 | 107 | 103 | 107 | 4 13 6 | June and December | .. | .. |
| $7,216,000 | $100 | 7% | Commercial Cable Capital Stock | 107 | 109 | 108 | 110 | 6 7 3 | April and October .. | 108½ | .. |
| 16,000 | 10 | 8/0 | Cuba Submarine | 10½ | 11½ | 10½ | 11½ | 6 19 2 | February and August | .. | .. |
| 6,000 | 10 | 10% | Do. Preference 10% | 16½ | 17½ | 16½ | 17½ | 5 14 3 | ,, ,, | 17½ | .. |
| 12,931 | 5 | 2/4½ | Direct Spanish (£4 paid) | 3¾ | 4¼ | 3¾ | 4¼ | 6 11 9 | April and October.. | .. | .. |
| 6,000 | 5 | 10% | Do. Preference 10% | 9 | 10 | 9 | 10 | 5 0 0 | ,, ,, | .. | .. |
| 60,710 | 20 | 3/6 | Direct United States | 10¼ | 10¾ | 10¼ | 10¾ | 6 15 0 | Jan., Apr., July, Oct. | 10⅝ | 10¼ |
| 400,000 | 10 | 2/6 | Eastern xd | 14¼ | 14¾ | 14¼ | 14¾ | 4 10 5 | ,, ,, | 14⅝ | 14⅛ |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference xd | 15¼ | 15¾ | 15¼ | 15¾ | 3 16 2 | ,, ,, | 15⅝ | .. |
| £1,200,000 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock | 108 | 111 | 108 | 111 | 3 12 1 | May and November | 108⅛ | .. |
| £200,000 | 100 | 5% | Do. 5 per Cent Debentures, 1899 | 107 | 110 | 107 | 110 | 4 10 11 | February & August | 109½ | 107½ |
| 250,000 | 10 | 2/6 | Eastern Extension | 14¾ | 15¼ | 14¾ | 15¼ | 4 13 4 | Jan., Apr., July, Oct. | 15¼ | 14 13/16 |
| £320,000 | £100 | 4% | Do. 4 per Cent. Debenture Stock | 105 | 108 | 105 | 108 | 3 14 1 | .. | 106½ | 106 |
| £91,800 | 100 | 5% | Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900 | 103 | 106 | 103 | 106 | 4 14 4 | January and July .. | 105¼ | 104½ |
| £145,300 | 100 | 5% | Eastern & S. African 5 per Cent. Mor. Deb., 1900 | 103 | 106 | 103 | 106 | 4 14 4 | ,, ,, | .. | .. |
| 180,227 | 10 | 1/9 | Globe Telegraph and Trust xd | 9¼ | 9½ | 9⅛ | 9⅜ | 5 9 4 | Jan., Apr., July, Oct. | 9½ | 9 3/16 |
| 180,042 | 10 | 6% | Do. 6 per Cent. Preference xd | 14⅞ | 15⅜ | 14⅞ | 15 | 4 0 0 | ,, ,, | 15¼ | 14½ |
| 150,000 | 10 | 5/0 | Great Northern | 17¼ | 17¾ | 17½ | 18 | 4 3 4 | Jan., April, and July | 17¾ | 17½ |
| £15,000 | 100 | 5% | Do. 5 per Cent. Debentures, 1881 | .. | | .. | | .. | January and July .. | .. | .. |
| £230,000 | 100 | 5% | Do. 5 per Cent. Debentures, 1883 | 103 | 106 | 103 | 106 | 5 13 2 | March & September | .. | .. |
| 17,000 | 25 | .. | Indo-European | 40 | 42 | 41 | 43 | 5 16 3 | May and November | 42½ | 42 |
| 38,348 | 10 | 2/6 | London Platino-Brazilian | 6½ | 7½ | 6½ | 7½ | 5 14 4 | ,, ,, | .. | .. |
| £100,000 | 100 | 6% | Do. 6 per Cent. Debentures | 105 | 108 | 105 | 108 | 5 11 1 | March & September | .. | .. |
| 9,000 | 8 | 4/0 | Reuter's | 9 | 9½ | 9 | 9½ | 5 6 10 | April and October.. | 9⅜ | 9¼ |
| 3,381 | £100 Cert. | 6% | Submarine Cables Trust 6% x Oct. Coupon | 115 | 120 | 113 | 118 | 5 1 8 | ,, ,, | 118½ | .. |
| 15,609 | 10 | 4/0 | West African Telegraph | 8 | 9 | 8 | 9 | 5 11 1 | January and July .. | .. | .. |
| £290,900 | 100 | 5% | Do. 5 per Cent. Debentures | 98 | 101 | 98 | 101 | 4 19 0 | March & September | .. | .. |
| 30,000 | 10 | 3/0 | West Coast of America | 2½ | 3½ | 2½ | 3½ | .. | January and July .. | 3 | .. |
| £150,000 | 100 | 8% | Do. Debentures 8% 1902 | 92 | 97 | 92 | 97 | .. | June and December | 95 | .. |
| 88,321 | 10 | .. | West India and Panama | 2¾ | 3 | 2¾ | 3 | .. | .. | 3 | 2 15/16 |
| 34,563 | 10 | 6/0 | Do. 1st Preference 6% | 11½ | 12 | 11½ | 12 | 5 0 0 | May and November | 11⅞ | 11¾ |
| 4,669 | 10 | £3 | Do. 6 p. c. 2nd Pref. | 11½ | 12½ | 11½ | 12½ | 4 16 0 | ,, ,, | .. | .. |
| 64,174 | 15 | 6/0 | Western and Brazilian | 12 | 12½ | 12 | 12½ | 4 16 1 | ,, ,, | 12⅝ | 12¼ |
| 27,873 | 7½ | 6/0 | Do. 5 per Cent. Cumulative Preferred | 6¾ | 7¼ | 6¾ | 7¼ | 5 4 2 | — | 7 | 6⅞ |
| 27,873 | 7½ | 4/6 | Do. 5 per Cent. Deferred | 5¼ | 5¾ | 5¼ | 5¾ | 6 11 7 | .. | 5⅝ | 5½ |
| £200,000 | 100 | 6% | Do. 6 per Cent. Debs., Series "A" 1910 | 103 | 106 | 103 | 106 | 5 13 2 | February & August | .. | .. |
| £250,000 | 100 | 6% | Do. 6 per Cent. Mort. Debs., Series "B" 1910 | 103 | 106 | 103 | 106 | 5 13 2 | ,, ,, | .. | .. |
| $1,336,000 | $1,000 | 7% | Western Union 7 per Cent. 1st Mortgage | 120 | 125 | 120 | 125 | 5 12 0 | May and November | .. | .. |
| £175,100 | £100 | 6% | Do, 6 per Cent. Sterling Bonds | 100 | 104 | 100 | 104 | 5 15 5 | March & September | .. | .. |
| | | | **TELEPHONES.** | | | | | | | | |
| 224,850 | 14/0 | 0/4½ | Consolidated Telephone Const. & Maintenance. | 7/16 | 9/16 | 7/16 | 9/16 | .. | May and November | .. | .. |
| 220,000 | £1 | 3½% | Oriental (11s. paid) | 5/16 | 7/16 | ¼ | ⅜ | 5 2 11 | Yearly | .. | .. |
| 438,984 | 5 | 2/6 | National | 4⅜ | 4⅝ | 4¼ | 4½ | 6 2 3 | June and December | 4½ | 4 5/16 |
| 15,000 | 10 | 6/0 | Do. 6 per Cent. Cumulative 1st Pref. | 13 | 13½ | 13 | 13½ | 4 8 11 | ,, ,, | 13 7/16 | 13 5/16 |
| 15,000 | 10 | 4/9⅜ | Do. 6 per Cent. Cumulative 2nd Pref. (£8 pd) | 10 | 10½ | 10 | 10½ | 4 11 7 | ,, ,, | .. | .. |
| 209,750 | 1 | ½% | South of England, Ordinary | ⅛ | ¼ | ⅛ | ¼ | .. | — | .. | .. |
| 20,000 | 5 | 2/1 | Do. 6 per Cent. Cumulative Pf. (£3 10s. pd) | 3 | 3½ | 3 | 3½ | .. | .. | .. | .. |
| 58,000 | 5 | 1/0 | United River Plate | 2½ | 3½ | 2½ | 3½ | .. | January and July .. | 3 1/16 | .. |
| £146,128 | Stock | 5% | Do. 5 per Cent. Debenture Stock | 85 | 95 | 85 | 95 | 5 5 3 | .. | .. | .. |
| £3,200 | 100 | 7% | Do. 7 per Cent. Debentures | .. | | .. | | .. | — | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | | | |
| 19,900 | £5 | .. | Electricity Supply Co. of Spain | 4½ | 5 | 4½ | 5 | .. | .. | .. | .. |
| 111,000 | 5 | .. | London Electric Supply | 2⅜ | 2⅝ | 2⅜ | 2⅝ | .. | .. | .. | .. |
| 43,900 | 10 | .. | Metropolitan Electric Supply (£9 paid) | 8¾ | 9¼ | 8¾ | 9¼ | .. | — | 9 | .. |
| 7,730 | £5 | .. | St. James' and Pall Mall | 6½ | 6¾ | 6 | 6½ | .. | — | .. | .. |
| 42,853 | 5 | .. | Westminster Electric Supply (£4 paid) | 3⅞ | 4⅛ | 4⅞ | 5⅛ | .. | — | 5½ | .. |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | | | |
| 63,416 | 3 | .. | Brush Electrical Engineering | 2⅜ | 2⅝ | 2¼ | 2½ | .. | .. | 2 7/16 | 2 5/16 |
| 63,416 | 2 | 1/1 | Do. 6 per Cent. Preference | 1⅝ | 1⅞ | 1⅝ | 1⅞ | 6 8 0 | June and December | 1⅝ | 1 11/16 |
| 20,000 | 5 | 3/6 | Crompton and Co., 7 per Cent. Pref. Shares | 5¼ | 5¾ | 5 | 5½ | 6 16 4 | January and July .. | .. | .. |
| 17,139 | 5 | .. | Edison and Swan United | .. | | .. | | .. | — | .. | .. |
| 45,000 | 10 | 6% | Electric Construction | 5½ | 6½ | 5½ | 6½ | .. | — | .. | .. |
| 70,000 | 2 | 10/0 | Elmore's Patent Copper Depositing | 2¾ | 3¼ | 2¾ | 3¼ | .. | — | 3 | 2 13/16 |
| 20,000 | 5 | .. | Fowler-Waring Cables (£4 paid) | 2½ | 3½ | 2½ | 3½ | .. | .. | 2¾ | 2⅝ |
| 41,600 | 10 | 10/0 | India Rubber, Gutta Percha & Telegraph Works | 18½ | 19½ | 18½ | 19½ | 5 2 7 | February & August | 19⅝ | 19 |
| £200,000 | 100 | 4½% | Do. 4½ per Cent. Debentures, 1896 | 102 | 104 | 102 | 104 | 4 6 7 | March & September | .. | .. |
| 11,334 | £10 | 6/1 | International Okonite Limited Ordinary | 7½ | 8½ | 7½ | 8½ | 11 15 3 | .. | .. | .. |
| 11,334 | £10 | 5/0 | Do. Preference | 9¼ | 9¾ | 9¼ | 9¾ | 8 4 1 | .. | .. | .. |
| 78,949 | 5 | 4/10½ | Swan United (£3. 10s. paid) | 4½ | 5 | 4¾ | 5¼ | 6 13 4 | May and November | 5 | 4⅞ |
| 37,350 | 12 | 36 0 | Telegraph Construction and Maintenance | 45 | 47 | 45 | 47 | 5 0 0 | March and July | 46¾ | 45¾ |
| £150,000 | 100 | 5% | Do. 5 per Cent. Bonds, red. 1894 | 102 | 105 | 102 | 105 | 4 15 3 | January and July .. | .. | .. |
| | | | **RAILWAYS.** | | | | | | | | |
| 50,000 | £10 | .. | City and South London Railway | 5½ | 6½ | 5½ | 6½ | .. | .. | .. | .. |


IMPROVEMENTS IN DYNAMOS



STATTER - BRUNTON
DYNAMO.

**The latest design in the market, made with all the advantages of the latest scientific knowledge and the highest mechanical skill.**

The woodcut represents our B TYPE DYNAMO. A most efficient machine, working noiselessly, and without sparking or overheating; is highly finished and well proportioned. The output is so rated in our Catalogue that the machines may be worked very much in excess of their stated full output for short periods.

**STOCK SIZES UP TO 77 KILOWATTS.**
MACHINES BUILT TO 500 KILOWATTS.

THE ELECTRICAL ENGINEERING CORPORATION, LIMITED,
[STATTER'S] [UNITED.]
68, Victoria Street, London, S.W. WORKS:—ALLIANCE ENGINEERING WORKS, WEST DRAYTON, NEAR LONDON.


Digitized by Google

# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

## ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 675.—Vol. XXVI. FRIDAY, APRIL 24, 1891. Price Fourpence.

## NOTES.

The debate initiated by Earl Compton in the House of Commons last Friday did not give rise to any serious complaints against the Postal Telegraph administration. Telegraph clerks have still some grievances to be redressed; but they may think themselves lucky in belonging to a service which is able and generally willing to listen to them. As to the public, it seems that they have little or nothing to complain about. Mr. Henniker-Heaton's contribution to this branch of the discussion did not go beyond deprecating the charge made for addresses and ridiculing the rules for counting certain double-barrelled compounded words. As to the former, Mr. Heaton will have to shout himself dumb before he induces any Government to relax the present regulation, which is both fair and logical. He is on surer ground when criticising the unmeaning restrictions and contradictory rules laid down for the counting of words whether in the addresses or the texts. Everybody has experienced the vexation of these arbitrary regulations, which are unintelligible apparently even to the post-office clerks themselves, who often spend five minutes on a matter which ought to be perfectly clear without any references whatever. When one attempts to settle the point by throwing down an extra halfpenny, it is declined with thanks, the clerks seeming quite as much afraid of taking too much as of accepting too little. We once took the trouble to look up the "Postal Guide" in order to account for some eccentricity of this kind. To our amazement we found that if the word in dispute was *A*, it counted as one word; but if *B* it is counted as two; and that we might learn to which of the two categories it belonged by referring to another part of the Guide, or, failing that, to a list of places somewhere else. We did not pursue the subject, and have ever since felt a sort of sneaking respect even for the member for Canterbury.

It is difficult to give comforting advice to the firm whose letter on the wiring of their works will be found in our present issue. There are numerous rules for wiring, and the subject has been frequently dealt with in our columns. The rule about 1,000 amperes to the square inch was made in the early days when the heating of conductors was not understood. The Paper by Prof. Forbes, in 1884, ought to have exploded the idea, and the experiments of Mr. Kennelly, in 1888, have set the matter on a practical footing; while the Board of Trade, in their latest rules, abandon altogether current density, and specify a limit of temperature. According to Mr. Kennelly, and no one has as yet disputed his figures, a No. 18 wire will carry 11 amperes at a density of 5850 amperes per square inch, without raising the temperature more than 15°C. However, the thousand ampere rule is on the safe side for all ordinary work. Our correspondents appear to put forward the fact that they run their lamps 5 per cent. under their proper voltage as though this were a precaution or matter of safety. They lose just about 20 per cent. of their light by doing this, and without any possible advantage other than prolonging the life of the lamps. For every penny thus saved many times that sum is wasted in power. The use of wire of so large a gauge as No. 8 is universally condemned by electrical engineers, and all conductors whose area is greater than that of No. 14 should be stranded.

It is true that small switch connections and lamp terminals are rarely soldered, but we strongly approve of soldering the conductors at switch-board instruments and switches and at the dynamos, not to the terminals, but to suitable thimbles or sockets which may be firmly attached to the terminals. The only really unsightly detail in the engine-room of the City and South London Railway was the connection of the conductors to the dynamos, the ends being squashed out in a flat bunch and jammed against the terminal by screws. We should like to see the end of every conductor larger than $\frac{7}{22}$ sweated into a thimble.

Cut-outs are very much overdone. Mr. Preece pointed out some years ago that an enormous number of dry joints offering resistance and chance of difficulty are introduced by the lavish use of fuses, but our correspondents are mistaken in supposing that a loss of 20 per cent. could thus be produced. The proper place for a cut-out is at the branch as close as possible to the joint. They are to protect the wire, not the lamp. The remaining point in the letter is a very difficult one. The electrical advisers to insurance companies are very fond of setting up rules drawn from their general experience, and are quite at sea when a peculiar case is put before them. The conditions of a dye works are very peculiar, and have sorely puzzled many electrical engineers. This particular case cannot be so bad as many, as it appears that iron staples are used; in many dye works copper would have to be employed. Metal staples in any case are bad, and sheet copper saddles would be but little better. Where there is merely steam and no acid vapour, the

Digitized by Google

use of well varnished teak casing should suffice, if carefully put up, as in ship work, with a cement filling. Creosoted wood cleats, fastened with copper screws, would probably stand the peculiar atmosphere of dye works better than anything else, a first-rate insulation varnished with the new flexible acid-proof varnish that is now used for accumulator work being employed.

MR. TOLVER PRESTON's article on "The Ether as a Source of Motion," which we print in another column, touches a subject of the greatest possible interest, as it really raises the whole theory of the circumstances under which we may expect to obtain energy available for useful purposes. The first law of thermodynamics, that of the conservation of energy, is consoling for our descendants because it asserts that, in spite of all the work which has been done in the world, the amount of energy in it is now as great as ever. The second law of thermodynamics, or the law of available energy, is of quite a different character. It asserts that there is a natural tendency for all available energy to dissipate itself and become useless, and, when very roughly interpreted, is equivalent to the assertion that the industries of the world will come to a standstill when our coal supplies become exhausted. While, however, the first of these laws is quite unalterable, it has been shown by Maxwell that the second is only strictly true of inanimate bodies, and that it is possible to imagine processes by means of which the tendency can be checked or even reversed in any particular case, although these methods may be as yet quite impracticable. It is to processes of this character that Mr. TOLVER PRESTON is alluding when he refers to his screens.

THE existence of such screens is not contradictory to any law of nature, and it is, therefore, theoretically possible to find them. Moreover, there is no doubt about the correctness of his assertion that the ether is an inexhaustible source of energy, and that, if a means could be found of making this energy available, engines could be continuously worked by it as from a new kind of coal. The perpetual motion so obtained would, after all, be quite analogous to that shown in a mill wheel urged round continuously by water power. But such screens, and such methods, are none the easier to find on this account. No one has any right on scientific grounds to say that it is impossible to find a metal with conducting powers so good that its specific resistance would be represented by a cipher. There is no doubt of the warm welcome such a metal would receive among electricians; but the question naturally arises whether the probability of finding such a substance makes it worth while looking for it in spite of the many great advantages it would undoubtedly possess.

IN connection with the screening of magnetic force, which Mr. TOLVER PRESTON alludes to, it is quite possible that the screen he suggests the search of is simply a sheet of metal of infinite conductivity. If a magnet is moved about in the neighbourhood of such a sheet, currents are induced in it which exactly counteract the effect of the magnet, as far as the side of the sheet opposite the magnet is concerned. The currents so induced do not die away, because the sheet, having no resistance. does not absorb any energy in heat. The strength of the currents alter according to the position of the magnet, and they are always so arranged that the lines of force due to them are equal and opposite to the lines of force due to the magnet. The effect is exactly as if none of the lines of force due to the magnet penetrated the sheet, which accordingly acts as a perfect magnetic screen. A line of force cannot cut a piece of metal whose conductivity is infinite, so that if the field magnets of a dynamo were once excited, and the limbs surrounded by two or three rings of this metal, the magnetising current could be removed altogether, for the lines of force would be, as it were, tied in place.

A METHOD, by means of which a system of electrical supply at constant potential may be utilised to supply electrical energy at constant current, is of considerable interest, even although it may be quite impracticable at present. A device with this object in view has been suggested in *L'Electricien*, by M. P. BOUCHEROT, and its action depends on the curious properties of choking coils and condensers. Several Papers recently appearing in our columns have made our readers familiar with the fact that, when an alternating current is passed through an inductive coil and condenser connected in series, the voltages on coil and condenser may each exceed the voltage which is driving the current through the combination. This action is due to resonance, and may become very marked under certain conditions. If, now, the condenser or coil is shunted with a resistance, the voltage falls, and the smaller the resistance the lower the voltage. This is the state of things needed for a constant-current system of supply, and M. BOUCHEROT has succeeded in showing that, under certain circumstances, the current through the shunt is independent of the resistance. Such a combination placed across the mains of a constant potential system will therefore supply a constant current to a circuit connected with the terminals of either the coil or condenser.

THE suggestion is highly ingenious, but is far too theoretical to be of service at present. In the first place it is necessary to procure choking coils and condensers which do not absorb any appreciable energy when alternating currents pass through them, since M. BOUCHEROT assumes that the resistance of the coil is nothing, and makes a similar assumption with regard to the condenser. It is also needful that the resonance condition should be fulfilled, and, if the choking coil is to take any appreciable current, this condition implies that the condensers will require to be of enormous capacity, unless alternating currents of high frequency, such as Mr. TESLA advocates, come into use. All such devices are unworkable at present owing to the great expense of condensers of suitable capacity, and the difficulty of getting them to stand high alternating potentials. The idea of M. BOUCHEROT can only be carried out in practice when condensers are obtainable which compare as favourably with those in use at present as the accumulators of to-day compare with the original cells of PLANTÉ. Of course it does not necessarily follow that the improvements will take as long to bring about.

Digitized by Google

**Birmingham.**—Electric lighting at Birmingham was formally inaugurated on Wednesday by the Mayor at the Birmingham Electric Supply Company's central station in Dale End.

**Leeds.**—At the last meeting of the Town Council assent was given to the application of the Yorkshire House-to-House Electricity Company for a Provisional Order.

**King's College, London.**—A special course of practical work in Light and Spectrum Analysis will be given in the Wheatstone Laboratory on Wednesday evenings from 7 to 9 p.m.

**Fire at Siemens and Halske's St. Petersburg Factory.**—On the night of the 13th inst. a fire occurred at Messrs. Siemens and Halske's lamp factory in St. Petersburg, by which damage to the amount of 250,000 roubles was done.

**Electrical Bills in Parliament.**—In the House of Commons on Friday last, the London Overhead Wires Bill was read a third time.—The Central London Railway Bill was read a third time and passed in the House of Commons on Monday.

**The Chicago Exhibition.**—The construction department for intramural transit in Jackson Park for the World's Fair, has decided to adopt the Adams system of single track elevated railway. The stations will be about 1,000 feet apart. Each car will be supplied with an electric motor and will hold 30 passengers. The track will be three miles continuous loop.

**The South African Correspondent of** ***Machinery*** understands that the executive have decided to declare the letters of incorporation of the Johannesburg Electricity Company of no value, as they have not been published in the *Staatscourant* in terms of the law. There is some probability of the Transvaal Government buildings in Pretoria and Johannesburg being lighted by electricity.

**Oxford.**—Under the Provisional Order granted to the Electric Installation and Maintenance Company, works are now in progress for the supply of electricity to the whole of this city. The system of distribution adopted is the "Chelsea" system of battery sub-stations. The works are being pushed forward with great rapidity, and it is expected that the supply to the public will be commenced about the end of October.

**Provisional Orders.**—The Board of Trade has granted Provisional Orders relating to Bolton, Canterbury, Dewsbury, Hanley, Harrogate, Sunderland, Ealing, Norwich, Southport, Stockport, Surbiton, Tynemouth, Bishops Stortford, Croydon, Heckmondwike, Londonderry, Southend, Weston-super-Mare, Acton, Chiswick, Coventry, Kidderminster, Llanelly, and South Shields. These Orders have been embodied in Bills which are to be submitted to Parliament for confirmation.

**The Elmore Copper Process.**—The troublesome method of giving the iron mandrils a preliminary coating of copper by the cyanide process has been discontinued, and copper rollers are now employed. The deposited copper adheres with just sufficient strength to withstand the friction of the burnisher, and is easily removed by a few light blows. Some large cylinders about 13ft. 6in. long by 3ft. 4in. in diameter have been turned out. These are for use in the wire-making department.

**A Curious Cause of Increased Coal Consumption.**—According to the *Revue Industrielle*, M. Cornut, chief engineer to the Association des Proprietaires à Vapeur du Nord, having been called in to investigate the cause of a considerable augmentation in the consumption of fuel by a large battery of boilers, discovered that this phenomenon was due to the presence of water in the smoke shafts. The measures which were taken to exclude the water have resulted in a saving of 16 per cent. in the annual coal bill.

**Lundy Cable Company.**—Mr. G. F. Rogers informs us that some time ago the liquidator of this Company offered this cable for sale, and he purchased it. He found the cable in perfect condition, except in one or two places where it had been chafed by the rocks, and also found a break, caused probably by some wreck having driven over it, the cable on both sides being in absolutely perfect condition. He thinks that if the cable be relaid to the Devonshire coast at Braunton there would be no further trouble in maintaining it, as it would be lying upon sand for the whole distance.

**Electricity in Mines.**—Mining engineers, says the *Mining Journal*, cannot afford to overlook the fact that electricity now occupies a position of ascertained value among the resources of their profession. Messrs. Atkinson's Paper and the discussion at the Institution of Civil Engineers show that both its capabilities and limitations have been carefully determined in actual practice, and that it has long since passed beyond the experimental stage as a means of transmitting power through the workings of a mine.

**Electric Traction Statistics.**—The statistics of the electric railways of Massachusetts for the year ended September 30, 1890, are as follows:—

| | |
|---|---|
| Number of companies having electric lines in operation | 17 |
| Overhead trolley system, total miles | 157·77 |
| Storage battery system, total miles | 3·09 |
| Total miles electric railway in State | 160·86 |
| Number of companies having electric lines under construction | 7 |
| Overhead trolley system, total miles | 28·45 |
| Storage battery system, total miles | 6 |

**The James Accumulator.**—In this accumulator the positive plates consist of lead alloyed with 1 per cent. of cadmium, whilst the negative consist of lead alloyed with 2 per cent. of antimony. The plates are pierced with circular holes, in which the active material is placed. Those on the positive plates are filled with a mixture of 8·5 parts of minium, 1 part of litharge, ·4 part of carded asbestos, and ·1 part of powdered carbon. The holes in the negative plates are filled with a mixture of 9·4 parts of litharge, ·1 part of sulphur, with ·4 part of asbestos, and ·1 part of powdered carbon.

**The Boy Messengers Company.**—The terms of the arrangement between the Postmaster-General and this Company are as follows: The Postmaster-General grants license for the "Electric Call System" in the County of London, including the City, and any other place not within the county but within five miles of the General Post Office. The Postmaster-General will connect the Company's offices with fire and police stations by telephones. Terms of the license 12 years. Royalty £25 per annum and 2s. 6d. per instrument (call box). The Company to act as agents of the Postmaster-General, delivering letters stamped with 1d. royalty.

**A Peculiar Accident.**—A peculiar accident recently occurred at Lynn, Mass. The central station caught fire, and the wires from the dynamos were burnt, breaking the circuit. Relieved of its load, the 700 H.P. engine became unmanageable, and started off at such a rate of speed that the large fly-wheel was broken into fragments, and flew in all directions, causing much damage to the building. An excellent illustration of the principle of the transformation of energy, as the power produced by the engine, instead of being transformed into electrical energy, was, on account of the breaking of the circuit, able to devote itself to wrecking the fly-wheel.

**Austrian Telegraph Statistics.**—The statistics of the Austrian Post Telegraph Department for 1889 have just been published. The receipts were, including international telegrams, 4,181,087fl., against 3,899,628 in 1888, an increase of 7 per cent. The total number of messages was 25,192,235, as against 23,839,620 in 1888, an increase of nearly 6 per cent. The Government now owns 26,677 kilometres of trunk lines, comprising 73,003 kilometres of wires. During 1889, 42 central telephone stations were opened, including those belonging to private companies, and 96,322 telegrams were transmitted by telephone to telegraph offices, and 128,094 telegrams were transmitted by telephone to subscribers.

**Utilisation of the Water-Power of the Rhone.**—As is well-known, the water-power of the Rhone is being largely utilised for industrial purposes in the neighbourhood of Geneva. Colonel Turettini (head engineer of the St. Gotthard Tunnel), who carried out the works, has just issued a report as to the state of the work. The canal on the left bank is provided with 20 turbines, working up to 4,400 H.P., of which only half is at present in use. During the past year 216 motors, totalling 1,565 H.P., have been driven from the works. The smallest, of ⅓ H.P., have been used to run sewing machines, whilst the largest (625 H.P.) has driven the electric light

Digitized by Google

installation for the town of Geneva. The total cost of the works was £227,200, and the year's receipts reached £82,600.

**Exports of Telegraph Apparatus.**—The value of the exports of telegraph wires and apparatus connected therewith during March was, according to the Board of Trade returns, exceptionally large, the total value having amounted to nearly £400,000, as compared with a little over £51,000 in the corresponding month of last year. As the January exports were also exceptionally heavy, the aggregate exports for the first quarter of the current year compare very favourably indeed with the corresponding figures for the two previous years. The following are the details for the three months, and for the quarter, in comparison with the corresponding figures of the two previous years :

| | 1889. | 1890. | 1891. |
|---|---|---|---|
| January ............ | £113,230 | ... £71,686 | ... £238,223 |
| February ............ | 32,086 | ... 201,594 | ... 22,306 |
| March ............... | 285,993 | ... 51,390 | ... 392,552 |
| First quarter ...... | £431,309 | ... £324,670 | ... £653,081 |

**Leamington.**—At the last meeting of the Town Council, the Town Clerk stated that the Board of Trade suggested several courses with regard to the rival applications for Provisional Orders made by the Corporation and the Midland Electric Light and Power Company. (i.) Both Orders might be granted ; (ii.) the Corporation Order might be granted with a purchase proviso ; (iii.) the Company might be granted an Order. The Corporation, the Board of Trade said, had allowed the Company to come into the town and spend a very large sum of money, and they thought it only fair that it should be allowed to compete in the supply of electric light with the Corporation or be bought out. The Mayor thought the Corporation would be wanting in common sense if they were to think of supplying electric light in a town where gas could be obtained at 2s. 6d. per 1,000. It was then moved that the Town Clerk have full power to drop the application. The proposition was carried unanimously.

**The Telephone Service of the Metropolis.**—Referring to the formation of the Association for the protection of the subscribers to the National Telephone Company's Metropolitan system, the *Economist* remarks in its last issue :—"This is a step which is perfectly justified by the circumstances of the case. In the matter of charges for telephonic service, the Metropolis is not only behind Continental and American cities, but also behind provincial towns. . . . The Company has, to some extent, been compelled to move with the spirit of the times in the provinces, and has recently made very considerable reduction in the charges to its subscribers ; but in the Metropolis, every effort to induce the Directors to improve their service, or reduce their charges—both steps are required—has been futile, and telephony has remained at a standstill. . . . The only explanation which can be found for the defiant attitude assumed by the Company towards the public in London is that, in the Metropolis, the Company thinks it has not much reason to fear competition. . . . Fortunately, the public are not without the possibility of a remedy. The telephone service is merely a branch of the telegraph service, and it is not only the duty of the Post Office to see that the public is sufficiently served, but it has all the machinery at hand with which to undertake the service. The difficulties in the way of a new private competition to the National Telephone Company, therefore, do not apply in the case of the Post Office. . . ."

**Cambridge.**—At the last meeting of the Town Council, Alderman Finch said that it would be in the recollection of the Council that a resolution was passed instructing the Electric Lighting Committee to prepare contracts for the electric lighting of Cambridge, and submit them for the approval of the Council. The Committee proceeded to prepare contracts in accordance with the instructions they had received. The Committee invited tenders for the erection of a station, and when they came to examine the tenders they found that instead of the sum being £4,900, as was put down in the report of the probable expenditure, the lowest tender was £11,260. That result surprised the Committee. It then occurred to the Committee that there might, perhaps, be a scheme that was not quite so costly as the one recommended by Dr. Fleming. They therefore appointed a Sub-Committee to proceed to other stations to study some of the schemes. The system the Sub-Committee recommended was remarkable for its mechanism, and for the small amount of labour that was required. Dr. Fleming, they believed, would be unwilling to take upon himself the responsibility of carring out a scheme which he did not recommend, and as the Committee were not electrical engineers, they would like to be in a position to ask for information from an authoritative and responsible person. They had ascertained there were already persons in different parts of the town prepared to take the light to the extent of 2,700 lights. He proposed : "That the Committee prepare the contracts they were directed to prepare, with liberty, if necessary, to consult another expert." The proposition was carried.

**Telephones on Shipboard.**—The Société Génerale des Téléphones, have, says *Engineering*, erected a considerable number of installations on board ship to enable communication to be maintained between the various parts with greater facility than by the use of speaking tubes. Among the more important ships fitted are the ironclads "Devastation," "Redoubtable," "Admiral Duperre," "Courbet," "Admiral Baudin," the crusier "Cecille," the torpedo cruiser "Sfax," and the Spanish ironclad "Pelayo." In these, all the circuits radiate from the conning tower. Care has been taken to make every part as strong as possible, and to avoid all chances of breakdown. To this end the conductors are made of copper ribbon and efficiently insulated. In those cases in which an officer or a man has two lines through which he can speak, each line is provided with its own complete apparatus for sending and receiving, and no attempt is made to make one apparatus serve for both lines. The telephonic apparatus consists of "Berthon" microphone transmitters and "Ader" receivers. Experiments on board the "Devastation" proved that with this apparatus a conversation was not interrupted between the conning tower and the central battery, even during the firing of the heavy guns. The "Berthon" microphone is so constructed that damp has no influence upon it. This is also the case with the "Ader" receiver, the coils of which are let into a bituminous block. On board the "Devastation," an apparatus has been used after having been immersed in a pailful of sea water. The cells employed are Léclanché Agar-Agar cells (dry.) The call-bells have different sounds, so as to distinguish them from one another.

**Bath.**—At the last fortnightly meeting of the Surveying Committee of the Bath Urban Sanitary Authority, Prof. Forbes' report was laid upon the table, but its consideration was postponed for a fortnight. Prof. Forbes states in his report that Mr. Massingham has at the central station ample power and plant for supplying the present requirements of Bath. The defects are (*a*) that proper arrangements have not been made for cutting off the steam pipe from any single engine ; (*b*) that there is no automatic device for regulating the electric pressure on the incandescent circuits ; and (*c*) there is no compensated voltmeter for indicating the pressure which ought to be maintained at the station, in order to keep the pressure at the consumers' lamps fairly constant. In the contract, lamps of 1,200 c.p. were specified, but the total quantity of light given out by each of the street lamps is, Prof. Forbes thinks, certainly not more than 300 or 400 candles. The arrangements for the private lighting appear to Prof. Forbes to be good on nearly every point, the chief defect being the inadequate arrangements for keeping the pressure constant. Appended to the report is a correspondence between Mr. Massingham and The Laing Wharton and Down Construction Syndicate who supplied the plant, and between the Clerk to the Urban Authority and Prof. Forbes, more particularly with reference to the great discrepancy in the candle-power of the lamps. The contractors state that although the 6·8 ampere Thomson-Houston arcs are called nominal 1,200 c.p., they actually give, when measured, without a globe, at an angle of from 40 deg. to 60 deg. below the horizontal, even more candle-power than this ; but with opal globes it is possible to reduce the candle-power even more than 50 per cent. They add that they have never had complaints before. Prof. Forbes admits that the arc lamps do emit 1,200 c.p. at their greatest intensity, and offers to carry out photometric tests.

Digitized by Google

## LIGHTNING CONDUCTORS.

BY DR. OLIVER LODGE.

### Experiments with Leyden Jar Discharges.

It may be remembered that in 1888-89* I began describing a series of experiments which I had made in connection with lightning conductors, especially a series of experiments on "the alternative path." These consisted in arranging that a couple of Leyden jars, charged up to a known potential determined by the length of their spark—which I called the spark A, should discharge round various circuits, and that specific portions of these circuits should be tapped off by an air-gap shunt, at which a spark might occur if it were able—this shunting or short-circuiting spark being called B; and the portion of the conductor thus tapped off or shunted out was called the alternative path. It was shown that the length of the B spark was a measure of the E.M.F. needed to send the given discharge through this conductor, and the ratio which the length of the B spark bore to the length of the A spark was shown to be calculable from theoretical considerations; being indeed this:—

$$\frac{B}{A} = \frac{\text{(total impedance of alternative path)}}{\text{(inertia portion of impedance of entire circuit)}} \times \text{(damping,}$$

or reduction of amplitude, during a quarter swing.)

There remain, however, a good many other experiments which have not yet been described, some of them of the same nature, and some on a different plan, and I propose to continue the description of the more interesting of them.

I take first some more experiments on the alternative path plan, made with the object of verifying still more certainly the effect of different metals, and of ascertaining more completely the effect of iron, especially of iron cores introduced into a coil of wire included in the discharge circuit.

### Effect of Iron introduced into Alternative Path Spirals.

§ **58.** Referring back to § 18, where iron inside a circuit is reported as having no effect on the length of the B spark, I proceeded to test the matter further.

*September* 28, 1888.—Wound a spiral of uncovered No. 12 copper wire on a long glass tube, with interspaces of between ⅛in. and ¼in., and made a long paraffined bundle of fine iron wires, say 2ft. long and ¾in. diameter, to fit the tube. Used this spiral as alternative path both with and without the iron core. A spark between machine knobs 4·1 centimetres long.

| — | B spark with spiral as alternative path. | — |
|---|---|---|
| Without iron core...... | 2·27 | Centim. length at which B sparks just fail. |
| With iron core inserted | 2·27 | They still just fail. |
| Ditto ................ | 2·12 | They occur and fail about equally often. |
| Remove iron core ...... | 2·12 | They do just the same. |

But this is noticeable, that whenever the B spark fails, so that the discharge has to go round the spiral, *the noise of the A spark is distinctly less when the iron core is in the spiral than when it is withdrawn.* Repeated this many times, and made quite sure of the observation. The difference is very marked: without the iron core the discharge is much noisier. Compare this with the effect of an iron wire as alternative path as reported in § 55.

### Magnetisation Observations.

§ **59.** Tried whether the iron bundle was magnetised after this treatment. It was. It lost some on tapping, but not much. Inserted it the other way into helix, and passed a spark: no change in the magnetism. Passed three sparks: magnetism destroyed. Passed more sparks: magnetism put back in old direction. Passed still more: magnetism reversed.

* The paper began in Vol. XXI., page 815, and ended temporarily in Vol. XXIII., page 269.

Put the core in now the original way, and sent sparks: magnetism not destroyed till after several sparks, then it became reversed again. On the whole it appears that the magnetisation caused by discharge current is somewhat accidental, but that there is a tendency in one direction.

*October* 1.—Tried this further with a set of 4 steel knitting needles, kept well separate by corks and inserted inside spiral.

Whenever the B spark failed, so that the whole discharge had to pass round the spiral, the magnetisation produced was feeble but in the correct direction. It took several sparks to produce much effect.

Wherever the B spark occurred, so that probably all the oscillations after the first were short-circuited through the air gap, the magnetisation excited was much more vigorous, but it was almost a toss-up which polarity it had; a preponderance was found for the same direction as before. Often, however, it was suddenly and violently reversed.

Lengthening the B gap so that all the flash had to go by the helix again, the magnetism was gradually set right even if it had been started wrong, but the residual magnetism was now only feeble.

To sum up:—The entire discharge gave feeble magnetism definite in direction; while, when partially shunted by a B spark, it gave strong magnetisation uncertain in direction.

### Further Alternative Path Experiments comparing Iron, Copper, and Lead.

§ **60.** *October* 13, 1888.—Having found that the effect of iron wire used as alternative path was to shorten the B spark, and to diminish the noise of the discharge altogether, I proceeded to examine and make sure of this; and for this purpose had had the new wires rigged up round the room as reported in § 54. Six wires altogether, of iron, of copper, and of lead, a pair of each metal, one thick and one thin, their particulars being given above (Vol. XXIII., p. 268).

Gallon jars standing on table connected up with short wires to machine, their outer coats connected to knobs of spark micrometer (where the B spark occurs).

Distance between the A knobs (those of the machine) 4·0 centimetres.

| Alternative Path. | Length of B spark in cms. | Remarks. |
|---|---|---|
| None .................... | 5·354 | .................................... |
| No. 12 Copper Wire ... | 5·20 | B spark occurred sometimes. } Copper is always less definite than iron in fixing a B spark-length. |
| Ditto .................... | 4·425 | Spark still often fails. } |
| No. 12 Iron .......... | 3·074 | Pretty definite. Spark on the verge of failing altogether. |
| No. 12 Lead .......... | 3·925 | Spark fails to pass 4 times out of 5. |
| No. 12 Copper again ... | 4·075 | Fails 3 times out of 4. |
| No. 12 Lead .......... | No perceptible | difference in noise, or anything between lead and copper. |
| No. 12 Iron .......... | 2·975 | Fails 9 times out of 10. Noise of spark much less. |
| No. 12 Lead ........ .. | 4·074 | Fails 5 times out of 6. |
| Thin Lead ........... ... | 3·250 | Fails 3 times out of 4. Nearly as quiet as iron. |
| Thin Iron .............. | 3·250 | Fails 4 times out of 5. |
| Thin Copper ............ | 3·600 | Fails 1 out of 2, but pretty definite. Noisier than either iron or thin lead. |
| To compare with some old altern | ative paths. | |
| Old circle of No. 5 Copper (see § 42) ... | 0·952 | Fails 3 times out of 4. |
| Ditto, No. 2 Iron ...... | ·915 | Fails 7 times out of 9. |
| Same length of No. 12 Lead ................. | 1·00 | Fails 3 times out of 4. |

### Summary of Table.

§ **61.** It is here to be noticed that the B spark with iron as its alternative path is shorter than with either of the other metals, as if it formed an easier path for the discharge; the real reason being its enormous resistance or throttling to an alternating current. Thereby the vibrations are rapidly damped out, and the difference of potential considerably reduced even

Digitized by Google

in the time of a quarter-period, *i.e.*,the time which elapses after an A spark before the B spark occurs. This same resistance it is which so markedly reduces the noise and violence of the A spark, *i.e.*, of the discharge altogether, when iron forms part of the circuit. A thin lead wire has something of the same effect, but a thick lead wire permits nearly as noisy a discharge as does copper. The throttling effect of even a thick iron wire is very marked.

It is noteworthy also that the adjustment for the critical B spark-length is decidedly sharper and more definite for iron or thin lead than it is for copper, especially for thick copper.

### Singular Effect of Iron Cores.

§ 62. It is further to be noticed that the introduction of iron into a helix, through which the discharge has to pass, although it does not affect the difference of potential required to propel the discharge through that helix, yet exerts a very marked effect in quieting the discharge. It may be understood as increasing the radiating power of the circuit, and thus aiding the quiet dissipation of energy. But if it did this alone it ought to shorten the B spark, as iron does when forming part of the circuit. It does not affect the B spark at all, so far as I have been able to ascertain, when inserted into helices; hence it would appear that it must increase the impedance of the alternate path, as well as the damping factor, and that the two effects, the one tending to lengthen the B spark, the other to shorten it, just neutralise each other.

I see no theoretical reason why these two different effects should just balance each other, and hence was at first disposed to explain the constancy of the B spark, when iron cores were introduced or removed, by supposing that they produced no effect whatever. But they do produce some effect, as is evidenced by their quieting of the noise of the discharge.

It is therefore singular that the E.M.F. needed to drive a discharge through a coil should be independent of the presence of iron in its core.

Referring back to § 34, theory gives for the ratio of the B spark potential to the A spark potential

$$\frac{\mathrm{B}}{\mathrm{A}}=\frac{\sqrt{(p_o^2+\mathrm{R}_o^2)}}{p+p_o}\,e^{-\frac{\pi(\mathrm{R}+\mathrm{R}_o)}{4\,(p+p_o)}}$$

where $p_o$ is the inertia part of the impedance of the alternative path, and $p$ the same thing for the rest of the circuit; and where $\mathrm{R}_o$ is the resistance or dissipation of energy constant for the alternative path (inclusive of its radiating power), and R the same thing for the rest of the circuit. Now an increase of $p_o$ alone would almost always increase the ratio B/A, but an increase of $\mathrm{R}_o$ alone need not. The effect of an iron core may naturally be supposed to consist in an increase of both $p_o$ and $\mathrm{R}_o$; and experiment suggests that while $\mathrm{R}_o$ is largely increased by the insertion of iron cores, there is also a corresponding increase in $p_o$ of such magnitude that the above ratio $\frac{\mathrm{B}}{\mathrm{A}}$ remains appreciably constant.

(*To be continued.*)

## THE ETHER AS A SOURCE OF MOTION.

BY S. TOLVER PRESTON.

The recent discoveries of Prof. Hertz having experimentally proved that all electric and magnetic "attractions" and "repulsions" are *ether thrusts*, additional confidence must be excited in the view that molecular "attractions" and "repulsions" are also *ether thrusts*. For "action at a distance" is now being generally discarded, and if so, what else can influence or act on molecules but the ether in which they are immersed? Besides, Faraday thought that molecular "attraction" (chemical action) was electric. Now, it is proved by Hertz's experiments (which confirm Maxwell's theory) that light and heat waves are *electric*; if so, Faraday's view that molecular actions are electric in their nature, must be true. Indeed it appears highly probable, if not certain, that molecular "attractions" are at least partly electric, if not wholly so. Such being the case, coal must be regarded (assuming the above highly probable view to be true) as a new *machine* for deriving motion from the ether; coal "combination" with oxygen being effected by ether thrusts.

It appears to me highly important at once, without waiting for this view to be *absolutely* proved, to ask ourselves now what we are doing, if this view be true. In our way of using coal (in the steam engine), we let the machinery—coal and oxygen—be thrown away after having made one stroke,* so to speak. The question is, is it necessary in deriving power from the ether, to *waste machinery* in proportion to the power derived? Can we not use our machinery in the same way as we employ all normal machinery for deriving power from *subsidiary* sources, winds, waterfalls, &c., *i.e*, can we not employ the machinery permanently, and not throw it away after having made one stroke, which is a very expensive process?

Would cooling down by suitable mechanism, the products of combustion to a point far lower than that yet reached, so weaken the molecular attractions by weakening the assumed cause of stress (viz., vibration), that by some imagined chemical process (?) the work required to separate out the carbon would be† notably reduced; and so the carbon could be used again as a normal machine for deriving motion from a source?

It must be so far true (on the above view) that—contrary to preconceived ideas—the energy expended in separating the carbon from the oxygen is not "stored up" so as to be available again for the approach of these molecules. It is no more necessarily "stored up" than the energy expended in separating a keeper from a magnet is necessarily "stored up," for, as far as we know, this expended energy is dissipated in the ether, and is not available for the return of the keeper. The keeper can return by an ether thrust or stress, and the ether can have inexhaustible energy to draw upon for effecting the return of the keeper; even if we expended no energy on the ether in separating the keeper. As a somewhat parallel instance—if the kinetic theory of gravity be true it is *certain* that in lifting a weight, the energy is *not* stored up for the fall of the weight, but dissipated beyond recovery in the ether.

"Why, then, expend energy in‡ lifting a weight or in separating a keeper at all?" it may be asked; or rather, "What is the *theoretic* necessity for this?" Obviously there is none, if the energy expended be not available for approach. If, then, a "screen" could be invented which reduced magnetic "attraction," we could separate the keeper with reduced work, and so the keeper could return again under the action of the ether, and we should have a second example of a *machine* for deriving motion from a source in a normal way. The same applies to electric "attractions." Surely it is important to recognise the theory of this.

It may be observed, too, that the ether gets at any rate all the energy back ultimately (although doubtless it does not want it, as its own store of energy is inexhaustible). For suppose we could invent a "screen" for nullifying or reducing the work expended in separating electric and magnetic bodies, and so derive energy continuously from the ether for industrial purposes, we should not cheat the ether of this energy. For, obviously, we cannot accelerate matter infinitely; if not, then, *whatever form the work takes*, the energy must return to the ether ultimately. Take the case of the locomotive, for instance. Suppose we drive it by coal; the same coal being employed as a normal machine (*i.e.*,

* I pointed out this (to be a consequence of rejecting "action at a distance") in the "Physics of the Ether," pp. 94—97. But now from the recent discoveries, this theoretic view is strongly confirmed by experimental means.

† Was any possibility of diminishing the force of molecular attraction contemplated in forming the second law of thermo-dynamics; and would the above hypothetical case be opposed to this law (which, however, it should be remembered, is not rigid, but self-violated on molecular scale in gases). Possibly we have not yet cooled down far enough to judge decisively what effect this has on the molecular forces.

‡ Under the old (statical) idea that the energy is "stored up," there seemed to be a theoretic necessity for expending energy; as it was argued the weight could not fall or the keeper return without. But in modern science we are concerned with dynamics, not with statics.

Digitized by Google

over and over again). Then, supposing this, for the sake of argument, to be possible; yet the ether which does the work gets all the energy back. For we know, as a fact, that all the energy expended on the locomotive and train, passes continuously to the ether, in the form of waves of heat. The products of combustion in cooling down (by radiation) give their energy—*back*, we may say, on our view—to the ether. The disturbed air in cooling down does the same, also the warmed axle-boxes, rails, &c. Not a particle of energy can be abstracted permanently from the ether; it must return to it. Why, then, it may be asked, waste energy, by giving energy (superfluously) to the ether which it does not want, when we separate (electrically charged?) molecules, electrically charged masses, and magnetic bodies? We have only to discover "screens," if they exist, or some other dodge or device, for avoiding performing work that serves no useful or rational object at all; and we then shall be able to utilise the ether as a source of motion in a way that is practical, and appears only normal and natural. Such is the problem, I venture to think, we should have clearly before us (and realise clearly the theoretical principles involved); since, if this problem be soluble, it can only be solved under that condition.

It may give additional confidence to note that in a Paper "On the Ultramundane Corpuscules of Le Sage" (relating to gravity), *Phil. Mag.* May, 1873, Sir William Thomson makes the remark incidentally, that if a crystal were permeable by the gravitation particles more easily in the direction of one axis than in the direction of another (as the crystal is in regard to light), then such a crystal would be slightly heavier according to which axis is vertical. So that we could derive work from the ether by employing such a crystal as a permanent machine (in the way I have elucidated); we could let the crystal fall when in a position of *maximum* weight and lift it up again when in a position of *minimum* weight. This would be deriving work from the ether by a machine, which (unlike coal), is not used *once* only, can be retained in permanent employ like a normal machine. So that Thomson admits that the principle *is not opposed to theory*, as we see. I may mention, as a fact, that I saw this Paper of Thomson's on Le Sage's theory of gravity, in 1877, when working on gravity at that time, my first Paper on that subject having been published in September, 1877. I had evolved the principle, however (from a somewhat different and more general point of view from that of Thomson), independently, as I need scarcely mention, in the "Physics of the Ether," pp. 94-97.

It may be remarked, perhaps, that I tried some experiments with very large tuning-forks in the late Prof. Guthrie's laboratory some seven years ago, and found it possible with a fork weighing, perhaps, some four to six pounds, to suspend floating in the air below the vibrating prong, pieces of carboard some 4in. long, ¾in. wide, and about $\frac{1}{16}$in. thick. Now, although I did not actually make the following experiment, there is no doubt that by suspending a strip of cardboard vertically by two threads, it could be deflected from the perpendicular by a vibrating fork placed at some distance. It would be easy then to introduce a "screen," such as a thin plate of metal between the cardboard and the fork, when the threads would resume their vertical position, owing to the "attraction" being neutralised by the screen. On taking away the screen, the cardboard will be attracted a second time, and the procedure may be repeated as often as wished.* So that this seems to be an illustration (experimental) of the possibility of deriving work through vibrating matter, with the co-operation of the medium in which this vibrating matter is immersed, and by means of a machine (here the fork) which is constantly used, and not only *once* used and then thrown away, like coal. This case would seem, therefore, to have considerable theoretic interest in regard to the problem of deriving work from the ether.†

* If the tuning fork be kept in vibration by an electromagnet, this would be comparable to a molecule kept in vibration by the sun (as we know it is).

† Of course, it is not of the slightest consequence how feeble the "attraction" of the fork for the cardboard is (if the effect be only visible), since we are not concerned with quantitative effects here, but with a principle. In the *Phil. Mag.* for November, 1870, and June, 1871, it is stated that attractive actions with forks were visible at the distance of a metre.

## THE MAGNETIC CIRCUIT OF TRANSFORMERS: CLOSED VERSUS OPEN.

BY S. EVERSHED.

(*Continued from page 725.*)

§ 69. To return to condensers. Imagine a simple conducting circuit of no resistance (Fig. 22). Suppose that at some time or other a current C was started in it. Some work was done in starting C—work stored in the surrounding medium as magnetic induction—but once having arrived at a steady value no more work is required and C will remain constant for ever. The total induction threading the circuit under these conditions may be called B. Now, what will happen if we suddenly put the condenser S into the circuit? Will the current stop instantly? Evidently not, for the moment that it began to do so, B would diminish, and so set up an electromotive force equal to $\frac{dB}{dt}$, driving the current on. If it does *not* stop it will begin charging the condenser, and creating a potential difference between its terminals in a direction tending to stop itself. It will therefore decrease, and while decreasing there will be the corresponding decrease in B, acting as a forward electromotive force against the back electromotive force due to the charging of the condenser. But the current does not want either a forward or a back E.M.F.; there being no resistance it needs exactly no E.M.F. Clearly then, the current will diminish just sufficiently fast to allow $\frac{dB}{dt}$ to be exactly equal at every instant but opposite in direction to the growing potential difference V at the condenser terminals. Now V is equal to

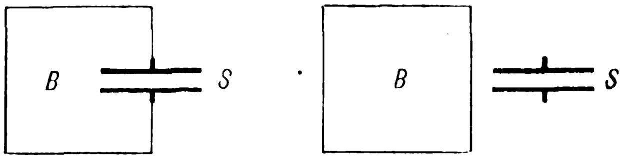



FIG. 22. -Electric Circuit of no Resistance, and Condenser.

the ratio of the quantity of electricity stored in the condenser to its capacity, K, or

$$V_t = -\frac{q_t}{K};$$

the minus sign is used because the charge would reverse the current if it could, and the current is considered to be positive. The E.M.F. due to the decreasing induction is $\frac{dB}{dt}$, and if we assume, for simplicity, that the magnetic medium is air or other non-magnetic substance, we know that B is directly proportional to C, so that we may write

$$B = LC,$$

where L is the induction due to unit current multiplied by the number of times it threads the circuit. L is usually called the coefficient of self-induction; it does not matter what it is called so long as it is clearly understood what it is. In the present case the induction is only linked once, there being only one turn of wire, so that L is simply the induction due to unit current.

§ 70. Now, $$\frac{dB}{dt} = L\frac{dC}{dt},$$

and this must at every instant exactly balance V;

therefore $$L\frac{dC}{dt} + V = 0 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

or $$L\frac{dC}{dt} = -\frac{q}{K}.$$

If this is differentiated with respect to $t$, we have

$$L\frac{d^2C}{dt^2} = -\frac{1}{K}\frac{dq}{dt} = -\frac{1}{K}C.$$

Digitized by Google

Each side may now be made a perfect differential by multiplying by $2\frac{dC}{dt}$; thus we have

$$2\frac{dC}{dt}\frac{d^2C}{dt^2} = -\frac{1}{LK}2\,C\frac{dC}{dt}.$$

Both sides being integrated, we arrive at

$$\left(\frac{dC}{dt}\right)^2 = -\frac{1}{LK}C^2 + A \quad . \quad . \quad . \quad . \quad . \quad (2)$$

A being the necessary constant of integration, the variables $c$ and $t$ can now be separated, preparatory to the final integration, thus:—

$$\frac{dC}{dt} = \frac{1}{\sqrt{LK}}\sqrt{ALK - C^2};$$

or

$$\frac{dC}{\sqrt{ALK - C^2}} = \frac{1}{\sqrt{LK}}dt.$$

The integral of the left-hand side is $\sin^{-1}\frac{C}{\sqrt{ALK}}$, so that

$$\sin^{-1}\frac{C}{\sqrt{ALK}} = \frac{t}{\sqrt{LK}} + \theta$$

and

$$C_t = \sqrt{ALK}\sin\left(\frac{t}{\sqrt{LK}} + \theta\right) \quad . \quad . \quad . \quad . \quad (3)$$

§ 71. This may be simplified, for we reckon time from the instant when $q = o$, that is to say, from the instant when the condenser was put into the circuit, and the current was then at its maximum, namely C′. But the above sine function is at its maximum when $\frac{t}{\sqrt{LK}} + \theta = 90°$, so that $\theta = 90°$ since $t = o$, and

$$C_o = C' = \sqrt{ALK}\sin\theta = \sqrt{ALK},$$

also $\sin\left(\frac{t}{\sqrt{LK}} + \theta\right)$ is equal to $\cos\frac{t}{\sqrt{LK}}$, so that (3) is reduced to

$$C_t = C'\cos\frac{t}{\sqrt{LK}} \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

The current then varies according to a simple periodic law. When $t = 0$ the current is at its maximum, and when $\frac{t}{\sqrt{LK}} = \frac{\pi}{2}$ the current is zero, so that the value of $t$ given by the equation

$$t = \frac{\pi}{2}\sqrt{LK},$$

corresponds with one-fourth of the complete period T, consequently

$$T = 2\pi\sqrt{LK},$$

or

$$F = \frac{1}{2\pi\sqrt{LK}}.$$

§ 72. The proof just given that the current becomes oscillatory when the condenser is inserted in the circuit has a somewhat fraudulent air of wisdom about it. It is either unreal or clumsy, according as it is seen from the point of view of the practical man or the mathematician. The latter may be referred to Sir W. Thomson's original Paper on the subject, or to Dr. Fleming's exhaustive discussion of condenser discharge ("Alternate Current Transformer," Vol. I., page 368). To the practical man we may be permitted to remark that the so-called solution of such a differential equation as (1) is in its very nature only guess-work, and the result is consequently no proof in the strict sense of the term. All we have really done is to find a function to express the relation between current and time, such that its rate of change at any instant is directly proportional to its integral from 0 up to that instant. For the electromotive force due to changing induction is proportional to the rate of change of current, and the potential difference at the condenser terminals is proportional to the quantity in it at any instant, that is to the integral of the current. Now in hunting for some function which fulfils this condition we soon discover the Cosine; its differential coefficient is a sine, its integral is a sine therefore if the current varies according to the Cosine of the time $\frac{dB}{dt}$ will vary directly as V, and consequently by using proper constants, we can make the induction E.M.F. always equal to V. The proof then, merely points to the Cosine as *a* function which fulfils the conditions, but it does not tell us that it is the only one. However having found a suitable function, the application of a little common-sense soon convinces us that it is the only possible one. The diagram given in Fig. 23 will serve as an aid to thought in arriving at orthodox convictions. The current C is shown as constant up to the time 0, when the condenser is put into the circuit. The current immediately falls off, and after a time $\frac{1}{4}$ T, reaches zero. At first sight it might seem the more rational course for the current to remain zero; but imagine it to do so and it is at once recognised that $\frac{dB}{dt}$ would immediately fall to zero also, leaving V to drive an *infinite* current back through the circuit, there being no resistance.

§ 73. Having thus started an alternating current in a condenser circuit, will it ever stop? Only a short time ago one would have said no, with a light heart. We are now, however, compelled to admit that the current waves do really produce radiation waves in the ether, or rather the two things are part and parcel of the same phenomenon. At all events light waves—very long ones—emanate from the circuit as a centre, and a little energy goes flying off into the uttermost parts of the universe, doing some good there let us hope, but, so far as our circuit and condenser are concerned, the available store of energy put into the circuit when we started the current C is gradually frittered away, and becomes lost to us. Consequently the alternate current would slowly die away, even if the resistance of the circuit were really zero as we have assumed.

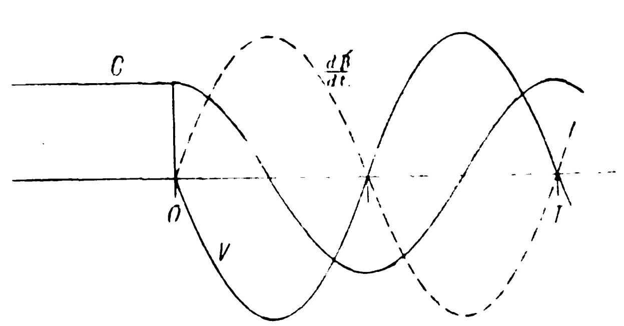



FIG. 23.—Diagram of Electromotive Forces and Current in the circuit shown in Fig. 22. C is the steady current. The condenser is put in the circuit at the epoch O. The full line V is the potential difference at the condenser terminals. The dotted line $\frac{dB}{dt}$ is the counter E.M.F. due to the changing induction in the circuit.

§ 74. Fig. 23 shows that the oscillatory current in a condenser circuit is necessarily an idle current, and therefore exactly what is wanted to supply the idle part of the exciting current of an open transformer. But real circuits have a tangible resistance, and this leads to a rapid diminution of the amplitude of the current waves, unless we can devise a method by which the energy thus lost by the circuit may be continuously replaced by a fresh supply. Suppose the circuit in Fig. 22 has a finite resistance R, then we might imagine a magnet to be spun round anywhere in the circuit so that its induction threaded it alternately in reverse directions. If the magnet is rotated so that the impressed E.M.F due to it has the same frequency as the current, and if we further arrange that its E.M.F. is cophasal with the current and at every instant exactly equal to C R (plus something very small for the power supplied to the universe as extra-double-infra-red-light), the state of things shown in Fig. 23 becomes possible and stable, although it is not exactly what is wanted and does not represent what Mr.

Digitized by Google

Swinburne is trying to achieve. Given a circuit and condenser like that in Fig. 22, can the necessary power be supplied in any other way? Yes. The condenser may be shunted by a branch circuit G. (Fig. 24).

§ 75. The current will want to divide itself between P and G, and as it is all required to traverse P which represents a transformer primary, we will have an alternator A in the G circuit running at the same frequency as the alternating condenser current in P, and impressing an E.M.F. cophasal with V and $\frac{dB}{dt}$, and of the same magnitude and shape. This will prevent any current flowing through A, so that the condenser current will alternate through P exactly as though the G circuit were absent. Now let us put another alternator *a* into the G circuit, running at the same frequency but a quarter period ahead of A, so as to have its E.M.F. cophasal with the alternating condenser current. The E.M.F. of the little alternator, being adjusted to the right value, will supply the $C^2R$ loss in the transformer primary circuit P in precisely the same way as the spinning magnet was supposed to do. Of course in practice the alternator A not only supplies the E required to keep the current out of G, but by being run slightly out of step with the phase of V and $\frac{dB}{dt}$, it can be made to have a component E a quarter period ahead, and of the right value to provide for $C^2R$ lost in P. All this sounds very alarming but in reality there are no adjustments. The condenser settles everything without human aid, for when connected across the mains it immediately monopolises just so much of the idle

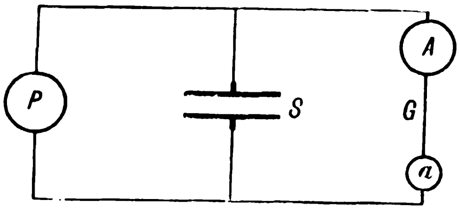



FIG. 24.

current in P as will make its potential difference equal at every instant to that on the mains, and it is a simple matter to calculate what capacity the condenser ought to have to deal with the whole of the idle current in P and no more. Of course the switching on of the condenser tends to lighten the load on the alternator by the equivalent of the waste of power as $C^2R$ in its armature coils due to the idle current. We say tends to lighten—it is by no means certain that condensers can be made to absorb no power, and the $C^2R$ loss saved in the armature may possibly be balanced by a different kind of $C^2R$ loss in the dielectric of the condenser.

§ 76. The condenser capacity required to supply an idle current of given value is readily found from the following considerations. Assume the idle current C is really sinoidal, so that

$$C = C' \cos \frac{2\pi}{T} t.$$

Suppose the system is working at an effective pressure E on the transformer primaries, then at the instant at which $C = 0$, that is when $t = \frac{T}{4}$, the potential difference between the mains is a maximum, and approximately equal to $\sqrt{2}$ E. The quantity of electricity available for the condenser during the quarter period is

$$Q' = \int_0^{\frac{T}{4}} C\,dt,$$

and the capacity of the condenser must be such that this quantity Q′ raises V to exactly $\sqrt{2}$ E; but

$$Q' = \int_0^{\frac{T}{4}} C\,dt = \int_0^{\frac{T}{4}} C' \cos \frac{2\pi}{T} t\,dt = C' \frac{T}{2\pi};$$

and therefore since $V' = \frac{Q'}{K}$,

$$V' = \frac{C'T}{2\pi K} = \sqrt{2}\,E;$$

or remembering that $C' = \sqrt{2}\,C$,

$$K = \frac{CT}{2\pi E}; \quad \text{or } K = \frac{C}{2\pi E F},$$

an equation which gives the capacity K in farads when E and C are effective volts and amperes, and T is the periodic time in seconds, or F the frequency. But how if the idle current is not sinoidal? We have seen that in order to keep it out of the alternator it must follow a sine law, otherwise V cannot be made equal to E at each instant, and if these two variables are not always equal and opposite, some current will succeed in passing beyond the condenser terminals and traverse the armature of the alternator. If the current is not a simple sine function of the time the condenser cannot possibly be made to take the whole of it; it will only absorb what may be called the sine component of the current, leaving all irregularities in the current-wave—*ripples* as they are poetically called—to be supplied by the alternator. But for all practical purposes the formula just given is perfectly reliable, as only a comparatively rough guide is wanted to enable a condenser of suitable proportions to be made up, leaving the final adjustment until it is in actual use, when its capacity is readily varied until an ammeter in the main between the alternator and condenser indicates that the former is supplying the minimum current.

§ 77. A transformer circuit with a condenser across the mains presents the curious paradox of a complete metallic circuit in which the current is very much greater in one part than in the remainder. Perhaps it was this paradoxical behaviour (first described by Mr. Blakesley) which directed Mr. Swinburne's attention to condensers. One is so accustomed to consider it an axiom that the total current flow at any instant is the same at every part of a complete conducting circuit, that the condition tacitly implied in the axiom, namely that the circuit has no electrostatic capacity, is forgotten. To the eye of Maxwell and perhaps also of Faraday, the condenser itself was just as much a part of the circuit as the wires themselves, and from this point of view there is nothing anomalous in a condenser circuit. Counting the condenser as a part of the circuit the algebraic sum of the currents in the three branches P, S, and G (Fig. 24) is at every instant exactly zero.

*(To be concluded.)*

## THE ELECTRIC LIGHTING OF ST. BRIEUC.

BY GASTON ROUX.

Saturday next, the inauguration of the electric light at St. Brieuc will take place. The installation is unimportant from the point of view of mere size, but it is worthy of notice as being the first one on the Thomson-Houston system which has been erected in France. It possesses, moreover, one or two peculiar features, the power being generated eight miles from the lamps to be lighted, and the alternators employed being regularly worked in parallel with compounded excitation. Having spent several days at St. Brieuc, in carrying out some experiments with alternating currents, I was able to study every detail of the installation, a brief account of which may not be without interest.

The generating station is situated at Ponts-Neufs, and the motive power is furnished by two Hercules turbines, fitted with automatic governors and running at 250 revolutions, made by Singrün, of Epinal, one being of 125 H.P., and the other of 75 H.P. They can run separately or simultaneously the same shaft on which are two active and two idle pulleys. They are fed by a 36ft. fall from a reservoir of about 33,000,000 gallons capacity, into which three small streams run.

The dynamos are two 70-unit Thomson-Houston composite-field alternators, giving from 2,100 to 2,600 volts at 1,070 revolutions. The difference of potential at the dynamo terminals varies within wide limits, since the fall of pressure on the line at full load is 20 per 100. The main excitation is furnished by

Digitized by Google

small continuous current machines as usual, but the additional excitation required to compensate for the fall on the line is supplied by a rectified current taken from the alternator itself. The manner in which this is carried out is shown by the accompanying diagrams (Fig. 1). The armature is wound in two halves, $A_1$, $A_2$. One end of each half winding-terminates at the collector ring, $C_1$ and $C_2$ respectively, and the other ends are connected, as shown, to opposite sides of the rectifying commutator, R, to the two brushes of which are joined in parallel the compensating field-magnet circuit and the adjustable resistance. This commutator R is arranged at the end of the watched, and at the moment when they burn brightly the new machine is switched into circuit. Owing to the great impedance of the reactive coil the new machine gives but little current at first. The copper is, however, now slowly swung over until it completely covers the coil, when the reactive apparatus is switched out of circuit.

At the preliminary trials at Ponts-Neufs the total load was only half the maximum output of a single alternator, yet running in parallel was easily carried out. A wattmeter was introduced into the circuit of the loaded alternator, and it was easy to see that the load was divided the moment the second machine was

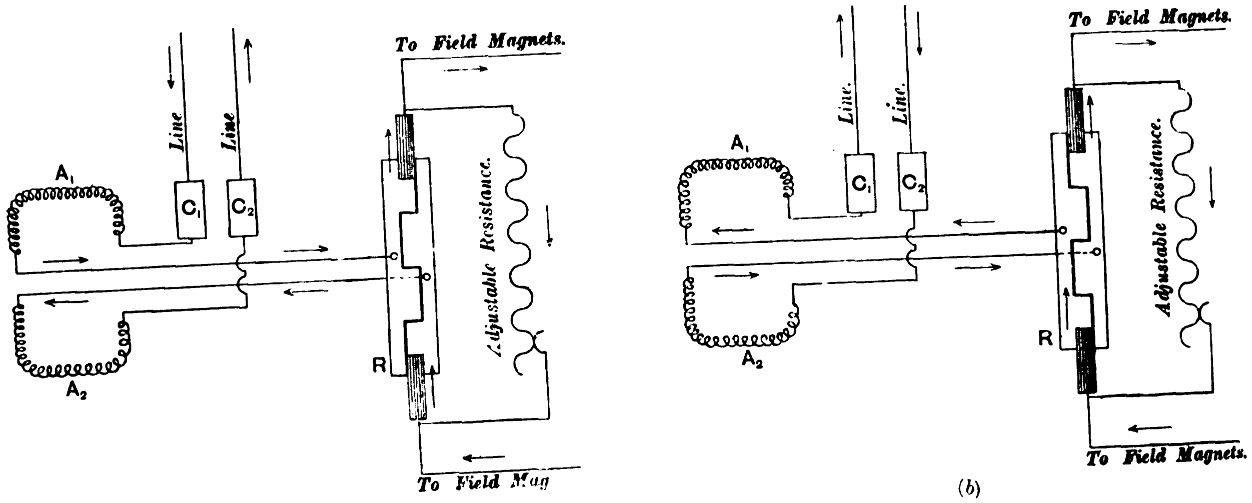



Fig. 1.—Diagram of the Connections of the Thomson-Houston Composite-Field Alternator.

dynamo spindle, and has as many divisions as the alternator has poles, with the result (*see* Fig. 1, *a* and *b*) that the current in the field-magnet circuit is kept uni-directional, and increases as the total current flowing in the armature increases, so that the increased loss on the line is compensated for by increased excitation. The low resistance of the adjustable shunt entirely prevents sparking at the brushes. Great care has been taken to insulate the alternators from earth. They are mounted on blocks of paraffined wood resting on a thick sheet of indiarubber, which in turn rests on more blocks of paraffined wood, the holding-down bolts being cased in indiarubber tubes. The two machines are arranged to run in parallel as soon as one is

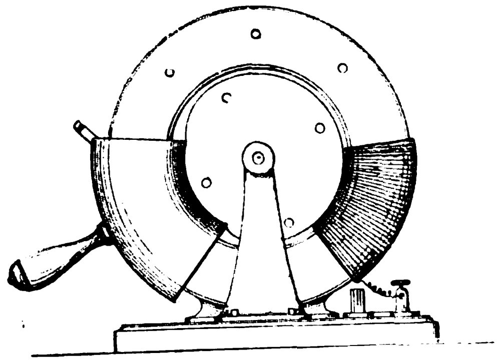


Fig. 2.—Reactive Coil or Dimmer.

working at maximum load. As the switching over has to be carried out without fluctuation of the lights, a reactive coil (Fig. 2)* is first of all brought into circuit with the new machine and its inductance slowly diminished until the new machine is giving the required current.

The exact *modus operandi* is as follows:—The additional machine is first of all speeded up and excited, and the reactive coil thrown into circuit, the copper sheath being well away from the primary coil. Two pilot phase lamps, which are connected in series to the secondaries of a double transformer, the primaries of which are in series with the two machines, are then

* For description see *The Electrician*, January 2, 1891, p. 256.

switched in. At each passage of the seam of the belt over the pulleys, however, there was a small transfer of energy.

The switchboard, it should be mentioned, is provided with the ingenious Thomson-Houston lightning arresters* and earth detectors. A sketch of the earth detector is given in Fig. 3, by which it can be seen that if the switch L is connected to the + main, the existence of an earth on the − main will be shown by the lamp lighting up, provided the fault is of fairly low resistance.

The wires are run overhead, 18in. apart, on double-bell porcelain insulators, supported on wooden posts 20ft. high.

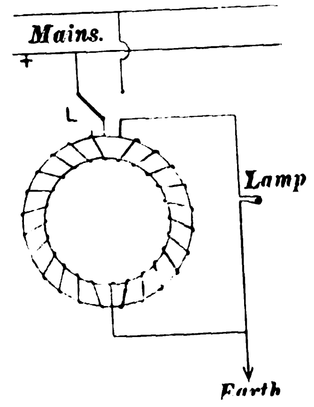



Fig. 3.—Thomson-Houston Earth Detector.

The conductor is of stranded Mouchel copper. It has a cross-section of ·075 sq. in., and is lightly insulated. The resistance of the line is 8·9 ohms. Near the town the line runs under the railway, and here Berthoud-Borel concentric cables are used.

The fuses which are fitted on the primary circuits of the transformers are of a somewhat peculiar kind. Unlike Mr. Ferranti's, these fuses are very short, being only 1¼in. long; and as they are bent into the arc of a circle the distance between terminal and terminal is barely ¾in. The lead strips are, however, enclosed in a loose indiarubber tubing. Several tests were made to see if a permanent arc would not form

* See *The Electrician*, January 9, 1891.

Digitized by Google

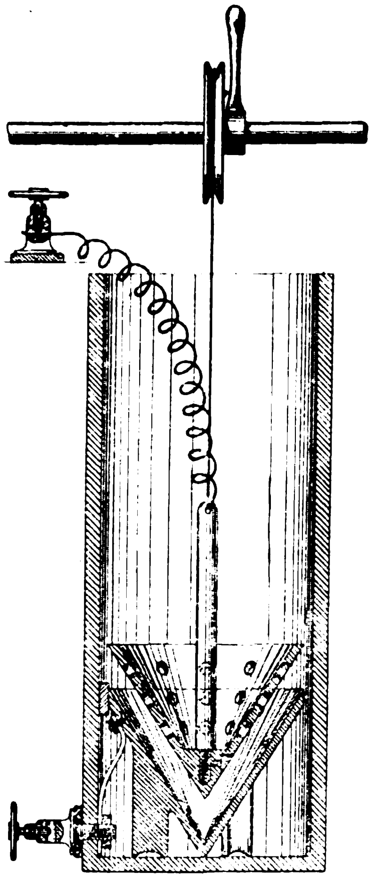
across this short break whenever a fuse melted. So long as the indiarubber tube was retained, nothing happened on melting the fuse, but an arc invariably formed (even with a much longer break) when the experiment was tried without the protective tube.

The charge is by meter, or on a three years' agreement, the lamps being replaced by the Company. The price of a Board of Trade unit is 7d.

## LYON'S LIQUID RESISTANCE.

The stage lighting of the Lyric Theatre is controlled by resistances invented and patented by Mr. H. Lyon, and, after being used at every performance for nearly six months, they have proved to be very well adapted for the purpose.

Provision is made for the control of 21 separate circuits, and for each of these a resistance is provided. The apparatus consists of a stoneware jar or cylinder two feet deep by nine inches



diameter. An inverted cone of lead, having three feet cast on it, stands on the bottom of the jar, and is connected to one of the conductors by a bolt passing through a hole near the bottom, a water-tight joint being made of india-rubber washers. This cone is fixed in place by wooden wedges. A second cone is attached by a flexible conductor to a terminal fixed near the top of the jar, and is suspended by a cord, so that it can be raised or lowered by means of a pulley. The jar contains a suitable electrolytic solution of metallic salts, and the movable cone is provided with holes to allow it to move more readily through the liquid. The cones are turned in a lathe so that they may make a good fit when in contact. The column of liquid for 50 amperes is about 10in. deep. It is found that when the cones are in contact, the resistance is quite negligible, there being only a very small fraction of a volt fall when 30 amperes are passing. On slowly moving the handle attached to the pulley, the cone rises and resistance is gradually introduced, the motion being perfectly smooth. It is, indeed, impossible to jerk it owing to the dash-pot action of the cone in the liquid.

Resistances of this kind are particularly suitable for stage effects since the illumination may be changed insensibly, and coloured lamps may be very gradually substituted for white, by allowing one resistance to increase and another to decrease simultaneously. Not only is the resistance introduced by the separation of the cones, but when the movable one begins to emerge from the liquid, the area of contact diminishes until, just before breaking contact, the current is reduced so much that there is no visible spark. The effervescence is very trifling, and, owing to the depth of the jar, no spray whatever is given off. The temperature of the liquid under ordinary daily work does not appreciably vary. The resistances at the Lyric Theatre are arranged in two sets, each separate circuit being provided with an independent lever, but each half can be worked simultaneously by a worm gear.

It is evident that a resistance which is capable of such smooth working affords great facility for accuracy of adjustment to any desired value, and cannot inflict the serious shocks on dynamos supplying the current, which nearly always happen when ordinary switches are used. Mr. Lyon, therefore, has designed special forms of his resistance for use in electroplating and electrotyping, and in connection with an important plant for transmission of power.

## MEETINGS OF SCIENTIFIC SOCIETIES, &c.

**FRIDAY, April 24th** (To-Night).

Institution of Civil Engineers.

*7.30 p.m.* Students' Meeting. Papers to be read: (1) "A New Type of Water-Motor." By A. Sealy-Allin, Stud. Inst. C.E. (2) "Hydraulic Power as applied to Pressing-Machinery." By H. Evington, Stud. Inst. C.E.

Old Students' Association.

*7.30 p.m.* Smoking Concert at Mason's Hall Tavern.

Royal Institution.

*9 p.m.* Evening Discourse. "Euphuism—Past and Present." By Rev. Canon Ainger, LL.D.

**SATURDAY, April 25th.**

Royal Institution.

*3 p.m.* Afternoon Lecture. "The Dynamo." By Prof. Silvanus P. Thompson, D.Sc.

**TUESDAY, April 28th.**

Institution of Civil Engineers.

*8 p.m.* Ordinary Meeting. Paper to be further discussed: "The Cost of the Generation and Distribution of Electrical Energy." By R. E. B. Crompton, M. Inst. C.E.

**WEDNESDAY, April 29th.**

Society of Arts.

*8 p.m.* Ordinary Meeting. "The Use of Petroleum in Prime Motors." By Prof. William Robinson.

**THURSDAY, April 30th.**

Royal Institution.

*3 p.m.* Afternoon Lecture: "Recent Spectroscopic Investigations." By Prof. Dewar, F.R.S.

Institution of Mechanical Engineers.

*7.30 p.m.* Ordinary General Meeting. Papers to be read and discussed, as far as time permits: "Research Committee on Marine-Engine Trials: Report upon Trial of the steamer 'Iona.'" By Prof. Alexander B. W. Kennedy, F.R.S. "On some details in the Construction of modern Lacashire Boilers." By Samuel Boswell.

**FRIDAY, May 1st.**

Royal Institution.

*5 p.m.* Annual Meeting.
*9 p.m.* Evening Discourse. "Hawks and Hawking." By J. E. Harting, F.L.S.

Institution of Mechanical Engineers.

*7.30 p.m.* Ordinary General Meeting.

**SATURDAY, May 2nd.**

Royal Institution.

*3 p.m.* Afternoon Lecture. "The Dynamo." By Prof. Silvanus P. Thompson, D.Sc.

*** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

Digitized by Google

# The Electrician.

**Published every Friday, Price Fourpence; Post Free, Fourpence Halfpenny**
**Editorial, Publishing, and Printing Offices:**
**SALISBURY COURT, FLEET ST., LONDON, E.C.**
*Telephone No.* 2714. *Telegrams:* "ELECTRICIAN NEWSPAPER, LONDON."

*All Letters relating to Subscriptions, Advertisements and other business matters should be addressed to the Publisher,* "THE ELECTRICIAN," *Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to* "THE ELECTRICIAN" *Printing and Publishing Company, Limited, and be crossed* "*Coutts and Co*" *All other letters to be addressed to the Editor.*
*All letters intended for insertion in* "THE ELECTRICIAN," *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

"THE ELECTRICIAN" *is published every Friday morning, in time for the morning mails. Subscribers should receive their copies by the first post on Friday morning.*
"THE ELECTRICIAN" *is on sale at the railway bookstalls throughout the Kingdom on Friday morning, and can be obtained of all Booksellers and Newsvendors; or direct from the Publishing Offices as above.*
*New Volumes of* "THE ELECTRICIAN" *commence in May and November.*



## SUBSCRIPTION RATES.

The rates for Subscriptions to "THE ELECTRICIAN" are as follows:—

| | 3 months s. d. | 6 months. s. d. | 12 months. s. d. |
|---|---|---|---|
| For the United Kingdom | 5 0 | 10 0 | 19 6 |
| For Foreign Parts and Colonies:— Within Postal Union | 6 6 | 12 6 | 24 0 |
| For Aden, Borneo, Ceylon, China, India, Japan, Java, Labuan, Mozambique, New Caledonia, Persia, Philippine Islands, Siam, Transvaal, and Zanzibar | 7 6 | 14 6 | 28 0 |

## TO ADVERTISERS.

"THE ELECTRICIAN" *offers exceptional advantages to Advertisers.* **It has by far the largest circulation of any English Electrical paper, and circulates all over the World.**
*Particulars relating to Advertisements will be promptly forwarded on application to the Offices as above.*
TRADE ADVERTISEMENTS *intended for the current issue must reach the Offices not later than First Post on Thursday morning. Renewals of expiring advertisement orders and alterations to standing advertisements should be in the Publisher's hands by Wednesday at latest. No alteration can be made in Wrapper advertisements after Wednesday evening.*
SMALL PREPAID ADVERTISEMENTS *(for Rates see page xvii.) are accepted up to 4 p.m. on Thursday.*

## TECHNICAL PRINTING.

"THE ELECTRICIAN" PRINTING AND PUBLISHING COMPANY (LIMITED) *inform Electricians, Electric Light Engineers, &c., that they make a specialty of Technical Printing, and have a large Staff thoroughly acquainted with Electro-Technology. They can, therefore, promise Accuracy and Despatch in the Printing of Electro-Technical Literature, &c.*

## "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. (Royal 8vo.)

*Early in each year is issued* "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. *The* DIRECTORY *was established in 1883, and the 1891 Edition, published on the 23rd February, 1891, consists of 900 pages of printed matter. The names and addresses of all persons engaged in the Electrical Industries at home and abroad may be relied upon as accurate. Useful Tables and Electrical Formulæ, and information specially compiled for this work are given, together with popularly-written Biographical Notices of the leading Electricians, Electrical Engineers, &c., accompanied in many cases by Portraits.*
*The issue for 1891 is ready, and should be ordered at once. Price 5s., post free 5s. 9d. Abroad postage extra. Full particulars on application.*

## ELECTRICAL BOOKS AND PUBLICATIONS

*All Books, Newspapers, and other publications, dealing with Electrical and kindred subjects, can be ordered direct of* "THE ELECTRICIAN" *Printing and Publishing Company, who are proprietors of the well-known* "ELECTRICIAN" *Series of Standard Electrical Works, and are agents for all the leading publishing houses at home and abroad.*


## CONTENTS OF THE CURRENT NUMBER.


NOTES ... 749
Lightning Conductors. By Dr. Oliver Lodge ... 753
The Ether as a Source of Motion. By S. Tolver Preston ... 754
The Magnetic Circuit of Transformers: Closed versus Open. By S. Evershed. Continued. Illustrated ... 755
The Electric Lighting of St. Brieuc. By Gaston Roux. Illustrated ... 757
Lyon's Liquid Resistance. Illus. 759
Meetings of Scientific Societies 759
ECONOMY IN THE USE OF GLOW LAMPS ... 760
Reviews ... 762
The Effect of a Condenser introduced into an Alternating-Circuit. By Dr. Oliver Lodge 762
Note on the Relative Degree of Disturbance caused by Electrostatic and Electro-Magnetic Induction between Telephone Circuits. By A. E. Kennelly. Illustrated ... 763
Tanning by the Aid of Electricity 763
Physical Society—On a Property of Magnetic Shunts ... 764
An Alternating Current Influence Machine ... 764
Report of High-Speed Electric Railway Work. By O. T. Crosby ... 765
Books Received ... 766
Some Remarks on Herr H. Luggin's Work on the Mode of Conduction in Arc Lights. By F. Uppenborn ... 767
Parliamentary Intelligence ... 767
American Notes ... 767
CORRESPONDENCE—
The Split Dynamometer for Determining Differences of Phase between Two Alternating Currents of Equal Period—Chas. Steinmetz ... 767
Inductive Disturbances in Telephone Circuits—A. R. Bennett ... 768
Wiring of Calico Print Works—M. & Co. ... 769
Contractors' Grievances — W. H. ... 769
Legal Intelligence ... 769
Trade Notes and Notices ... 770
PATENT RECORD ... 771
COMPANIES' MEETINGS, &c.—
Eastern Extension, Australasia and China Telegraph Company (Limited) ... 772
South of England Telephone Company (Limited) ... 774
Reuter's Telgram Company Limited ... 774
New Companies registered ... 775
City Notes, &c. ... 775
Companies' Share List ... 776



## STEEL-PLATE PORTRAITS

*Of W. H. Preece, F.R.S.; Michael Faraday; Sir John Pender, K.C.M.G.; Sir William Thomson, F.R.S. (Past-President of the Institution of Electrical Engineers); C. H. B. Patey, C.B. (Late Secretary of Telegraphs, G.P.O.); Dr. John Hopkinson, F.R.S. (Past-President of the Institution of Electrical Engineers); Dr. Oliver J. Lodge, F.R.S., and Prof. William Crookes, F.R.S. (President of the Institution of Electrical Engineers), have been issued as Supplements to* "THE ELECTRICIAN." *A few Copies of these admirably-executed Steel Engravings can be supplied, price 1s. each, post free on roller, 1s. 2d. Or framed in neat Black Pillar or Brown Ornamental Frames, price, post free, 4s. 6d.*


## ECONOMY IN THE USE OF GLOW LAMPS.

An advance proof of an article on the highest economy in the use of glow lamps has been forwarded to us by Mr. H. WARD LEONARD, of the Edison General Electric Company of New York. Unfortunately, the conclusions which he draws, and the data by which they are arrived at differ so widely from the practice of this country, that in its present form the article would be of little interest to our readers. The subject, however, is one that concerns every user of electric light, and every supply company, though it affects them in different ways. In the United States the lamp renewals are often undertaken by the supply companies, and it is not unusual, we believe, for contracts to be made for the supply of so much candle power. Nothing of the kind is to be found with us, nor will be until street lighting is undertaken by supply companies. There is little indication of any extension in this direction at present, since it is well known that street lighting is generally done at a contract price which does not pay the gas companies. While there are a few examples of street lighting by glow lamps as at Weybridge and Fareham, it is probable that in the larger towns this will only be undertaken when the local authorities themselves supply the current. The interests will then be identical, as

Digitized by Google

both coal bill and lamp renewals will be paid for from the same purse.

At present, the consumer naturally tries to keep down his meter readings, and at the same time, his lamp bill; all he wants is light, and for the minimum cost. The supply company, on the other hand, wants to induce the customer to take as much electrical energy as possible. The efficiency of lamps affects the company in two ways, while the cost of lamp renewals does not concern them in the slightest degree. If wasteful lamps at five watts per candle are fashionable, the meters will run round, and the earnings will be increased, but as Mr. F. Bailey pointed out at the Society of Arts in December last, "an improved lamp efficiency will benefit the supply companies by enabling them to increase their lamp connection." Given a house wired for a number of lamps, the majority being eight candle-power nominal, and the pressure being fairly constant at 100 volts; given also the price of a lamp at 3s. 9d., and the cost of electrical energy at 7d. per unit, what is the best efficiency at which to run the lamps, or with the ordinary Edison-Swan make, what nominal voltage should be chosen? The lamp makers reply that their lamps should be run at four watts per candle—that is to say, 100 volt lamps are to be used, and the consumer gets about 36 candle-power hours for one penny. If he uses 95 volt lamps, they will give about 20 per cent. more light, and will consume about 4½ per cent. more current, giving at about 3½ watts per candle some 41 candle-power hours for a penny. But the life will be shortened. On the other hand, if he uses 105 volt lamps, there will be more than 20 per cent. decrease in the light, which will be of a dull quality; he will save about 3 per cent. of current, the lamp will run at about 5 watts per candle, giving 29 candle-power-hours for one penny, but the cost of renewals will be very considerably decreased. From the consumer's point of view it should not be difficult to arrive at the best possible point at which the cost of current and of lamp renewals is a minimum. In a Paper before the Physical Society in 1885 this was shown, but the lamps were of foreign manufacture, and not comparable with those of the present day. Our information as to the life of glow lamps is very meagre, and it is not likely that any very important contribution will be made to our knowledge of the subject, until the present master patents expire. We shall then have a flood of promises, but shall be unable to judge of their accuracy until the new lamps have run their thousand hours or so. Even before the first batch have had their day, the makers will have probably gained such further experience that a second edition of their prospectuses may be nearer the mark as to the durability of their goods. At present, we have a general notion that lamps last from 1,000 to 2,000 hours, if run steadily at their marked voltage. It is customary to accept the recommendation of the manufacturer, and to use the lamps at the pressure marked upon them. Of course, everybody grumbles at a monopoly except those within the ring, but almost every English electrical engineer has reason to be thankful that the lamps to which we are restricted in this country are as good as they are, and it is generally felt that the extravagant price at which they are sold contributes in some measure towards the careful and scientific development of the very important work which is done at Ponder's End.

The life of the lamps could possibly be arrived at by instituting extensive observations in large concerns, but such statistics are always rendered uncertain owing to a want of perfect uniformity in the pressure. A given variation in the pressure undoubtedly produces a much greater variation in the life of a lamp. For this reason the mean voltage is not to be relied upon. A *short* spell of high pressure will tell on the duration of a filament, but a similar spell of low pressure will not materially prolong its life. If the pressure be 105 volts for four hours and 99 volts for the remaining twenty hours of the day, the mean will be one hundred, but the life of the lamps will be shorter than if the voltage had remained constant at this mean value. But there must be some well defined and probably some simple relation between the life of ordinary glow lamps and the pressure, this pressure being constant—we are only concerned at present with the single make of lamps commonly used in this country. This relation is perhaps buried in the bosoms of the directors, or, more likely, of the manager and scientific adviser of the Company, and it is jealously guarded, not, we are sure, because they are ashamed of it, but because any statement might "be used against them" as a guarantee. At present, then, it is not possible to decide in this country, as is done by Mr. Ward Leonard, at what strain it is desirable to run any given lamp. He arrives at 3·1 watts per candle with 600 hours' life, but bases his calculations on 1·7 cents per horse-power hour, and 44 cents as the cost of a lamp. The lamps to which he refers have a life of 300 hours at 2·77 watts, 900 hours at 3·6, and 1,500 at 4 watts. He finds that these last conditions are the most economical when fuel costs nothing, and ·1007 cent per hour is charged for labour, insurance, taxes, &c.

Accepting as we do the nominal volts of a lamp, we assent to the recommendation of the lamp makers, that four watts per candle is a desirable strain to apply to the filament. Having already disclaimed any hostile disposition towards them, we venture to raise the question as to whether they are altogether the proper authorities from which such a recommendation should come. That it is generally accepted is an unmistakable proof of the confidence which is felt both in their honesty and in their intimate scientific knowledge of the physics of the glow-lamp, for it is to their immediate interest to advocate a short life and a merry one. Has, then, the "co-efficient of involuntary mendacity" anything to do with this four watts per candle as far as the consumer is concerned? and does the life of the filament at four watts per candle give best possible economy when the electrical energy costs 7d. per unit? We have not any intention of attempting to pry into trade secrets, but there are several matters of great interest to the electric lighting industry which might be revealed in the form of percentages or factors without disclosing any actual statistics. Mr. Bailey, for example, in the paper to which we have already alluded, gave some information as to the candle power of lamps mostly used. He gave statistics comprising several thousand lamps. The makers could easily give the relative numbers without alluding in any way to the actual numbers. They might also recommend that lamps should be run at, say, their nominal voltage when energy costs 7d. per unit, and may with economy be overrun to a certain amount when 9d. is charged. From such a recommendation the life of the lamps might perhaps be calculated by some inquisitive person, but the result would have to be arrived at by so roundabout a method that there would not be much danger to the makers of any confrontation with the figure as constituting a guarantee. Of course there is another argument in support of their reticence, and that is, that they do not want to teach their trade to those who will soon begin to compete with them.

The matter is one which concerns large users of electric light, but which hardly touches the supply companies, cutting as it does in two directions as far as they are concerned. In America they have a great advantage, and the Paper by Mr. Ward Leonard, coming as it does with such authority, places at the disposal of consumers of electric light in that country some very valuable information.

Digitized by Google

## REVIEWS.

**Wiring Slide Rule.** (Crompton and Co., Limited.)

Most engineers are so familiar with the slide rule which is usually placed in the ordinary two-foot rule, that the contempt they frequently show by not using it is remarkable; it is, in fact, more generally employed for taking dimensions of small holes than for arithmetical work. Slide rules have also been designed for calculating the strength of girders and for similar work; but no slide rule has hitherto been introduced which shows greater promise of utility than the Wiring Slide Rule invented by Mr. A. P. Trotter, and now being issued by Messrs. Crompton and Co. (Limited). Electrical Engineers can now obtain all the information they require for wiring purposes from a small card provided with two slides. The range covered by the card includes any number of lamps up to 100, from 5 c.p to 40 c.p., and taking from 20 watts to 150 watts supplied at any distance up to 500 yards with any given fall of potential from one to 25 volts.

Easy manipulation of the slides gives the size of cable required, the current density, the maximum current for cased conductors for a limiting rise of temperature of 35° Fahr., and other information. The sizes of cables are given in both S.W.G. and B.W.G., and for solid and stranded conductors; a most instructive line being devoted to the amperes per square inch for two volts fall. When so many price lists and catalogues issued by the manufacturers of covered conductors are disfigured by a column professing to give the "capacity (!) in amperes" or "working current," mostly calculated not only at 1,000 amperes per square inch, but even at 2,000 amperes per square inch, the advent of this wiring slide rule comes at an appropriate time, and cannot fail to be appreciated. Wiring contractors will find it invaluable, and as five minutes' practice will enable anyone in charge of wiring work to understand its use, it may reasonably be hoped that users of the electric light will never have to say, "We get a good light in the basement, but the lamps are very dull upstairs."

The slide rule is at present constructed on a card, which might well be glazed or varnished; and it is to be hoped that it will be produced as an ivory rule, with, say, bevelled edges, one marked off in inches and the other in millimetres.

F. B.

## THE EFFECT OF A CONDENSER INTRODUCED INTO AN ALTERNATING-CURRENT CIRCUIT.

BY DR. OLIVER LODGE.

The history of the reaction of a condenser on alternating currents, which has recently excited some interest in connection with the Deptford mains, and has been called by the undesirable name of "the Ferranti effect," seems to be as follows:—

In March, 1868, Sir W. R. Grove described in the *Phil. Mag.* an observation he had made as to the increased power of a magneto-electric machine to excite an induction coil when a condenser was interposed in the circuit: not as a lateral expansion as usual, but directly in the circuit.

In May of the same year, Clerk Maxwell explained the effect entirely, expressing it both mathematically and popularly (*see Phil. Mag.*, 1868, or *Scientific Papers*, Vol. II., page 121).

Then Dr. Alexander Muirhead re-discovered the effect, and told Dr. Hopkinson of it; and the latter, in November, 1884 (*Journal*, Society of Telegraph Engineers, XIII., p. 513), explained it on the same lines as Clerk Maxwell. Then Mr. Ferranti re-observed it, this time on a commercial scale, and the matter has become well known.

The shortest statement of the theory is, perhaps, as follows:—

The equation to the current of a condenser connected to an alternating dynamo is

$$L\frac{dC}{dt}+RC+\frac{1}{S}\int C\,dt=E\sin pt$$

instead of $=0$ as usual.

The solution of this equation is, writing $\frac{pRS}{1-p^2LS}=\tan\epsilon$,

$$C=\frac{pSE\cos(pt-\epsilon)}{\sqrt{\{(1-p^2LS)^2+p^2R^2S^2\}}},$$

or, for the difference of potential between the terminals of the condenser,

$$V=\frac{E\sin(pt-\epsilon)}{\sqrt{\{(1-p^2LS)^2+p^2R^2S^2\}}}$$

Everything depends therefore on the value of this denominator; and, according as it is less or greater than unity, the amplitude of the reverberations of potential V is greater or less than the exciting amplitude E.

The maximum possible effect is obtained when the natural period of the condenser-circuit agrees with the period of the impressed E.M.F., and when resistance is small; *i.e*, when $p^2LS=1$; and in that case we have for the amplitude of V simply

$$\frac{V_0}{E}=\frac{1}{pRS}=\frac{\sqrt{(LS)}}{R}=\frac{\text{impedance of circuit}}{\text{resistance of circuit}},$$

a ratio always greater than unity, and sometimes much greater.

Clerk Maxwell's popular mode of putting the matter is something like this:—

Capacity acts as a spring,
Self-induction acts as inertia.

Now, if you want to wag a massive load to and fro you will find it much easier to wag if it be mounted on a spring, so as to have a natural period, than if it were perfectly free on rollers; especially if you are willing to accommodate your pushes and pulls to its natural period of vibration under the circumstances; and you can thus get up in it pretty big swings. The resilience of the spring exerts most of the force, and very small impulses accumulate. Resistance acts as treacle, and opposes the motion anyhow. If resistance formed the greater part of the obstruction, as it would if the body were light (*i.e.*, a circuit of small self-induction), then the special advantage of the spring (*i.e.*, the condenser) would not be felt.

One might put the Deptford case like this: Two massive pendulums are connected by a long rod. One of the pendulums is then swung to and fro regularly over a given arc by hand, in the direction of the length of the rod; the other must of course swing equally, if the rod is rigid. This represents two transformers connected by an aërial line without appreciable capacity, and one of them excited by an alternating dynamo.

But let the rod be elastic, and proceed to swing one pendulum as before. It is now possible to have a different extent of swing in the second pendulum: it may be less; but it may, by proper timing, be made considerably more. This represents two transformers connected by a cable with capacity.

Anyone can try attaching a spiral spring to a heavy pendulum bob, and getting up swing by means of it. An almost imperceptible motion of the hand at one end is sufficient.

In recently writing out the notes of my Leyden jar experiments on "overflow" and "recoil kick," briefly and hastily mentioned in my lectures on Lightning Conductors, I find they fall into the same category as these effects; and this it is which has directed my attention to the subject. Mr. Preece was good enough some months ago to send me particulars of the occurrences in the Deptford mains, under the impression that the phenomenon must be allied to what I had been interested in; but at that time I did not see the connection between what was observed there and my Leyden jar surgings. I saw, moreover, that the matter was in competent hands, and did not occupy myself with it. This article comes, therefore, rather late in the day.

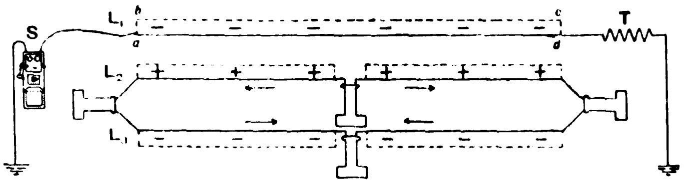
**Physical Society.**—The meeting of the Physical Society of London advertised for May 8th will not be held, but a meeting will take place at Cambridge on May 9th. Members proposing to attend this meeting are requested to communicate with the Hon. Secs., Prof. J. Perry and Mr. T. H. Blakesley.

Digitized by Google

## NOTE ON THE RELATIVE DEGREE OF DISTURBANCE CAUSED BY ELECTROSTATIC AND ELECTRO-MAGNETIC INDUCTION BETWEEN TELEPHONE CIRCUITS.*

BY A. E. KENNELLY.

Referring to Fig. 2 of Mr. Carty's Paper† let $L_1$ be a primary line, $L_2$ and $L_3$ the lines of a secondary circuit. Suppose also, to simplify the conditions, that $L_3$ is so far remote from $L_1$ and $L_2$, by comparision with the half-inch of distance separating these latter, that all inductive influence on or from $L_3$ may be omitted from consideration. The most convenient way of dealing with $L_3$ is to replace it by the ground, and we have then only to consider the two circuits, $L_1$ and $L_2$, each as taken negligibly small for the case under discussion.




By considering, first, the amount of disturbance that would be statically set up in $L_1$, if electro-magnetic action did not exist, and, second, the magnetic disturbance on the hypothesis that no static induction took place, it is possible to form a comparative estimate of the relative proportions of these disturbances, when, as in practice, both influences act together. The result will not be accurate, because the influence of each not only combines with, but also to a certain extent modifies, the action of the other; but the discrepancy due to so elementary a treatment will not, in all probability, invalidate the results of a first approximation.

Let $k$ be the mutual electrostatic capacity of $L_1$ and $L_2$ per centimetre length of each, in absolute electro-magnetic units

Let $\mu$ be the mutual electro-magnetic capacity, or mutual inductance, of $L_1$ and $L_2$ per centimetre of each in absolute electro-magnetic units.

Let $l$ be the length of each of the wires in centimetres.

Let $e$ be the primary circuit electromotive force, which is periodic in value.

Let $n$ be the number of periods completed by $e$ per second.

Let $\omega_1$ be the impedance in the circuit of $L_1$ in absolute electro-magnetic units.

Let $\omega_2$ be the impedance in the circuit of $L_2$ in absolute electro-magnetic units.

Let $\gamma_e$ be the current in each of the two end telephones of the secondary circuit owing to electrostatic induction when electro-magnetic induction is supposed to be absent.

Let $\gamma_m$ be the current in each of three telephones in the secondary circuit (one at the centre of $L_2$ and the others at its ends), when electro-magnetic action is supposed to exist between the circuits to the exclusion of static induction.

Let $q$ be the total electrostatic charge induced on $L_2$ at any moment by static induction.

Let $r$ be the radius of each wire (copper) in centimetres.

Let the wires be parallel and the distance between their axes be $d$ centimetres in the horizontal plane elevated $h$ centimetres above the ground.

Then if the end of $L_1$ distant from the transmitter be disconnected from the ground and electrostatic influence only be supposed to act upon the secondary circuit, the potential of $L_1$ at any moment will be $e$, the value of the periodic electromotive force, while the induced charge upon $L_2$ will be expressed by

$$q = -e\,l\,k.$$

The flow of current from $L_2$ to ground will at any moment be the time rate of change in $q$, or numerically

$$\frac{dq}{dt} = l\,k\,\frac{de}{dt};$$

and since this by symmetry will divide equally between the two end telephones in $L_2$, the current in each is numerically

$$\gamma_e = \frac{l\,k}{2}\,\frac{de}{dt}.$$

Now, with electro-magnetic induction active, and static action suspended, the distant end of $L_1$ is connected to ground through a certain impedance. The current then existing in the primary circuit at any moment is

$$\frac{e}{\omega_1},$$

and in the secondary circuit $\frac{l\mu}{\omega_1}\frac{de}{dt}\cdot\frac{1}{\omega_2} = \gamma_m$ since this affects all three telephones alike.

Since $\gamma_e$ and $\gamma_m$ are periodic currents of the same frequency, they will produce equally loud sounds in the telephones when of equal numerical value, and the ratio of static to magnetic disturbance in the two cases will be

$$\frac{\gamma_e}{\gamma_m} = \frac{k}{\mu}\,\frac{\omega_1\,\omega_2}{2}$$

Provided, then, that the impedance of the primary circuit at the receiving end is always large, the ratio of static to magnetic disturbance will be approximately expressed by this equation. In order to apply it to the case of Fig. 2, we have to determine from the geometrical relations of the wires their mutual capacities $k$ and $\mu$.

The value of $k$ in absolute electrostatic units has been given by Mr. Oliver Heaviside in the *Journal of the Society of Telegraph Engineers* for April, 1881 (with a misprint in the formula here avoided) —

$$k = \frac{\frac{1}{2}\log_\epsilon \frac{\sqrt{d^2+4h^2}}{d}}{\left\{\log_\epsilon \frac{2h}{r}\right\}^2 - \left\{\log_\epsilon \frac{\sqrt{d^2+4h^2}}{d}\right\}^2}$$

Substituting for $d$ 1·25 centimetres or half an-inch.
,, for $h$ 1,000 centimetres or about 33ft.
,, for $r$ 0·1 centimetres or ·04 inch about representing No. 12 B. and S. gauge.

$k = 0·0794$ absolute electrostatic units $= 7·94 \times 10^{-23}$ absolute electro-magnetic units, or 0·0128 microfarads per mile.

The value for $\mu$ can also be found from another formula first published by Mr. Heaviside in the *Journal* of the above-mentioned Society for May, 1878, namely :—

$$\mu = \log_\epsilon \frac{d^2+4h^2}{d^2}$$

from which $\mu = 14·75$ absolute electro-magnetic units or 2·37 millihenrys per mile.

Thus for equality between $\gamma_e$ and $\gamma_m$ we must have with these values of $k$ and $\mu$.

$\omega_1\,\omega_2 = 3·717 \times 10^{23}$ absolute electro-magnetic units.

Three telephones of 75 $\omega$ and 90 $h$ each would to a frequency of $n = 435$ corresponding to the note $a_1$ offer an impedance of $7·72 \times 10^{11}$ or 772 ohms, the impedance of the three telephones to this frequency being more than three times their resistance.

For $\gamma_e \div \gamma_m = 1$, $\omega_1$ must now be $3·717 \times 10^{23} \div 7·72 \times 10^{11}$ or $4·816 \times 10^{11}$ or 481·6 in round numbers 500 ohms, while with the primary circuit of Fig. 2 having a transmitter of 165 $\omega$ and 730 $h$ with a call-bell at the distant end of 550 $\omega$ and 2·7 $h$, the total resistance would be 715 $\omega$, the total inductance 3·43 $h$, and the impedance to the same frequency of $n = 435$ would be $9·40 \times 10^{12} = 9400$ ohms or about 13 times greater than the total resistance. The impedance $\omega_1$ is thus nearly 20 times greater than that needed by the formula for equality between $\gamma_e$ and $\gamma_m$ and roughly the static disturbance in Fig. 2 may be estimated as 20 times greater than the magnetic.

* A discussion of Mr. J. J. Carty's Paper on "Inductive Disturbances in Telephonic Circuits," before the American Institute of Electrical Engineers, communicated to the Secretary after adjournment. From the *Electrical World* of New York.

† See *The Electrician*, April 10, p. 705.

## TANNING BY THE AID OF ELECTRICITY.*

The slow rate at which hide is converted into leather has induced many inventors to devise methods by which the chemical change might be accelerated, but the want of any definite knowledge as to the precise action between the gelatin and tannin has been a serious obstacle to the development of new processes. The authors described a number of methods for bringing the tanning liquor into intimate contact with the hides both by hydrostatic pressure and by mechanical agitation, the first one dating as far back as 1823. Various electrical processes for accelerating tanning were described, but little information could be given as to their success. The authors described the process of Worms and Balé and that of Groth, the latter being explained at considerable length, with full dimensions of the vats employed, of the electrodes within the vats and of the other details, mechanical, electrical and chemical. During the recent winter,

* Abstract of a Paper read by Dr. S. Rideal and Mr. A. P. Trotter before the Society of Chemical Industry on Monday, 20th April.

Digitized by Google

a very extensive series of experiments has been carried out at Bermondsey. The process (see *Electrician*, Jan 16 and 23, 1891) consists in stretching the hides upon frames, which are rotated in a circular vat resembling a brewers' mash tun. The current density upon the electrodes was about ½ ampere per square foot, and the density in the liquor was about $\frac{1}{20}$ of an ampere per square foot of the transverse sectional area of the vat. Currents of 1¼ to 4 amperes were used, and the mean resistance of the vat was from 8 to 10 ohms. while at work. The tanning liquor was in all cases of the ordinary character, consisting chiefly of mimosa bark and gambier. The strongest solution used contained 4¼ per cent. of tannin. It was found by first measuring the resistance of the liquor, and then putting in the hides and withdrawing the liquor until it stood at the former level, that the resistance of the green hides was practically that of the liquor, confirming the observations of Arrhenius, that the resistance of solidified gelatin does not differ materially from that of the liquefied substance.

From experiments on a small scale, made by Mr. W. Fox Bourne at Mr. Swinburne's laboratory it was found by the authors that the resistance of the strongest liquor was given by the empirical formula,

$$\text{Ohms per cubic inch} = 82 - 11\,d.$$

Where $d$ is the density of the current in amperes per square foot of electrode. The polarisation was found to be practically represented by the following empirical formula,

$$\text{Volts} = 1{\cdot}4 + {\cdot}194\,d + 8\,d^2.$$

Where $d$ is again the density in amperes per square foot of electrode. The resistance of the liquor was found to rise when diluted and proved to be inversely proportional to the strength of the liquor + the resistance of a saturated solution. The power spent in the liquor was only 36·8 watts. Thus only about $\frac{15}{1000000}$ of the whole body of the liquor was electrolysed. A very elaborate series of observations embracing the many quantitative tests by the Kjeldahl process were made to determine the nitrogen of the leather, and thus to ascertain the exact rate of absorption by the hides, during rest, during motion and during the combination of electricity and motion. The results of these tests were plotted upon diagrams, which gave a very clear idea of the rate at which the tanning proceeded, under the different circumstances. The general result was that leather is produced in eight to ten days instead of eight to ten months.

The Paper concluded with a *resumé* of the present knowledge of electrolysis and of the migration of the ions, as far as they appear to bear upon the subject of the Paper. The acceleration of the tanning does not appear to be due to osmosis any more than to electrolysis. Dr. Oliver Lodge has found, for example, that the migration of the ions in electrolysis of sulphuric acid is at the rate of $\frac{1}{385}$ centimetre per second for hydrogen and $\frac{1}{500}$ centimetre per second for $SO_4$ with a slope of potential of about one volt per centimetre. In these experiments it was about $\frac{1}{10}$ of this slope, but the progress of tanning was only about $\frac{1}{1300000}$ centimetre per second or 7½ inches per annum.

## PHYSICAL SOCIETY.

At the meeting of the Physical Society on April 17th, the following communications were made:—

### "On a Property of Magnetic Shunts,"

by Prof. S. P. Thompson. After referring to a few instances in which magnetic shunts are employed, as for example, the ordi-

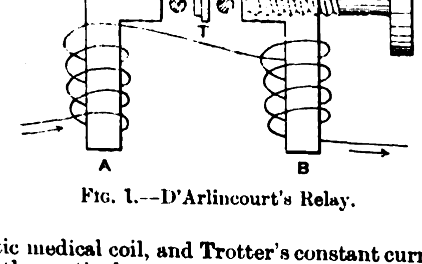



Fig. 1.—D'Arlincourt's Relay.

nary magnetic medical coil, and Trotter's constant current dynamos, he said that the particular property he wished to speak of was the time taken for such a shunt to lose its magnetism as compared with the other branch of the magnetic circuit. If these times were very pifferent, unexpected results might be produced, and these might be regarded as being due to a kind of magnetic time constants. Short pieces, as was well known, demagnetise much more rapidly than long ones, particularly if the latter form, or be part of, a closed magnetic circuit. Hence in alternators, such as Kingdon's Keeper Dynamo, in which both magnets and armature are stationary, it was important that the revolving keepers should be short. The most important application of a magnetic shunt occurred, he said, in d'Arlincourt's Relay, described in Vol. IV., *Journal* of the Society of Telegraph Engineers and Electricians, and shown diagrammatically in Fig. 1. In this relay the polarised tongue T plays between two projections $a$ and $b$, near the yoke Y, and it is claimed to have a quicker action than ordinary kinds. The reason of this the author explained was as follows (Figs. 2 and 3).

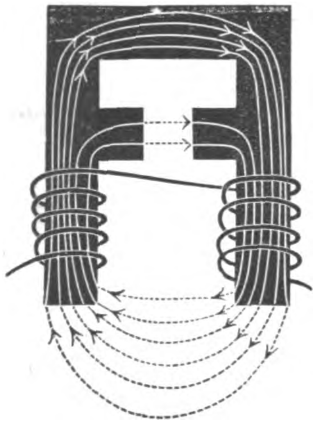


Fig. 2.

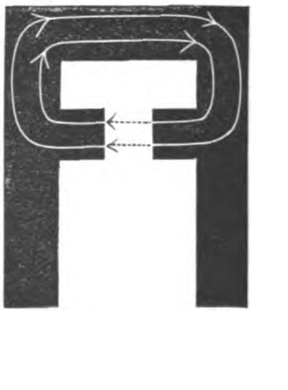


Fig. 3.

Diagrams showing the path of the lines of force through the relay when excited (Fig. 2), and the path of the lines of force when dying away after the magnetising current is broken (Fig. 3).

When a current flows through the coils the greater part of the magnetic lines pass through the yoke, but a few leak across from $a$ to $b$, and move the tongue against the contact P. On stopping the current, the magnetism in the extremities A and B dies away much more rapidly than in the yoke, consequently the direction of the field between $a$ and $b$ is reversed, and the tongue T thrown back against the stop Q.

DISCUSSION.

Prof. PERRY asked if any experiments had been made to test whether the throwing back actually occurred. He also inquired whether such action would be augmented or otherwise by having a thick copper tube round the yoke, or by laminating the iron.

Mr. BLAKESLEY asked if placing a yoke across A B instead of the present one would not improve the action.

Prof. AYRTON said he would be glad to know whether the relay was any more sensitive than an ordinary one as regards the ampere-turns, or the watts required to actuate the instrument. In India, he remembered that they used inductive coils, shunting the ordinary relays, in order to expedite the action and to avoid confused signals arising from the electrostatic capacity of long lines.

In reply, Prof. THOMPSON said he had tried an experiment on a horseshoe electro-magnet, and found evidence of throwing back when working near the bend or yoke. Putting a yoke across A B would, he thought, tend to neutralise the effect desired.

### "An Alternating Current Influence Machine,"

by James Wimshurst. This machine consists of a varnished glass disc, with or without metallic sectors, mounted on an axis, and rotating within a square wooden frame fixed in the plane of the disc. The frame carries four square glass plates, each of which has one corner cut away, so as to clear the box of the disc. These plates are placed one at each corner of the frame, alternately on the two sides, and the disc revolves between them. There are thus two plates on one side of the disc situated at opposite ends of a diagonal of the frame, and two on the other side of the disc, at opposite ends of the other diagonal. Tin-foil sectors fixed to the outer sides of the plates act as inductors, and wire brushes connected with them touch the disc about 90deg. behind the centre of the inductors. The peculiarity of the machine is that, although sparks can be readily obtained from it, a Leyden jar cannot be charged by bringing it to one of the terminals. From this the author concluded that the electricity produced was alternately of positive and negative sign, and this he showed to be the case by means of an electroscope. The alternations, he said, occurred about every three-quarters of a revolution, the suspended paper discs which he used as an electroscope remaining apart for that period and collapsing during the next quarter of a turn. Using discs with various numbers and sizes of sectors the author finds that the smaller sectors and the

Digitized by Google

the fewer the number the greater the quantity of electricity produced. Plain varnished glass is the best in this respect. Such a disc, however, does not excite itself quite so freely as one having numerous metallic sectors. By removing two of the inductors and placing an insulating rod carrying collecting brushes at its ends, across a diameter of the disc, the machine was used to produce direct currents. Numerous discs and various-shaped inductors accompanied the machine, by means of which a Holtz, Voss, or ordinary influence machine could be imitated.

DISCUSSION.

Prof. S. P. THOMPSON congratulated the author on the most interesting and puzzling machine he had brought before the Society. He inquired if the machine would work if the direction of rotation was reversed, or if two of the inductors were removed, and also whether all the four inductors are electrically of the same sign at the same instant.

In reply, Mr. WIMSHURST said the machine would not excite if the direction of rotation be changed without also changing the direction of the brush-arms; but it would work as a direct-current machine, when two inductors were removed.

## REPORT OF HIGH-SPEED ELECTRIC RAILWAY WORK.*

BY O. T. CROSBY.

The experiments here reported were the first serious efforts ever made to at once double railway speeds, and as such should, I think, be systematically recorded They were made for the Electro-Automatic Railway Company, of Baltimore, Md.

For the purpose of demonstration, a circular track nearly two miles in circumference was laid at Laurel, Md.; gauge, 28in.; weight of rail 16lbs., shape T. To the ties was built up a vertical frame-work on both sides of the track, this carrying from cross-pieces a 2 × 6in. wooden stringer, suspended above the middle of the track, while to the lower surface of the stringer was attached a small T rail, head down. This upper rail was intended to serve as an electric conductor, and also, in connection with upward pressing wheels, as a guide. The latter function was not successfully performed, the lateral oscillation of the car, on so slight a track, being too great. Part of the track was on trestle work crossing a swamp, the overflow of which caused frequent washouts.

The locomotive was very simple. Three axles carried 28in. wheels; on these were hung a steel box 16ft. long × 14in. high × 30in. wide. A slight vertical play of the box was provided for by springs, but, horizontally, the three axles were in rigid connection. On each of these axles it was designed to place a motor. The head was pyramidal; the weight of the car with three motors was about three tons. A second similar box of steel was made to be drawn by the motor-car, the two to be connected by a ball-and-socket arrangement, the interval between the cars to be flanged over, so that only one surface should be presented to meet atmospheric resistance. The tail was pyramidal. The second car was not in use more than once.

The track work and cars were completed as above outlined, when the matter was brought to the Sprague Electric Railway and Motor Company, with the request that they design motors of which the armatures should be placed directly on the three driving axles of the car, the construction of which was already nearly finished. It was further conditioned that the motors should do 20 H.P. of work each, at a normal speed of about 3,000 revolutions per minute. This corresponds to a car speed of about 250 miles per hour. Needless to say that on so light a track, none of which was straight, and with a car weighing three tons, and with only 60 H.P. available for work, no such speed was attained. The motors were carefully designed by Mr. H. F. Parshall, of the Sprague Company, for a normal impressed E.M.F. of 500 volts, and thoroughly filled the specifications. They were to be connected in multiple across the 500-volt circuit supplied with current from a dynamo made by the Edison Machine Works. When the motors were finally mounted and ready for action it was found almost impossible to start the car, due probably to stiff bearings, and when several trials of speed had been made the results were disappointing.

Work having been resumed, it was soon found that a given speed could be attained with less current if two motors were in service than with three, and consequently the motor on the middle axle was removed. The two motors were able to produce a greater speed than the track could stand. These machines were of the U type. The armature was wound with 100 sections of No. 12 B.W.G. wire, each section of two turns. This armature, with its commutator, was rigidly mounted on the axle. The pole-pieces were attached to brackets centred on the axle; the keeper was spring-supported on a cross-piece carried by the steel casing. Bearings were of phosphor-bronze, and lubrication was by oil from an ordinary cup. No trouble on this score was experienced. Each magnet core was wound with 120 turns of No. 4 B.W.G. wire. At 30 amperes, the armature induction was about 80,000 lines per square inch. These motors, since wound according to specification for the 500-volt circuit, were originally connected in multiple arc. This connection was changed, they being placed in series, thus diminishing the potential control required at the station, by reason of the fact that the machines were run at a speed so much below that for which they had been calculated. To supply the current, contact was made between the upper rail and brushes of sheet copper set against the rail by springs. These served their purpose well. The return circuit was through the wheels and rails, the steel casing being insulated from the axle by fibre plates and washers at joints and bolts. Rail bonds were used throughout: the resistance of the external circuit from the feeder junction to a point diametrically opposite was about 0·25 ohm. The station was placed inside the circle, about 200ft. from the track. The generator was a 70 H.P. Edison machine, not compounded originally, and was driven by a 90 H.P. high-speed Ball engine.

The usual course of a run was this: Speed-observers were stationed around the circle, distance apart being known. Watches of these observers and of recorders who read current and potential were compared. Potential readings were taken at station and at one or two points on the line, permitting easy reduction to horse-power. Mr. Dashiell, my assistant, then took the engine, and I managed the dynamo. A current of from 20 to 40 amperes usually started the car. When the car had attained a speed of 75 to 100 miles per hour, the line potential was about 450 volts. The time limitation of the runs was invariably caused by failure of the track to serve its purpose. On three occasions the car left the track; once at 45 miles per hour, once at 80 miles per hour, and once, the last time, at about 115 miles per hour. Curiously enough, on the two former occasions, the derailment was to the inside of the circle, super-elevation being about four inches. It was easy to tell in the station when a derailment was imminent, as the ammater was most violently agitated by the make and break of the circuit caused by the particularly bad spots in the track. The agitation increased with each trip round the circle, and ended in a run-off, or, after some experience had been gained, in a cessation of the trial. As the track limited the length of run in time, so also it limited the speed obtainable. Each trial the longest being about 22 minutes consecutive running--was followed by an overhauling of the track, requiring from a few hours' to a week's work by four or five men. Could the experiments have been made on a road-bed and track, deemed even second-class according to steam railway standards of rail-weight, &c., there can be no question that, without any other change, the car could have maintained for several hours a speed of 120 miles per hour.

The speed obtained in the first round—that is, in the first 9,240 feet—varied from 30 to 75 miles per hour; this determined by the management of the rheostat. The rate of acceleration from point to point in going round the circle was irregular, due to the grades, which, going in the direction usually followed, varied from 2 0 to 2·5 per cent. The fact that the track—always bad—went rapidly from bad to worse during each run, made it difficult to analyse the records with a view to determining the true coefficient of traction. Moreover, the coefficient for such a track, even in its best condition, would be greater than for the track that would necessarily be built for actual service. The figures obtained were of little worth as far as fixing absolute values at very high speed, but at least served to show the error of many train resistance formulæ found in the text-books. Some of these formulæ give good enough results when used for the low speeds on which they are based, but their algebraic form is such as to give rise to great error when higher speeds—say 80 to 120 miles per hour—enter. This whole matter of train resistance has been more fully treated in a Paper, "Limitations of Steam and Electricity," read by me before this Institute on May 21, 1890. The particular element of atmospheric resistance, for which special experiments were made at Laurel, was fully treated in a Paper read by me before the West Point branch of the Military Service Institute. The using for atmospheric resistance figures resulting from the experiment, we obtained the values, 46·0, 42·5, 50·0, 58·7, and 48·0 pounds horizontal effect per ton should be corrected for curvature, making them 30·7, 28·4, 33·4, 39·1, and 32 pounds respectively. Other and lower values were obtained when the track, as at first, was in better condition.

The maximum speed—that of the final derailment, could not be absolutely determined, since the car left the track at some distance from the last two observers, whose time record gave the speed attained between the points of observation. It was clear, however, that final speed was between 110 and 112 miles per hour. A length of 1,000 feet of track was injured, about 300 feet of the upper framework wrecked, and the car itself was landed about 30 feet from the track. It seemed clear that the Laurel plant had passed its days of usefulness.

* Abstract of a Paper read before the American Institute of Electrical Engineers, New York, February, 1891.

Digitized by Google

For purposes of demonstration I now proposed to the Company that they should build a track about four miles in circumference, and should run a train of two or three cars drawn by one locomotive. Calculations were based on the following data:—1. Speed, 150 miles per hour. 2. Cross-section of car, minimum, consistent with the seating of passengers. 3. Gauge of track, 4ft. 8·5in. 4. Character of track, the best. 5. Electromotive force, as high as possible. 6. Cars to be connected so as to present a continuous exterior. 7. Atmospheric resistance at 150 miles per hour, taken at 15lbs. per square foot of cross-section (wedge or parabolic locomotive head being used). 8. Traction coefficient (exclusive of air resistance), at 150 miles per hour, taken at 25lbs. per ton.

From the two resistance coefficients just given, it followed that for every square foot of cross-section, regardless of weight, 6 H.P. would be required, and for every ton of weight, regardless of cross-section, 10 H.P. must be supplied. For a locomotive of about 600 H.P. having 30ft. cross-section, the dead weight was calculated to be about 18 tons. Steel cars of equal cross-section were designed weighing, empty, about five tons, with carrying capacity of about five tons. The important question as to power required could then be thus tabulated:—

| | 150 miles per hour. | 120 miles per hour. |
|---|---|---|
| Locomotive alone | 360 H.P. | 288 H.P. |
| Locomotive and one car loaded | 460 " | 369 " |
| Locomotive and two cars loaded | 560 " | 446 " |
| Locomotive and three cars loaded | 660 " | 528 " |

To perform the work here indicated, two motors of the Manchester type were provided, one armature directly on each of the two axles of the locomotive cars. They were supposed to be at first connected in arc across a 1,500-volt circuit, each taking about 130 to 150 amperes, and delivering about 250 to 300 H.P. The armature conductors were to be of about 40,000 circular mils, cross-section. The cross-section of the core was to be 110 square inches net. Through this armature it was desired to force 22,000,000 lines, or 15,200 per square centimetre. The hysteresis loss in such an armature revolving at 1,200 revolutions per minute was calculated to be about 3,000 watts. The $C^2R$ loss ($C=135$ amperes, $R=0·26$ ohms when $T=75$deg. C.) $=4,740$ watts—or about 8,000 watts for the two losses. The number of armature conductors was to be 340, divided into 170 sections, wound in one layer, each conductor to lie in a slot. The magnets were to have a cross-section of 164 square inches, through which 14,300,000 lines of force were to be passed ($B=13,500$). The magnet coils of the two armatures were calculated to be in series with each other, but in shunt with respect to the two armatures. The commutator was designed to be 23in. in diameter.

The problem of brakes for a mass of, say, 40 tons, running at 150 miles per hour, is a serious one. The Galton and Westinghouse tests indicate a very low value for the coefficient of friction between brakeshoe and wheel, at high speeds; they report it in some cases at 60 miles per hour as low as 0·04. As, however, it rapidly increases at lower speeds, an average of 0·1 may be taken. The total retarding effort, *i.e.*, brake resistance and track and atmospheric resistance, must be kept below that which will just produce sliding of the wheels, and the coefficient of sliding may be taken on an average at 0·08 of the weight of the wheels. If, then, we represent by P the maximum allowable brake pressure on the wheels, by R resistances other than brake friction, and by W the weight on braked wheels, we may write the following inequality:

$$0·1\,P+R<0·08\,W.$$

The value of P should be determined as that which, with a small margin, will satisfy this condition of inequality. Following this calculation, it was found that a brake pressure of about 5,000lbs. should be applied to each wheel. This was designed to be produced by magnetic brakes similar to those used by Mr. Daft on the New York Elevated Railway. A mass of 80,000lbs. moving at 150 miles per hour represents 64,000,000 foot-pounds of energy. Average resistance due to brakes $=0·1\times60,000=6,000$lbs. Average resistance from track and atmosphere for average speed of 75 miles $=400$lbs. In addition, the motors may be required to generate a current which shall be wasted over the rheostat. Since the field circuit in the case of shunt-motors is independent, magnetisation may remain constant, and average E.M.F. of 1,500-volt motors (*i.e.*, motors generating 1,500 volts E.M.F. at 1,100 revolutions per minute, or, with 42in. wheels, at 150 miles per hour), would be, while the train was coming to rest, 750 volts. Make the external resistance such that, the two armatures being in series, an average current of 200 amperes shall flow. Then average dynamo resistance in pounds $=2,000$. Total retarding effort $=6,000+400+2,000=8,400$lbs. Dividing 64,000,000 by this last quantity, we have 7,620ft. (about $1\frac{1}{2}$ miles) as the length of run to come to a stop, and the time of stopping about 100 seconds.

For the mechanical construction of the locomotive, two plans were contemplated. The preferred has a 7ft. wheel base for the drivers and a pony axle in front, free to move laterally over a certain distance, dragging the drivers in the same direction. In this particular case the total weight of the locomotive is about 18 tons, each motor being six tons. Of the total, 15 tons rest on the drivers. If, then, the adhesion coefficient, while running, be taken at only 0·1, a circumferential effort of 3,000lbs. may be exerted without slipping the wheels. This is safe, since if 600 H.P. of work be required at 150 miles per hour $=13,200$ft. per minute, the horizontal effort $=\frac{600\times33,000}{13,200}=1,500$lbs. For starting the load the adhesion coefficient may be taken at ·25, giving 7,500lbs. possible pull, this being much in excess of the value required. The locomotive construction is such as to put the entire weight of the armature directly on the axle. In designing this, I did not overlook the fact that the armature must thus be subjected to much jarring. But I believe the difficulty should be met by excellent mechanical construction, rather than that spring movement should in any way be attempted.

As to the supply of current, it is proposed to use the double metallic system. This departure from the ground return so commonly employed in street railway work, seems justified mainly by considerations of the convenience of high voltages. The conductors will be placed in an inverted wooden trough, about 5·5 feet above the ground. The conductors for each side of the circuit to be two—one insulated and continuous: the other a bare, flat strip, broken into sections, these being normally out of circuit; the locomotive trolley-arm operating a switch which shall throw out the rear section and throw into circuit the section ahead. As to what the line voltage should be, progress in the arc of insulation can alone determine.

In the important matter of limiting curvatures, calculations were made in the ordinary way, using the particular values for weight and height of centre of gravity. A safe speed was then tabulated as that which is just one-half the speed that causes the resultant of weight and centrifugal force to pass through the outer rail of a curve. The beneficial effect of super-elevation, neglected in the calculation, would, of course, practically increase the factor of safety. The following table resulted from the method described:—

| Radius in feet. | Safe speed, by rule above, in miles per hour. |
|---|---|
| 1,000 | 71 |
| 2,000 | 93 |
| 3,000 | 120 |
| 4,000 | 140 |
| 5,000 | 158 |
| 6,000 | 172 |
| 7,000 | 187 |
| 8,000 | 198 |

Copper calculations were made, based on a station potential of 3,000, and also of 6,000 volts, stations being 50 miles apart (thus supplying current 25 miles on each side), and on a service requiring one train on each 25 mile section, the drop on the line being 35 per cent. of station potential. Then for a line of 1,000 miles, as from New York to Chicago, with copper at 15 cents per pound, and for 3,000 volts initial, total cost per mile works out at $66,000.

To arrive at operating expenses, suppose twenty trains each way each day, and a schedule of 125 miles an hour, I arrive at a total of $394.42 per trip. Income per trip, with 15 passengers, and 15,000 pounds of freight, $500. The total daily load of freight each way required to justify the service above treated is 300,000 pounds, or if 200 through passengers be carried (*i.e.*, 10 trains for passengers each way each day), then only 150,000 pounds of freight. The *present* movement between New York and Chicago, in mail and express, is not far from this figure.

To demonstrate all or nearly all that has been outlined in this Paper, will cost about $300,000, covering the construction and operation for a reasonable time of the four-mile circular line proposed above. Last year the Baltimore Company met unexpected difficulty in efforts to raise the needed money; their operations were suspended, and my connection with them ceased just at the time when plans were completed—even to working drawings. I have been much pleased to learn, within the last few days, that far from being discouraged, they are now confidently hoping that they may push on, in the near future, the great work to which they have laid their hands.

## BOOKS, &c., RECEIVED.

"Proceedings of the Royal Society." Vol. XLIX., No. 298. (London: Harrison and Sons.)

"Journal of the Institution of Electrical Engineers." Vol. XX., No. 92. (London: E. and F. N. Spon.)

"Collection de Mémoires relatifs à la Physique publiés par la Société Français de Physique." Tome V.—Mémoires sur le Pendule. Seconde Partie. (Paris: Gauthier-Villars et Fils.)

Digitized by Google

## SOME REMARKS ON HERR H. LUGGIN'S WORK ON THE MODE OF CONDUCTION IN ARC LIGHTS.*

BY F. UPPENBORN.

From the observation that the total difference of potential between a pair of electrodes does not undergo any great change when the current strength suddenly increases, H. Luggin arrives at the conclusion that the abrupt difference in potential between the anode and the arc does not increase proportionately to the current density. The author does not consider this deduction to be justifiable; the non-appearance of any increased difference of potential with increased current density may be due to a decrease in that part of the voltage dependent on the length of the arc when the current density is raised. If Δ represents the total potential difference between a pair of electrodes, then for any strength of current we have pretty approximately

$$\Delta = a + b\,L,$$

where $a$ and $b$ are constants and L is the distance between the electrodes. The author has drawn up a series of results of measurements he has taken, which clearly show the above-mentioned influence of current strength on $a$ and $b$. The increase in sectional area of the arc as the current strength rises, which is very difficult to observe and to measure, is not the only cause of the diminution in the value of $b$. As the current strength rises the temperature of the arc increases, which gives another reason for a decrease in the total voltage.

## PARLIAMENTARY INTELLIGENCE.

HOUSE OF COMMONS.—THURSDAY, APRIL 16TH.

### Central London Railway Bill.

On the order for the consideration of this Bill,

Mr. STUART rose to move the first of a series of amendments with reference to the running of workmen's trains on the proposed railway. He moved to leave out "three" and insert "six."

Mr. HOWELL seconded the amendment. He thought it effected a very reasonable extension.

Mr. BARRAN said that if unreasonable obligations were laid upon the Company the railway would, in all probability, not be constructed at all. He hoped that the House would maintain the Committee in their decision.

Mr. GANE said that no fact had been laid before the House which justified the imposition of a heavier obligation than had been imposed by the Committee. The Committee, in what they had done in this case, had gone considerably beyond anything previously done under similar circumstances, and in all fairness, before an additional burden was placed on the Company, very strong grounds should be shown for doing so. He was in hearty sympathy with the spirit of the proposal to place all the privileges they fairly could within reach of the working classes, but there must be a reasonable limit, and in this case the proposed increase in the number of trains was, in the circumstances, unreasonable.

The amendment was negatived.

Mr. STUART then moved the second amendment, to the effect that the hour at which the trains should run in the morning should be eight o'clock, instead of seven.

Mr. O. V. MORGAN said the amendment would entail no additional expense on the company, but would confer an immense boon on a large number of persons who would use the railway. He hoped, therefore, it would be adopted.

The House divided, when the numbers were—

| | |
|---|---|
| For the amendment | 68 |
| Against | 148 |
| Majority | 80 |

The amendment was therefore rejected, and the Bill ordered for third reading.

## AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *April* 12, 1891.

**Accumulator Cars.**—Storage battery traction has received another rebuff at the hand of its old foe, experience. For two years vigorous efforts have been made by a company in New Orleans to operate storage battery cars, but these have resulted in disaster; the cars have been taken off and the company that operated them has disappeared from public view. This, coupled with the stoppage of the few storage battery cars that were operated in New York, has had anything but a wholesome effect on the prospects of electrical storage.

**The Chicago Exhibition.**—The electrical section of the World's Columbian Exposition is starting off vigorously, and plans on a considerable scale are being drawn up. There will be active rivalry between the various electrical companies for prominent places at the Exposition, and it will take no ordinary amount of skill and tact to deal with their demands satisfactorily. Mr. Barrett, the chief of the electrical section, however, is thoroughly up to his work.

**The Rapid Transit Question in New York.**—The Rapid Transit Commissioners in New York have had under consideration during the past few months a vast number of schemes for the solution of this great problem, and have, it is stated, narrowed down the selection to about half a dozen. A premature report that went the rounds of the daily press a few days since stated that the decision reached was, for the present, extended elevated facilities and a tunnel for the New York Central Railroad from its present station at Forty-second-street down to the Battery; and, for the future, the Greathead system. This is vigorously and authoritatively denied. The Greathed system, however, has been rather a favourite without any very good reason. As a large proportion of the work on Manhattan Island would have to be done through rock, the Greathead plan of excavation loses much of its characteristic advantages. It is at its very best when pushing through soft material, but is certainly not particularly well adapted for driving a tunnel through hard rock. The feature of a tight iron tube is good, but as the principal difficulty as regards percolation of water through the sides of a tunnel comes from tunnelling too deep, the precautions necessary in London would hardly be needed New York, unless the cutting was deliberately made far below the surface and through the solid rock.

**Alternate Current Distribution Patents.**—A decision recently arrived at by the Commissioner of Patents has an important bearing on alternating current work in this country. The question involved was that of priority in the parallel system of distribution as developed in this country. The first application was by Mr. M. M. Slattery, of Fort Wayne, Indiana. Mr. Wm. Stanley, jun., had sometime previously had such a system in operation, and immediately presented an unfiled specification dating back to 1885. As important interests were at stake, the contest in the Patent Office has been a bitter one, and finally has come up to its ultimate decision before the Commissioner of Patents, being appealed from the Commissioners-in-Chief to him. The decision was unhesitatingly in behalf of Mr. Stanley, who had a plant in operation in Great Barrington, Mass., in March, 1886, antedating Mr. Slattery beyond a reasonable doubt. The Westinghouse Company conducts its operations largely on the basis of the Stanley patents, and this decision has an important bearing on its rights in the alternating current field that were rendered decidedly shaky by its being beaten in the Gaulard-Gibbs controversy. As it stands now, the Westinghouse Company has a strong case against other alternating current companies in this country.

## CORRESPONDENCE.

### THE SPLIT-DYNAMOMETER FOR DETERMINING DIFFERENCES OF PHASE BETWEEN TWO ALTERNATING CURRENTS OF EQUAL PERIOD.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I just happen to notice your remark in the number of Feb. 25, 1891, of your paper, *The Electrician*, about a note on the determination of differences of phase between two alternating currents of equal period, which I published a short time ago in the *Electrical Engineer*, New York.

You say there that I describe this "split-dynamometer method" in the *Electrical Engineer* of Feb. 4th without any reference to the work of Mr. Blakesley, and in apparent ignorance that the method is quite old. Indeed, I consider the method as quite old—as old as the electrodynamometer-

* Exner.'s Rep., Vol. XXVII., part 2.

Digitized by Google

wattmeter, when it was first used by an electrician who knew what he was doing. My note does not contain anything which could be construed as a claim to the invention of this method; but I merely described it, because the publication of a rather complicated method, by means of a couple of synchronous-motors and other devices, led to the discussion of this subject. I must confess myself guilty of not having explicitly mentioned Mr. Blakesley in connection with this method.

But I fear I have committed such crimes more than once, for instance, by describing Wheatstone-bridge methods or using Ohm's law, without mentioning Mr. Wheatstone or Mr. Ohm, supposing that everybody would know that I do not claim the invention of Wheatstone's bridge or Ohm's law.

In this particular case I omitted reference to Mr. Blakesley the easier, as just one or two weeks before my article "Blakesley's Split-dynamometer Method" for power measurements had been mentioned in the very same paper. Indeed, I did not know, and I do not believe that Mr. Blakesley claims the invention of this method, although I read it in Mr. Blakesley's book on "Alternating Currents of Electricity," which is just as well known on this side of the Atlantic as on the other. I thought that the very first electrician, whoever deliberately connected a dynamometer-wattmeter into an alternating electric circuit controlled by voltmeter and ammeter, was really determining the difference of phase between E.M.F. and current, and I for my part do not think so little of the European electricians, to assume that before 1885 nobody had insight enough to see that the well-known ratio of the apparent watts into the real watts, which the wattmeter gives—the plant-efficiency, as Kapp calls it—is nothing else but the cosine of the shifting of phase.

That his wattmeter method is of but little value for the determination of the difference of phase between E.M.F. and current, I cannot agree with either. In a proportionally built wattmeter, the self-induction of the fine wire coil can easily be kept so low, that it can either be neglected entirely, or introduced into the reduction as a correctional member.

In a wattmeter built by me a short time ago the self-induction of the fine-wire coil (100 turns) was found to cause a shifting of phase of $1\frac{1}{2}°$ in 200 ω resistance, so that the maximum correction for self-induction amounted to only 2·6 per cent. of the apparent number of watts, for 100 complete periods, or 200 reversals per second. The instrument gives with 13 watts still a deflexion of 9°. That the impedance of the coil, and therefore the correction of the instrument, varies with the frequency is self-evident. I use a table with the instrument, giving the angles of retardation and the percentage of correction for the different frequencies.

After a long and continuous use of electro-dynamometers as voltmeters, wattmeters and ammeters, I must say that I was always very much satisfied with them, and must consider the electro-dynamometers as the most reliable and exact instruments, if properly handled and properly understood. Therefore, I was very much astonished to read in the discussion of Mr. Swinburne's "Transformer Design" lately, that so *evidently wrong* results should have been got by the "split dynamometer method," as the "observed" decrease of the hysteresis of the converter for increasing load from 69 watts to three watts proves.

By a deviation of the current-wave or E.M.F.-wave from the sinusoidal form such an enormous difference cannot be accounted for; because even a large deviation from the sine-shape must be still of very little influence upon the correctness of wattmeter-readings. Indeed, when reducing wattmeter-readings for self-induction, it must be borne in mind that the wattmeter correction for self-induction depends not only upon the frequency of the alternating current, like in the voltmeter, but also upon the difference of current phase between fixed coil and movable coil, so that for the same frequency the wattmeter correction can have quite different values, depending upon the amount of retardation. A neglect of this latter dependence must indeed introduce a serious error into the wattmeter readings.

Under the assumption of a true sine-wave, let $\overline{OC}$ = the maximum value of the current, in length and position, in ordinary polar-co-ordinates, with $\overline{OA}$ as zero-line; let $\overline{OE}$ = the maximum value of impressed E.M.F.; let $\overline{Oe}$ = the maximum value of resulting E.M.F. in the fine wire coil, that is resulting from the impressed E.M.F. and the E.M.F. of self-induction; $\overline{Ee}$. $\omega = EOe$ is then the retardation caused by self-induction in the fine wire coil.

The reading of the wattmeter gives:

$$\overline{OC} \times \overline{Oe'} = \overline{OC} \times \overline{Oe} \times \cos \phi.$$

while the real power of the alternating circuit is:—

$$\overline{OC} \times \overline{OE} \times \cos (\phi + \omega) = \overline{OC} \times \overline{OE'}.$$

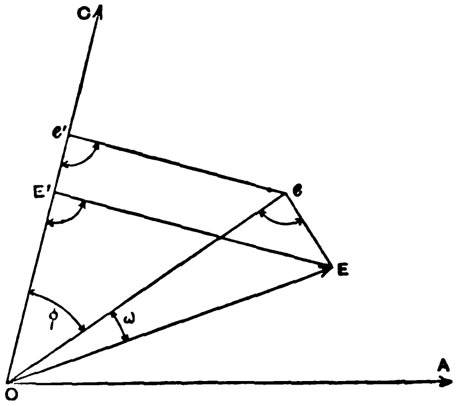
Hence the wattmeter-reading is too large by the amount:—

$$\overline{OC} \times \overline{E'e'} = OC \times \overline{OE} \times \sin \omega \sin \phi.$$

Therefore, when using a wattmeter for power-determination, &c., its readings have to be decreased by the amount:—

$$\text{Sin}\ \omega \tan \phi,$$

and this wattmeter correction is variable, depends upon the angle of retardation $(\omega + \phi)$ of the alternating circuit.




It is small only for small values of $\phi$, where it can be neglected, because $\omega$ is small too, but increases for larger retardations, and will then introduce serious errors if not properly accounted for.

For instance, in the wattmeter mentioned above is $\omega = 1·5°$. Therefore the correction is, for an angle:—

| | | |
|---|---|---|
| $\omega + \phi = 0$ (no self-induction in circuit) | + ·07 | per cent. |
| $\omega + \phi = \omega = 1·5$ degrees ................. | ·0 | |
| $\omega + \phi = 10°$ ................................ | − ·39 | " |
| $\omega + \phi = 30°$ ................................ | − 1·4 | " |
| $\omega + \phi = 60°$ ................................ | − 4·2 | " |
| $\omega + \phi = 80°$ ................................ | − 13 | " |

for 100 complete periods per second.

Chas. Steinmetz.

Yonkers, N.Y., April 2, 1891.

## INDUCTIVE DISTURBANCES IN TELEPHONE CIRCUITS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: A perusal of the article in your issue of April 10th suggests that Mr. J. J. Carty is pursuing with commendable assiduity, at a distance of some ten years, a path already, to no inconsiderable extent, explored by English telephonists.

In his Fig. 11, Mr. Carty sketches a plan from which he evidently expects important results, for reducing in a single wire the disturbing influences of neighbouring conductors. The same plan is described, figured, and claimed in my patent No. 4,428, of 1881. It has never been of much use practically, because the dividing and earthing of the wire at its centre prevented the necessary call signals being transmitted without the intervention of special apparatus. This objection has recently been overcome, but the plan can scarcely be made as efficient and simple as a metallic circuit.

Shunts, both of low and high impedance, on the plan illustrated in Mr. Carty's Fig. 10, but applied to single wires (their use with a metallic circuit is unnecessary, since that should in itself be sufficient to suppress all disturbances), I

Digitized by Google

employed as long ago as 1885. On the single trunk lines between Falkirk-Stirling, Stirling-Dunfermline, and Dunfermline-Kirkcaldy, telegraphic induction was greatly reduced by their aid without spoiling the speaking. But lines so fitted are liable to be stopped by faults that would not fatally affect an unshunted wire.

Mr. Carty's assumption that the important part played by static induction in telephonic disturbances has been hitherto overlooked, surprises me, for I was under the impression that it had been recognised years ago. Personally I had satisfied myself on the point by direct experiment. In practice, however, all problems in connection with metallic circuits can be solved by assuming the presence of current induction only, a fact which may account for the little prominence given to static induction in published discussions.—Yours, &c.,

A. R. BENNETT.

## WIRING OF CALICO PRINT WORKS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We place the following circumstances before your readers, in the hope that it may be of interest. Three years ago we put the electric light in our works, where the processes of bleaching, printing, and dyeing calico are carried on. The installation consists of about 320 glow lamps, employing a Manchester dynamo producing 200 amperes at 100 volts.

The mains and wiring complete were all done by ourselves, and are of ample capacity, being reckoned at 1,000 amperes per square inch, and the lamps are run at 95 volts. All the wires were supplied by a well-known firm, and are the best quality of insulation.

The mains are supported with wooden cleats, and the branches of 8 S.W.G and less, are fixed with iron staples to the beams of the roofs or floors.

The insurance companies not being satisfied for several reasons, got an electrician to examine this installation carefully, and he insists on many changes which we think unnecessary for a public work. Among them—all the mains and wires to be put into wood casing, every joint to be soldered, and a safety cut-out placed at every lamp.

Wood casing we strongly object to, owing to the atmosphere of steam all over the place saturating the wood, which we think would cause the insulation to decay, prevent the wires drying during the night, prevent inspection, and revarnishing the insulation when required. Also it would be difficult to carry out in our works, and involve great expense.

As to the iron staples, they are most carefully put up, of ample size, and the insulation is not abraided.

As to the soldering of "every" joint, this is something new, and we do not believe there is an installation in this country where dynamo connections, switch-board instruments, small switches, and lamp terminals are soldered. Lastly, a safety cut-out at every lamp to be effective would mean a loss of energy of perhaps 20 per cent. We would be glad to hear what your correspondents have got to say to this, remembering that public works are not like a private house, that expense is a consideration, and that the engine is fully loaded, has little surplus power, and that the amperes taken are noted every evening.—Yours very truly,

M. & Co.

April 17, 1891.

## CONTRACTORS' GRIEVANCES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: There is a growing evil at the present day which not only manufacturers and contractors, but users of electric lighting plant, should unite for their mutual interest to put a stop to. It is the practice of sending inquiries broadcast, and of advertising for tenders.

In the present instance I went from Leeds to Ipswich to tender for lighting the Asylum. I was informed that I was the thirty-eighth person who had thus called, whilst there, number 39 came in from Newcastle, and No. 40 telegraphed he was coming. Assuming that only 40 persons tendered at an average expense of £5 each, the electric lighting industry is burdened with an expense of two hundred pounds (probably more). The final result of all this is a polite letter stating that the committee have for the present abandoned the idea of lighting the Asylum by electricity.

The greater part of this unnecessary expense would have been avoided by calling in a competent adviser, and asking tenders of a few firms only.—Yours, &c. W. H.

# LEGAL INTELLIGENCE.

### London Electric Supply Corporation v. Friese Greene and Collings.

In the Queen's Bench Division, on Tuesday, the case of the London Electric Supply Corporation *v.* Friese Greene and Collings came before Mr. Justice Denman and a special jury. This was an action to recover £64. 11s. 7d. for the supply of electric current to the defendants' premises, 192, Piccadilly, during the years 1888 and 1889. The defendants contended that the supply was bad, and that their business suffered in consequence, and they counter-claimed for damages.

Mr. Moulton, Q.C., and Mr. S. Lynch appeared for the plaintiffs, while Mr. Dodd, Q.C., and Mr. Lewis Coward represented the defendant Collings, and Mr. Leily the defendant Mr. Friese Greene.

Mr. MOULTON, in opening the case for the plaintiffs, said that for several years past there had been a supply of electricity from works at the Grosvenor Gallery to certain premises in Bond-street, W. The defendants were photographers, and they first applied to be supplied with the current in December, 1887. At that time it was quite impossible for the plaintiffs to accede to their request, because there were a large number of prior applications from other persons for the supply of the current. On April 4, 1888, however, the defendants were joined to the plaintiffs' system, and supplied with the light. Shortly after that Messrs. Collings left the firm, and he was prepared to withdraw the claim as against them. The defendant, Mr. Friese Greene, continued to use the arc lamps for purposes of photography, and the incandescent lamps in other parts of his premises. Quarterly accounts were sent in down to March, 1889, when the plaintiffs were informed that the defendants had ceased to use arc lamps. There was a breakdown on one occasion, and the plaintiffs wrote to their clients informing them of the way in which it occurred, and making a reduction in their charge. The defendants received an allowance of £1. 16s. The defendants made no complaint with regard to the light until just before the action was commenced. Now, however, they alleged that they took their present premises relying upon the plaintiffs supplying them with a steady and constant supply; that the plaintiffs were not able to keep up a uniform and constant current during the whole of the time; that in consequence they had sustained damages to the extent of £2,000, and that the whole object of their taking the premises had failed. He (the learned counsel) submitted that there was no ground for the counter-claim.

Major CHARLES WALLER, Secretary of the plaintiff's Company, then gave evidence, and the further hearing was adjourned till Wednesday.

WEDNESDAY, APRIL 22ND.

Mr. LEILY, in opening the case for the defendant, submitted that the plaintiffs had broken their contract. Instead of supplying the defendant with a uniform steady light they gave him an irregular and unsteady light, which irritated his customers and seriously injured his business. Sometimes the light would go out altogether, and leave the studio in total darkness. The light supplied by the plaintiffs in 1888 and 1889 was as bad as it could possibly be, and when the defendant complained he was met with the story that matters would shortly improve. Even when the current was on it was miserably below the standard pressure required for the defendants' purpose. He (the learned counsel) maintained that the defendant had suffered damage in consequence of the plaintiffs' breach of contract, and that he was entitled to compensation.

Mr. FRIESE GREENE, the defendant, gave evidence in support of the statement of counsel. He said his premises in Piccadilly were of no use for photographic purposes without an artificial light. He had the premises fitted up by Messrs. Verity, and he had a lamp in his studio of 4,000 c.p. The current supplied was never sufficient to light the lamp. In consequence of the plaintiffs failing to supply him with a sufficient current he had sustained considerable damage.

Other witnesses having given corroborative evidence,

The learned counsel summed up on behalf of their respective clients.

The jury found a verdict for the plaintiffs for the amount claimed.

Judgment accordingly, with costs.

### Jablochkoff's Patent.

A motion of the Electrical Engineering Corporation (Limited), asking that the requirements as to advertisements and notices, in reference to a petition for the confirmation of the Jablochkoff patent, should be dispensed with or modified, was heard on Wednesday, before the Judicial Committee of the Privy Council. Lord Watson, Lord Hobhouse, Lord Morris, Sir Richard Couch, and Lord Shand being present.

Mr. Moulton, Q.C., and Mr. Roger Wallace appeared in support of the motion; the Attorney-General and Mr. Sutton for the Crown.

Mr. MOULTON said, that on the last occasion the hearing was adjourned in order that they might make such advertisements as they could, and present such petition for confirmation as they saw fit. On examining

Digitized by Google

into the dates they had discovered that the ordinary period for confirmation would not expire until after the end of the patent, and therefore, after considering everything, they came to the conclusion that the only course would be to apply to their Lordships to remit the ordinary rules with regard to advertisements and to allow them to give such advertisements as their Lordships thought fit and proper in the circumstances, so that both petitions (for confirmation and prolongation of the patent) should come on for hearing before May 22nd, on which day the period of the patent expired. Before presenting the petition for prolongation they gave notice to all persons who had given notice of appearance, and to all persons who had a statutable right to notice. He asked that the requirements as to advertisements and notices in reference to the petition for confirmation of a patent should be dispensed with or modified.

The ATTORNEY-GENERAL said, he had nothing in the least to say with reference to any relaxation of the rule which their Lordships thought fit. It would be his duty to contend on behalf of the public when the application came on for hearing that it was not a case in which the patent should be confirmed; but he was not dealing with that now. He submitted that their Lordships should be satisfied that sufficient notice was given, and he suggested that advertisements should be inserted in the *London Gazette*, two London newspapers, and electrical newspapers.

Lord WATSON said, their Lordships were of opinion that this was a case in which the rule with respect to notice might be relaxed without detriment to the public. They would fix Wednesday, May 13th next, for the hearing of both petitions. They would dispense with the provisions of Rule 1, and direct that the petitioner give due notice of the hearing of the petition for confirmation in the *London Gazette*, *The Times*, *The Electrician*, the *Electrical Review*, *Industries*, and *Engineering*.

### The Chatham, Rochester, and District Electric Lighting Company v. the South-Eastern Railway Company.

The Chatham, Rochester, and District Electric Lighting Company has just been joining issue with the South-Eastern Railway Company upon the question of the amount of compensation which should be paid by the railway company for the compulsory acquisition of the land upon which the central lighting station is now situated at Rochester. The Electric Lighting Company claimed £11,000, and the Railway Company offered £5,000. The case was heard at Rochester before Mr. J. Brennan, Under-Sheriff of Kent.

Mr. Bidder, Q.C., and Mr. Lewis Levy were counsel for the claimants; the Solicitor-General (Sir E. Clarke, Q.C.) and the Hon. Bernard Coleridge appeared for the Railway Company.

Mr. BIDDER said that the progress made by the Electric Light Company had been remarkably encouraging. In 1889 the Company only supplied a few hundred lights, but it now supplied over 3,000. Plant costing £7,500 had been erected, and a well sunk at a cost of £1,400. The Company had found another suitable site near the river Medway, the price of which was £1,500, but there was work necessary to be done, which would involve a certain total of £5,000, so that by the time the works were re-established £7,500 would have been expended, which they considered the Railway Company should pay. In addition the Company would forfeit a rental of £55 per annum for 12½ years certain for a rental of £350, and they would have heavy rates and taxes to pay. It was, therefore, fair that the Electric Lighting Company should be compensated for the extra annual cost, and also that it should not be turned out of its premises until everything was ready to supply customers from the new site.

The Managing Director and Secretary of the Company gave evidence, as also did Mr. S. Z. de Ferranti, who stated that he was consulting engineer to the Company, and considered its business had now reached the critical stage. The price charged for current varied from 3¾d. to 4½d. per B.T. unit, which was lower than the tariff of any other company he knew of. Dr. John Hopkinson and Prof. Henry Robinson also gave evidence on behalf of the Electric Lighting Company.

The SOLICITOR-GENERAL, on behalf of the Railway Company, agreed to give undisturbed possession of a portion of the land for a year, and offered £5,000 compensation.

The inquiry, after lasting several days, terminated in an award of £7,000 for the Electric Lighting Company.

### The Fareham Local Board and the Fareham Electric Light Company v. Smith.

This was a motion which came before Mr. Justice Chitty on Thursday, 16th inst., and was treated as the trial of the action for an injunction to restrain the defendant from removing or interfering with the electric wires and apparatus placed in Osborne-road, Fareham. The defendant was owner in fee in possession of land having a frontage in Osborne-road. The defendant had sent in a copy of plans of intended buildings on his land, and alleged that the poles and wires which were erected on his side of the road would interfere with his intended buildings.

Mr. JUSTICE CHITTY said that the defendant claimed to have a right to cut the wires of the Electric Light Company because he was the owner of the soil of half of the road, subject only to any statutory rights vested in the Local Board. That was the main ground on which the defendant justified his threat to cut the wires. He would assume that the defendant was right in his claim to the soil of the road. The Local Board, however, had a proprietary right in the zone above the surface, or, at any rate, had a possession of so much above and so much below as fell within the objects of the Public Health Act of 1875. In the present case the Local Board had contracted with the plaintiff company for the supply of electric light for public purposes. In pursuance of such contract, and, as the plaintiffs contended, by virtue of the Local Board's statutory right, posts and wires had been erected. The defendant did not complain of the work done being unnecessary for its purposes or beyond what was justified to carry out its object. It appeared to his Lordship, therefore, that the defendant must fail unless he could show that what had been done by the plaintiffs was a trespass. The question, therefore, arose whether the works were within the area of user of the street. He thought that they were within that zone which the statute had vested in the plaintiff Board. That being so, the defendant was not entitled to assume the position of Attorney-General and interfere. He therefore granted an injuction as asked, with liberty to both parties to apply, so that if any unforeseen circumstance should arise the defendant might apply to modify the injunction. The costs would follow the event.

### The Oriental Telephone Company (Limited).

A motion in connection with the above Company came before Mr. Justice Kekewich in the Chancery Division of the High Court of Justice, on Friday, Sir Horace Davy, Q.C., and Mr. Kerry appearing on behalf of Mr. G. P. Ness, while Mr. Cozens-Hardy, Q.C., and Mr. Theobald held a brief on behalf of the Company.

Sir HORACE DAVEY said his client was a vendor of the Oriental Telephone Company, and held vendors' shares therein. The question upon which the decision of the Court was asked was purely one of the construction to be placed upon an agreement dated January 25, 1881. The substance of the agreement was that under its provisions the vendors of their rights to the Company were to receive, as holders of certain Preferred shares granted to them, a minimum dividend of 6 per cent. for a period of five years, or, in other words, 30 per cent. in all. One of the clauses in the agreement went on to provide that if, after the expiration of the limited period of five years, the vendors had not received their full 30 per cent. then, that the difference between what they had received and what they ought to have received should be made up out of the surplus profits of the concern. The difficulty that was experienced was with regard to these latter words. It now turned out that holders of the Preferred shares had not received their full dividend of 6 per cent. for the period of five years, and they claimed, under the agreement of January 25, 1881, a sufficient share of the profits as would make up their interest to 30 per cent., insisting that their claim should be in priority to any of the other shareholders. This view he (Sir Horace Davey) understood was not taken by his learned friend, Mr. Cozens-Hardy, who appeared for the Company, and whose contention was, he believed, that the agreement of January, 1881, was only a charge upon the profits of the Company for five years, and that the agreement having expired, the Preferred, or vendor, shareholders were only entitled to rank *pari passu* with the other shareholders.

His LORDSHIP thought that Mr. Cozens-Hardy's view of the agreement was the correct one, and gave judgment for the Company accordingly.

## TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

"THE ELECTRICIAN"

### ELECTRICAL TRADES' DIRECTORY & HANDBOOK for 1891.

The 1891 edition of our well-known Directory and Handbook is ready, price 5s., postage extra. The book consists of over 900 pages, and has entailed this year a heavy amount of work. The HANDBOOK DIVISION contains a mass of most useful information. The DIRECTORY DIVISION consists of 430 pages, and contains a very carefully compiled Alphabetical and Classified List of Firms and Persons engaged in the Electrical and Allied Trades in all parts of the world. This Division has been corrected up to date, and the book is thoroughly reliable, the very numerous changes which take place at the beginning of the year being incorporated. By the aid of this Directory, makers of Electrical Machinery, Apparatus, Instruments, Fittings, Sundries, Novelties, and other goods, may safely communicate direct with probable customers without the annoyance and great expense consequent upon using books which are mere lists of Members of Scientific Societies repeated again and again. The Colonial and Foreign Division of this Directory will be found extensive and reliable. *Orders should be forwarded at once.*

In the course of a few weeks "The Electrician" Company will publish "THE ELECTRICIAN" PRIMERS in two volumes, price per volume 2s. paper covers, 2s. 6d. cloth.

TENDERS WANTED.—The Aberdeen Town Council are prepared to receive tenders from any company or person willing to undertake the electric lighting of the area covered by the Aberdeen Electric Lighting Order, 1890. The Town Clerk will receive tenders until Friday, May 15th.

EDISON AND SWAN UNITED ELECTRIC LIGHT COMPANY.—This Company announce that they will be glad to receive from their customers lamp ends containing platinum. Notwithstanding the fact that the platinum is mostly covered with glass and often has brass caps attached by solder and plaster to it as well, the Company can estimate with great accuracy the weight of platinum contained in any consignment of ends, and will allow the full weight at the rate of 50s. per ounce, with the reservation that this price is

Digitized by Google

subject to market fluctuations. Bags to hold small quantities of ends will be supplied free. Packages containing lamp ends should be addressed to the Works, Ponder's End, Middlesex.

The Maquay Electric Light Company.—This Company, with works at Limehouse, are opening new show rooms at 9, Frith-street, Soho, where they have on view a large number of "Maquay" primary batteries, used in demonstrating the utility of the Maquay system of electric lighting. It is claimed for this system that it is artistic, convenient, and inexpensive. At a recent visit we were shown a number of very cheap portable lamps suitable for warehouses, stables, offices, &c., where danger from the use of naked lights is great. As these lamps are placed on the market at a guinea each, there should be a wide field for them. There is also an electric mining lamp at the price of 18s. 6d., and included in the particulars issued is an account of some experiments and tests made with the "Maquay" lamp at a large colliery at Rotherham, in May last, by Mr. C. E. Rhodes.

The Forthcoming Electro-Technical Exhibition at Frankfort.—We have received the first number of the official journal of the forthcoming Exhibition, which it is intended to publish weekly, and which will contain particulars of the various exhibits, &c., at the Exhibition. The first number appeared on April 15th, and the series is expected to contain 30 numbers in all. Further particulars can be obtained upon application to Messrs. Haasenstein and Vogler, Frankfort-on-Main. The cost of the 30 issues will be £1. 10s., post free.

The Central Station Companion.—This handy "Companion" for the central station, which was described in our issue of August 15th last, and which, as our readers will remember, is a compact form of testing apparatus designed by Messrs. Dowsing and Day, was shown at Sir William Thomson's reception at the Royal Institution on the 10th inst., and also at the Institution of Civil Engineers last week, and considerable interest was manifested in its practical utility and the many uses to which it can be put. An arrangement has been recently added for use as a potentiometer. The "Companion" is being made by Messrs. Poole and White, of Bread-street, Cheapside, E.C., and will soon be ready for delivery.

National Telephone Company (Limited).—This Company have just issued a circular giving particulars of reductions recently made in the charge for private wires within the Metropolitan area. For a three years' contract a reduction of 25 per cent. off the old one-year tariff is made; for a five years' contract, 10 per cent. off the new three years' tariff, and for a seven years' contract a reduction of 15 per cent. off the new three years' tariff is made. The circular also gives a full list of the call-rooms of the Metropolitan Exchange system, and contains a notification that non-subscribers can use the telephone on payment of 3d. per message of three minutes' duration, with the exception of a few outlying districts (which are charged at the rate of 6d. per three minutes' conversation).

Messrs. W. H. Willcox and Co.—We have received a copy of reduced price list and particulars of Bourdon's patent pressure vacuum compound water and blast gauges, with porcelain and painted dials, issued by this Company. It is claimed for these dials that, being made of the best porcelain, and of pure white, the figures show out in great prominence, and that no discoloration of the dials takes place. Heat does not affect the figures of the dial, which are permanent.

Mr. F. M. Rogers.—Mr. Rogers sends us particulars of an adjunct to a lathe, which may be useful for amateurs. A standard is bolted to the bed of the lathe; upon this slides a face-plate, to which the work is secured. This face-plate is moved up and down by a roller, or guide block, mounted upon a pin bolted to the ordinary lathe chuck-plate. With a tool in the ordinary slide-rest the work may be planed or shaped.

Messrs. O. Berend and Co.—This firm request us to announce that they have been compelled to prosecute two clerks who pleaded guilty to stealing correspondence and goods and embezzling moneys; and as Messrs. Berend and Co. have reason to believe that some hundreds of letters, to the writers of which they have no clue, have been destroyed, they trust that this intimation may be taken as an explanation of the seeming neglect to reply to correspondence. They would be glad if writers of unanswered letters would again communicate with them.

**BRUSH ELECTRICAL ENGINEERING COMPANY.**—The Duke of Marlborough has accepted the position of Chairman of the Brush Electrical Engineering Company, in succession to Lord Thurlow, who has resigned his seat at the Board of that Company.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY.**—At a meeting of the Board of this Company held yesterday, it was decided that, after placing £30,000 to the reserve fund and £5,936 to the Debenture redemption fund, the Directors would recommend at the forthcoming meeting a dividend of 9s. per share, free of income tax, making, with the interim dividend paid in November last, a distribution of £5 per cent. for the year 1890, carrying forward £6,070 to 1891.

# PATENT RECORD.

## APPLICATIONS FOR PATENTS.

March 16, 1891.

4,860. H. Howard. London. Improvements in apparatus for heating and welding by the electric arc.

4,869. H. H. Lake. London. Improvements relating to primary and secondary electric batteries, and to the manufacture of plates or electrodes for use therein (L. A. W. Desruelles, France).

4,877. H. H. Lake. London. Improvements relating to plates or electrodes for primary and secondary batteries, and to the production of compounds or agglomerates for the manufacture of such plates or electrodes (E. A. G. Street, and L. A. W. Desruelles, France).

4,881. A. M. Clark. London. Improvements in electric tramways or railways (S. Schuckert and Co., through Wirth and Co., Germany.)

4,882. F. J. Duck. London. Improvements in electric indicators.

March 19, 1891.

4,904. J. H. Turner. London. Improvements in or connected with electric alarum clocks or time-pieces.

4,949. J. Y. Johnson. London. Improvements in galvanic batteries (A. Tardy, France).

March 20, 1891.

4,988. W. Thompson. Thornton Heath. Improvements in type printing instrument for telegraphic purposes.

5,003. J. Y. Johnson. London. Improvements in holders or supports for incandescent electric lamps (T. Mace, Holland).

5,021. H. H. Lake. London. Improvements in electric accumulators (G. Gandidi, Italy).

5,022. J. Moeller. London. An improvement in incandescent illumination, and apparatus for that purpose.

5,043. A. W. Money and H. Nash. London. An improved apparatus for regulating the approach of the carbons in arc lamps.

March 21, 1891.

5,067. H. Lassen. London. A system of economic and private telegraphing.

March 23, 1891.

5,131. H. N. Lawrence. London. Means for applying electricity through jets, streams, or sprays of fluids and vapours for therapeutic and other purposes.

5,135. B. D. Southard. Manchester. Improvements in armatures for dynamos or electric motors.

5,162. B. J. B. Mills. London. Improvements in devices for transmitting power, the same being specially adapted for use with electric motors propelling cars or vehicles.

5,167. F. E. Elmore and A. S. Elmore. London. An improvement in the manufacture of tubes by electrolysis.

March 24, 1891.

5,192. W. S. Scales. London. Improvements in electric clocks.

5,247. M. W. Dewey. London. Improvements in electric heating apparatus.

5,252. E. D. Graff. London. Electric signal apparatus for railway trains.

5,280. W. P. Thompson. Liverpool. Improvements in electric switches (Willing and Violet, Germany).

March 25, 1891.

5,313. H. Aylesbury. Bristol. An improvement for driving electrical machinery.

5,318. F. R. Boardman and J. S. Fairfax. London. Improvements in or relating to arc lamps.

5,329. L. Bristol. London. Improvements in portable electric safety lamps.

5,338. T. P. C. Crampton and A. Essinger. London. Improvements in the form of carbons used in certain electric arc lamps.

5,341. A. Poleschko. London. Improvements in electrical transformers.

5,342. H. L. Callendar. London. Improvements in electrical thermometers or pyrometers.

5,343. J. Brockie. London. Improvements in electric arc lamps.

5,350. R. R. Harper. London. Mounting electrical dynamo machines or motors to enable them to be easily reversed for driving in alternate directions.

March 26, 1891.

5,370. P. H. Williams. Egham. Improvements in and connected with dynamos, or other electric generators, and motors, and accumulators and other appliances.

5,371. P. H. Williams. Egham. Improvements in and connected with telephones and telegraphs, and apparatus and appliances therefor.

5,404. J. Clift. London. Improvements in or relating to fittings for electric and other lamps.

5,406. H. C. Jobson. London. Improvements in attachments for telegraph poles for carrying insulators.

5,412. T. Parker. London. Improvements in means for supplying electricity to electric tramways or railways.

Digitized by Google

5,435. D. LICHTENSTADT and C. LICHTENSTADT. London. Improvements in electric magnetic massage kneaders. [Date applied for under Patents Act, 1883, Sec. 103, December 8, 1890, being date of application in United States.]

March 28, 1891.

5,461. A. DICKENSON. South Staffs. Improvements in masts and trolleys for the overhead system of electric traction.

5,485. E. MASSIN. London. Improvements in the means for telephonic communication.

March 31, 1891.

5,508. T. L. HEMMING. Birmingham. An improved method of electro-plating wire.

5,518. H. AYRTON and W. E. AYRTON. London. Electric and other meters.

5,547. C. KELLNER. London. Improvements in apparatus for electrolytic decomposition.

5,548. J. D. BISHOP. London. Insulated electric conductors.

5,595. M. W. DEWEY. London. Improvements in electric heating apparatus.

April 1, 1891.

5,617. W. MCGEOCH, junr., and A. J. MCGEOCH. Glasgow. Improvements in electrical meters or measuring instruments.

5,637. R. W. BARKER. London. Improvements in electric converters. (M. G. Farmer, United States.)

5,638. W. A. CROWDUS. London. Improvements in electric batteries, [Date applied for under Patents Act, 1883, Sec. 103, 7th October, 1890, being date of application in United States.]

5,641. A. E. ANGOLD. London. The improvement of electric arc lamps.

5,656. A. L. SHEPARD. London. Improvements in and relating to electric lamps or lighting apparatus.

April 2, 1891.

5,679. R. STEENBERG. Newcastle-on-Tyne. Improvements in or connected with telephones.

5,690. H. C. BULL. Liverpool. Improvements in and connected with electric batteries.

5,711. J. R. THAME. London. Improvements in the manufacture of seamless tubes or conduits for electrical and other purpose, and in the apparatus employed therein.

5,712. S. PITT. London. Improvements in insulating electrical conductors. (E. C. Davidson, United States.)

5,713. S. PITT. London. Improvements in insulating electrical conductors. (E. C. Davidson, United States).

5,714. S. PITT. London. Improvements in insulating electrical conductors. (E. C. Davidson, United States.)

5,715. S. PITT. London. Improvements in insulating electrical conductors. (E. C. Davidson, United States.)

April 3, 1891.

5,766. G. J. PHILPOTT and R. HAMMOND. London. Improvements in electrical apparatus for use as an electric current meter, or as an electromotor.

5,780. J. M. MCHAHAN. London. An improved safety device or cut-out for the protection of electric circuits, and of apparatus connected therewith.

5,790. E. BOEHM and E. BAILEY. London. Improvements in incandescent electric lamps.

April 4, 1891.

5,794. A. R. UPWARD and J. H. MACFARREN. London. Improvements in the application of light, heat, and motive power obtained from electrical circuits to the purposes of advertisement.

5,795. P. H. WILLIAMS. Egham. Improvements in and connected with electric lighting, and apparatus and appliances therefor.

5,802. W. MCGEOCH, junr., and A. J. MCGEOCH. Glasgow. Improvements in holders for incandescent electric lamps.

5,824. J. PITKIN. London. Improvements in the manufacture of filaments for electric glow-lamps.

5,834. G. WILKINSON. London. Improvements in electrical measuring instruments.

5,835. A. D. JONES. London. Improvements in or relating to electrical measuring or indicating instruments.

5,849. H. NEHMER. London. A dry battery for medical purposes.

April 6, 1891.

5,869. G. SCARLETT. Liverpool. Improvements in indicators for electric bells, or for the passage of electric currents.

5,903. J. WALTER and VISCOUNT GRIMSTON. London. An electro-pneumatic rock drill.

5,912. W. SANDWELL. London. Improvements in the transmission of electricity to portable cranes and other machinery, telpher lines, and the like.

5,918. H. I. HARRIS and W. H. POWER. London. Improvements in electric batteries.

April 7, 1891.

5,947. H. CHAPMAN. London. Method of and means for renewing or repairing the filaments of incandescent electric lamps.

5,953. W. A. BYRON and S. GEORGE. London. Improvements in and relating to voltaic batteries.

5,963. H. A. C. SAUNDERS and A. C. BROWN, London. An electric "hooter" or loud sound producing apparatus.

5,972. W. SILLERY. Liverpool. Improvements in electric storage batteries.

5,983. E. A. LE SUEUR. London. Improvements in or connected with means or apparatus employed in electrolysis.

5,989. E. W. LANCASTER. Birmingham. An improved means of wiring brackets, pendants, electroliers, and the like for electric lighting.

5,992. F. E. S. D'ODIARDI. London. Improvements in pneumo-dynamometers.

5,993. F. E. S. D'ODIARDI. London. Improvements in the electric cup.

5,994. F. E. S. D'ODIARDI. London. Improvements in electro-inhalers.

5,995. F. E. S. D'ODIARDI. London. Improvements in liquid electrodes.

5,996. F. E. S. D'ODIARDI. London. Improvements in magneto voltaic and static electrodes.

5,997. F. E. S. D'ODIARDI. London. Improvements in electric atomisers

6,003. J. C. REILLY. London. Terminals for cables of electrical conductors.

6,007. E. W. LANCASTER. Birmingham. Improvements in handles or taps for electrical switches.

April 8, 1890.

6,011. A. P. LUNDBERG. London. Improvements in ceiling roses for electric lighting.

6,012. A. P. LUNDBERG. London. Improvements in switches for electric lighting.

6,048. G. NORTH. London. Improvements in electric power apparatus.

6,072. C. E. CARPENTER. London. Improvements in electro-heating apparatus. [Date applied for under Patents Act, 1883, Sec. 103 September 27, 1890, being date of application in United States.]

April 9, 1891.

6,104. I. A. TIMMIS and A. I. SMITH. London. Improvements in dynamos and motors.

6,125. J. K. RITTER. London. Improvements in electrical apparatus for soldering, boiling, and heating.

April 11, 1891.

6,194. J. A. KINGDON. London. Improvements in electromotors for alternating currents.

6,232. E. GWOSDEFF and A. BUNGÉ. London. Improvements in microphones for telephonic circuits and in the induction coils thereof.

6,243. S. M. L. PATZ and R. GREBNER. London. Improvements in galvanic batteries.

6,247. J. Y. JOHNSON. London. Improvements in automatic regulating apparatus employed in connection with galvanic batteries (F. Gendron, France).

## SPECIFICATIONS PUBLISHED.

1890.

4,650. PALMER, Producing motion by electricity. (Price 11d.)
4,824. NEBEL. Dynamo-electric machines. (Price 8d.)
5,923. SLEEMAN. Electric currents. (Price 8d.)
13,463. MOSELEY. Galvanic batteries. (Price 8d.)
19,942. THOMPSON (Marx). Galvanic batteries. (Price 6d.)
20,986. LAKE (Lemp). Electrically welding, &c., metals. (Price 8d.)

1891.

641. SLAMMER. Electric clocks. (Price 8d.)
908. ROSS. Insulators for electric wires. (Price 6d.)
2,360. CHESWRIGHT. Accumulator plates. (Price 6d.)

# COMPANIES' MEETINGS & REPORTS.

## The Eastern Extension, Australasia, and China Telegraph Company (Limited).

The thirty-fifth ordinary general meeting of this Company was held on Wednesday last, at Winchester House, 50, Old Broad-street, under the presidency of Sir John Pender, K.C.M.G.

The SECRETARY (Mr. F. E. Hesse) read the notice convening the meeting by the Chairman, the minutes of the last ordinary general meeting, and the minutes of the extraordinary general meetings held, and the same were confirmed and signed. The report and accounts were taken as read.

The CHAIRMAN: Gentlemen, before asking you to approve the report I shall, as usual, put some figures before you, so that you may fully understand what has been done during the last six months. The gross receipts for the past half-year amounted to £279,095, against £264,103 for the corresponding period of 1889, showing an increase of £14,992 for the half-year, which is partly due to profit on exchange during the sudden but temporary rise in the value of silver, and partly from increased traffic with Australasia. The working expenses have been £74,090, against £73,498 for the corresponding half-year of 1889, or an increase of £592. The net revenue for the past half-year was £166,807, against £146,144 for the corresponding period of 1889, or an increase of £20,663, which is explained

Digitized by Google

by the additional revenue already referred to, and the disappearance from the accounts for the past half-year of the item of £6,500 charged in former accounts for the interest and sinking fund in connection with the Five per Cent. Manila Debentures which were paid off last year. The net saving on this account, as mentioned at the last meeting, is £5,000 a-year. The usual interim dividends were distributed during the past year, making, with the dividend proposed to be paid to-morrow, a total dividend of 5 per cent. for the year, which, with the proposed bonus of 4s. per share, will make a total distribution for the year 1890 of 7 per cent. After taking from revenue £100,000 on account of the Madras-Penang duplicate cable. and £1,120 for a new land line at Banjoewangie and additions to staff quarters, there remained a balance of £25,007, which has been carried to the general reserve fund, which now stands at £495,239. During the year 1890 this fund has been credited with £65,130, and debited with £280,004, as follows:—Amount of fund at end of 1889, £710,113; interest on investments during year, £18,786; profit on sale of investments, £21,337; balance from revenue, £25,007; total, £775,243; less cost of New Zealand duplicate cable, £188,433; Madras-Penang partial renewal, £83,678; other cable renewals, &c., £7,893—£280,004; leaving the fund as already stated at £495,239. In addition to this, nearly a million sterling has been taken from revenue for cable renewals and duplications since the Company was formed. The past year was the best the Company has ever had, the gross revenue having amounted to £533,951, or £27,458 in excess of the best previous year, viz., 1885, when the tariffs were in force which were subsequently reduced at the Berlin Conference. As stated in the printed report, the recent conversion of the Company's Six per Cent. Debentures into Four per Cent. Debenture Stock was attended with complete success, the whole of the stock having been taken up at par by the shareholders at a time when the bank rate was at 6 per cent., and the City was passing through a financial panic. An official quotation of the stock has been obtained, and it now stands at 5 to 7 premium. With the exception of a few hundred pounds all the Six per Cent. Debentures have now been lodged at the Company's bankers, and paid off. By this operation an annual saving of £6,400 a-year has been effected, making, with the saving of £5,000 already referred to, a permanent saving of £11,400 per annum. A further drawing of 320 of the Five per Cent. Australian Government Subsidy Debentures took place on the 7th instant, which, when paid off on July 1st next, will reduce the amount of the Australian Debenture debt outstanding to £354,500, the total issue having originally been £640,000. You will have observed from the report and Press announcements that the negotiations which have been so long in progress with the Governments of Australasia for a substantial lowering of the tariffs to Australia have at last been brought to a successful termination, and that the reductions will come into force on May 1st proximo. The agreement is made with the colonies of Victoria, New South Wales, South Australia, West Australia, and Tasmania, who guarantee the Company against one-half the risk of any loss resulting from the reductions, the Company accepting the other half; and the arrangement is for a tentative period of one year, to be extended if found to work satisfactorily; consequently, the continuance of the reduced rates depends upon the telegraphing public giving the experiment their hearty support, and thus making it a success. It was hoped that Queensland and New Zealand would have taken part in the arrangement, especially as in the case of the latter colony a substantial reduction of tariff would have followed between New Zealand and Australia; but after considerable negotiation between the various Governments, Queensland and New Zealand declined to take part in the arrangement, and the tariffs to those colonies will therefore remain unchanged. Since the report was issued an agreement has been formally concluded between the Company and the Indo-European department of Her Majesty's Indian Government, the Eastern Telegraph Company, and the Indo-European Telegraph Company, by which the guarantee and risk are shared between the parties according to their respective interests in the Australasian traffic. The maximum liability, if no increase of traffic were to result from the reduction, would be £131,810, of which the contracting colonies' share would be one-half, or £65,905, and the Extension Company's proportion, £42,500, the balance of £23,405 being divided between the Eastern and the Indo-European Companies and the Indo-European department. Should, however, the traffic increase by 25 per cent., the Extension Company's liability would be reduced to £34,000; 50 per cent., £25,000; 75 per cent., £17,000; and 100 per cent., £8,000. Since the close of the year the Telegraph Construction and Maintenance Company have successfully completed their contract with the Company for the duplication of the Madras-Penang cable (1,388 knots in length), and the Eastern Company's new cables between Suez, Aden, and Bombay having also been laid, the service is now in a thoroughly efficient condition to meet all requirements that may arise in connection with the reduced rates to Australia. As already stated, a sum of £100,000 has been taken from last year's revenue towards the cost of the duplicate Madras-Penang cable, and it is also proposed to pay the balance of £150,000 out of revenue as opportunities occur, so as not to increase the capital account. The total length of our system is now 15,700 nautical miles of cable, and owing to the policy so frequently referred to, and approved by the shareholders, of renewing and duplicating our lines out of revenue instead of adding to the capital, these cables now stand in our books at a comparatively low figure (applause). I have probably read you a report which it would be very difficult to beat. I think we must all congratulate ourselves on our affairs being in such a satisfactory condition. I am satisfied myself that the policy which your Directors have pursued in keeping down the capital, and paying as much as possible out of income, has been the real root, foundation, and success of these submarine telegraph companies (applause). We are now making a new departure, namely, the arrangement with the Australian Governments, and if it is successful, no doubt it will be extended elsewhere; but we are more likely to be successful in Australia, because every man there is more or less a merchant, large or small. A great many people desire to become merchants; and my view of this reduction is that a man spending to-day say, £1,000 upon telegrams will continue to spend the same amount with the reduced tariff. The reduction will also bring in a class that could not afford to send telegrams at the previous rates. Therefore, I think we shall not only have the money we have been hitherto receiving, but a number of additional customers coming forward. The vitality in the Colonies is very remarkable indeed. Six years ago at the Berlin Conference we were called upon to make reductions in our tariff, which involved us in an estimated loss of about £60,000, and the Australian proportion of this loss was recouped in less than three years. I hope the details I have given you will have convinced you that the present reduction is not going to put us in a disagreeable position. I think that we have shown that we have the courage to cope with great occasions of this kind, and, if successful, I think it will be a new era in submarine telegraphy. As you all know, submarine telegraphy is regulating the commerce of the world, and as the world grows and the colonies increase, so will the old country become more prosperous. Now, gentlemen, a great many people will be claiming the merit of having made this bold venture. I see in print sometimes the statements of people which make me smile. At the same time, every man has his own views on the subject; but I want you to know exactly what are the facts, because you are all, more or less, as members of this Company, entitled to the credit of what I may call this very remarkable departure. Well, then, the guarantee was first suggested to the Queensland Government in 1885, to the New Zealand Government in 1886, to the Jubilee Conference in 1887, and subsequently submitted to several conferences in Australia and elsewhere. I can only tell you that we have been working at this for six years, and you will appreciate our difficulties when I say that we have had to deal with Continental Governments, such as Germany and Russia, as well as all the different colonies of Australia, who are very jealous of one another. They are now, as you are aware, talking of federation, and probably this is the first step towards the accomplishment of that end, but it will take a long time, as we know, to bring federation about, but when it is accomplished I believe it will prove an immense benefit to the colonies themselves. You will see that we are taking a large risk in this reduction. Nobody knows the working of the system better than we do, and we think we are quite warranted in taking this step. I believe that the loss will be very small the first year, and probably the second year it will disappear altogether; but we have set the example, and after all, in securing the guarantee of those colonies we are practically securing upon the whole of our capital something like 2 per cent., which ought to materially improve the value of our stock, and give the investing public confidence in it. Some people say that you cannot have universal telegraphy, and that the working people do not benefit by it. I take a very different view. I think that the working people do benefit by every forward movement of this kind. You cannot have cheap telegraphy in a country without giving the working classes a share of its benefits. Some people say that we are taxing the products of the country. We are certainly taxing commerce to a certain extent, but when that commerce recoups itself many times over in the course of a year from such enterprise the working classes derive the benefit in increased wages. I must here express my regret that Queensland and New Zealand have not agreed to take part in the experiment. If they had done so, I think it would have been almost a complete federation, but from the beginning of this Company Queensland, more especially, has always stood aloof from us. She had a sore 20 years ago that has never been entirely healed, but as Queensland and New Zealand will practically participate to some extent in the benefits which we are conferring on the other colonies, I believe that by-and-by, when they see the advantages accruing to the other colonies, they will consider it a wise thing to join in the general guarantee. In concluding my remarks in regard to these protracted negotiations, I should like to bear testimony to the assistance and encouragement I have all along received from the Agents-General who so ably and intelligently represent their respective colonies in this country, and who are necessarily in a position to appreciate the advantages that must accrue to the colonies from cheaper telegraphic communication with the mother country and the rest of the world. Our relations with our friends the Great Northern Telegraph Company continue to be most satisfactory, and we are working together in a way to ensure success. I hope the next time that I shall have the pleasure of addressing you to be able to make a communication which will show that your interests are well guarded, and that we have completed with the Great Northern Company further negotiations for the purpose of making our Company more sound and prosperous. With these remarks I beg to move the following resolution:—

*"That the report and accounts of the Directors now submitted be received and adopted, and that a dividend for the quarter ended December 31st last be now declared of 2s. 6d. per share, together with a bonus of 4s. a share—both free of income tax—making, with previous distributions, 7 per cent. for the year 1890."*

The MARQUIS of TWEEDDALE seconded the motion, which was carried unanimously without discussion.

The CHAIRMAN: The next resolution is:—

*"That the Right Hon. Viscount Monck, who now retires by rotation, be and he is hereby re-elected a Director of this Company."*

Sir JAMES ANDERSON seconded the motion, which was carried unanimously.

The CHAIRMAN: The next resolution is:—

*"That George Garden Nicol, Esq., who now retires by rotation, be and he is hereby re-elected a Director of this Company."*

The resolution, having been seconded, was carried *nem. con.*

Mr. HAUKINS: Are both gentlemen here?

The CHAIRMAN: I shall be very plain with you. Lord Monck has

Digitized by Google

been associated with this Company from its inception. At the present moment he is suffering from illness. You have got a very efficient Board. I think that the report I have made to you to-day shows that. Every point affecting your interests is carefully considered. If I felt that the absence of any of the Directors weakened even for a time the deliberations of the Board, I should be the very first to call the attention of that member to the fact. But seeing that Lord Monck has been so long a member, and that he is in bad health, having specially requested to be allowed to be absent for a time, I think it would be ungracious and unkind on the part of his old colleagues if they had not granted that, and I am sure that the general body of the shareholders will share this opinion with me. But thinking that the question might be asked, I hold in my hand Lord Monck's resignation, which I can put into effect the moment that the interests of the Company require it. I may mention to you that these remarks not in the slightest degree apply to Mr. Nicol. I do not believe Mr. Nicol has ever missed a Board meeting. Some of his colleagues probably think that it would be better if he missed a few occasionally. I daresay you recognise Mr. Nicol as being always present. I am very pleased, indeed, Mr. Haukins, to find you looking so sharply after the Company's affairs.

Mr. HAUKINS thought it was a very wise policy to reduce the tariffs as proposed.

Mr. LEWIS proposed the re-election of the retiring auditors, Mr. Henry Dever, and Messrs. Welton, Jones and Co.

Mr. WELLS seconded the resolution, which was agreed to *nem. con.*

Mr. LEWIS congratulated the Chairman on the recent honour conferred upon him in Paris. It was an honour conferred not only upon him, but upon everybody connected with the Company (applause).

The CHAIRMAN: Gentlemen, I thank you most cordially on behalf of my colleagues and myself. The honour you refer to is a very great one, but it is one that applies to you all. You have been all, more or less, working with me, and have been backing me up in the great works we have successfully carried out for bringing the distant places of the earth nearer to each other. I accept the honour in that light, and also in the broad view that this is a great international system from which every one benefits alike. It is one of those enterprises that benefits humanity at large. It is a very high position to be at the head of such an institution, and when nations like France recognise our work in the way she has done in my person, I think we may all be satisfied that we are of importance to the world at large.

The proceedings then terminated.

## South of England Telephone Company.

A meeting of the preference shareholders of this Company, convened by Mr. Thomas Welton, the liquidator was held on Monday, at Winchester House, Old Broad-street, with reference to the proposal that the preference shareholders should have transferred to them 4½ per cent. debenture stock of the National Telephone Company (which, as reported in *The Electrician*, recently acquired the undertaking of the South of England Company), in satisfaction of their claims to be repaid £3. 10s. per share upon the preference shares of the South of England Company.

The CHAIRMAN stated that the meeting had been called in a great measure for the purpose of enabling the preferred shareholders to attend and ask any questions which they might think fit regarding the debenture stock which they now had the option of receiving in exchange for their preference shares. He might, perhaps, save them some little trouble by stating at the outset that of the whole amount of £70,000 of stock which was to be issued to him, he had received intimation from preference shareholders desirous of receiving the stock to the extent of very nearly two-thirds of the whole amount. With regard to the balance of £23,000 odd, unless any further assents came in, he considered it very probable that he could dispose of it at round about par. He had brought with him a copy of the prospectus of the National Company on the issue of £350,000 of this stock which was made by them a short time ago, and it was open to the inspection of any preference shareholder who desired to see it. This £350,000 would be increased by the £70,000 which was to be handed over to him, and the amount of the stock might be increased until it reached a sum not exceeding half the share capital of the National Company. The £350,000 required a net amount for interest of £15,750, and the present £70,000 would, of course, require an increased amount for interest; but there would still remain an extremely large margin, because the net revenue for the year ended April 30, 1890, was £185,000. Perhaps the important point for the consideration of the preference shareholders generally was that the most astute and the cleverest people who were interested in the shares had agreed to accept the debenture stock now offered to them instead of cash. It was obvious that by getting the debenture stock in the manner now proposed, holders would be saved any trouble in regard to stamps, as the stock would be transferred to them clear. His object originally in making this proposal was to prevent the necessity from being cast upon him of realising the whole £70,000 in the market at a blow—a proceeding which might have depreciated its value. The debenture stock now offered was not included at present under the quotation granted by the Stock Exchange for the £350,000, but it would be brought under that quotation at as early a date as possible. There would be no difficulty in obtaining an extension of the quotation.

In reply to questions, Mr. WELTON added that the quoted debenture stock was, he understood, sold at a premium. He had heard that its price had been something like 103, but he did not know the present quotation. He believed that only two of the shareholders out of the entire number had intimated their preference to have cash, but the amounts they held were only £350 and £140, and these holders had no special wisdom to bring to bear which should guide the holders as a body. What he would do now was to intimate what had taken place at that meeting to those who had not yet responded to the offer which had been made to them to take debenture stock for the preference shares. He would give these holders a few days more to make up their minds, and if they did not within a few days determine to take up the stock he would sell the amount and offer the holders of the shares their cash. If, however, he obtained a premium on the debenture stock thus sold, the preference shareholders would not get the benefit of the premium, simply receiving the amount in cash, and on the other hand, if he had to realise the stock at a discount the holders of the shares would have to put up with that discount.

The proceedings then terminated.

## Reuter's Telegram Company (Limited).

The following is the Report of the Directors to be presented at the twenty-seventh ordinary general meeting of the shareholders, to be held at the Company's offices, No. 24, Old Jewry, London, E.C., at noon, on Wednesday, the 29th day of April, 1891:—

The Directors beg to report that the net profits for the year ending December 31st last, after payment of Directors' remuneration, current expenses, and deducting rebate on unexpired subscriptions, amount to £4,594. 7s., including £113. 4s. 6d. brought forward from the last account.

An interim dividend of 4s. per share was paid in October last, and the Directors now recommend a further dividend of 4s. per share, making a total distribution for the year of 5 per cent. free of income-tax. This will absorb £3,691. 2s. 6d., and leave a balance of £903. 4s. 6d. to be carried forward. The dividend warrants will be payable on May 2nd next.

The High Court has sanctioned the alteration of the Memorandum of Association, enabling the Company to undertake Advertisement business,

PATENT
SILICIUM BRONZE AND SILICIUM COPPER WIRE.
The best for overhead Telephone and Telegraph Lines,
AND ALL ELECTRICAL PURPOSES.
Hard Drawn High Conductivity Copper Wire.
ROLLED AND DRAWN PHOSPHOR BRONZE.
PHOSPHOR BRONZE — VULCAN — PHOSPHOR — DURO METAL
PHOSPHOR BRONZE BEARINGS, BUSHES, AND OTHER PARTS OF ELECTRICAL MACHINERY
SOLE PROPRIETORS of the British, Indian and Colonial Patents.
THE PHOSPHOR BRONZE COMPANY (Limited),
87, Sumner Street, Southwark, London, S.E.
WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

Digitized by Google

and otherwise to enlarge the scope of its operations. Active measures are being taken to give effect to this extension of the Company's powers.

In conformity with the Articles of Association, Baron de Reuter retires from the direction, but offers himself for re-election. Mr. George de Reuter and Mr. Frederick J. Griffiths have been appointed Directors. Messrs. Welton, Jones and Co. offer themselves for re-election as Auditors.

## Metropolitan Electric Supply Company (Limited).

The following is the report of the Directors of this Company for the period commencing October 1, 1889, and ending December 31, 1890, to be presented to the shareholders at the fourth ordinary general meeting to be held at Winchester House on Wednesday, the 29th inst., at 11:30 a.m. :

The form in which this statement is presented is that prescribed by the Board of Trade under the provisions of the Electric Lighting Acts of 1882 and 1888.

It should be remembered that the period under review commences one month after the date when Parliamentary powers were granted, and comprises the time during which the greater portion of the Company's works of construction were being carried out. The growth of business may best be realised by comparing the gross revenue for the last three months of 1889, which was £2,866. 15s. 7d., with the corresponding period in 1890, when it amounted to £10,726. 19s. 0d. The number of lamp connections which, at the close of 1889, were 14,000, amounted at the close of 1890 to 48,000. This number has been since increased to 58,000, and the demand for the light in the Company's districts is steadily on the increase.

Having regard to the fact that the period under review has been mainly one of construction, it is a matter for congratulation that the Company's income, which was to a great extent the result of the last three months' working, has resulted in a profit, which, though a small one, gives the strongest grounds for confidence in the immediate future.

The earnings of the first three months of the present year are so encouraging that the Directors have decided to make an interim distribution of 2s. per share, which will be paid on May 1st next.

The Company's stations at Whitehall, Sardinia-street, Rathbone-place, and Manchester-square, are now completed, and their working has so far given great satisfaction to the Board. It is confidently anticipated that the new station for the Paddington district, the machinery for which is in a forward state, will be at work in time for next winter's lighting. These stations, with the mains and other necessary plant, will about absorb the Company's present issue of capital, but, as the demand for electric lighting increases, the Directors will be prepared to recommend steps being taken to meet it.

In accordance with the Articles of Association the following Directors, viz., Alderman Sir Robert N. Fowler, Bart., M.P., J. E. H. Gordon, Esq., and J. C. Parkinson, Esq., retire from the Board. Sir Robert Fowler and Mr. Parkinson, being eligible offer themselves for re-election. The Directors regret that Mr. Gordon, owing to his increasing business as a consulting engineer, has considered it advisable not to seek re election ; he will, however, continue to act as one of the Company's consulting engineers. The Auditors, Messrs. Deloitte, Dever, Griffiths, and Co., retire, and offer themselves for re-election.

## NEW COMPANIES REGISTERED.

**BRILL BRICK AND TILE COMPANY (LIMITED).**—The objects of this Company, which has been registered with a capital of £10,000 in £5 shares, with registered office at Brill, Bucks, include, in addition to those indicated by its title, the production and use of electricity, magnetism, or other power.

**CARBON ELECTRIC (LIMITED).**—Registered with a capital of £20,000 in £5 shares. Object: To carry on the business of manufacturers of carbon rods and plates for electrical purposes, in accordance with an agreement made March 7th between Henry J. Chappell of the one part and G. B. Cook of the other part.

**COLLIER AUDIBLE TELEPHONE SYNDICATE (LIMITED).**—Registered with a capital of £9,000 in £100 shares. Object: To acquire and develop the inventions of Arthur T. Collier in respect of improved telephonic receivers and transmitters. Arthur T. Collier is appointed Managing Director.

**INTERNATIONAL ELECTRIC SYNDICATE (LIMITED).**—Registered with a capital of £12,000 in £10 shares. Objects: To acquire and hold the rights granted by letters patent to J. F. Weyde, F. Clas, and J. Elsner, for improvements in the construction of electric accumulators ; to buy other patents, and to sell, deal in, work and develop the said patents and others that may be acquired. The first signatories (with one share each) are W. D. Edwards, G. L. Russell, A. Foglar, R. W. Davey, H. V. Tyrrel, T. H. Deakin, and J. A. Elsner. Registered office: 5, Guardian-buildings, Manchester.

**JOHNSON, MATTHEY AND CO. (LIMITED).**—Registered with a capital of £900,000 in £15 shares. Object: To acquire, as a going concern, the business of Johnson, Matthey and Co., and to carry on generally the businesses of assayers, refiners, and metallurgical chemists, and dealers in gold, platinum, silver, and in metals and chemicals of all descriptions.

## CITY NOTES, &c.

**BRAZILIAN SUBMARINE TELEGRAPH COMPANY.**—The receipts of this Company for the past week amounted to £5,750.

**CITY AND SOUTH LONDON RAILWAY COMPANY.**—The traffic receipts of this Company for the week ended April 19th amounted to £816.

**EASTERN TELEGRAPH COMPANY.**—This Company announce that, in view of the reduction of the telegraph rates to Australia to come into operation on May 1st next, and to meet all requirements that may arise in connection with the anticipated increase of traffic, two new cables of great carrying capacity have been laid between Suez and Aden, and Aden and Bombay, thus affording increased speed and security in the transmission of traffic over its lines. The Company also announce the payment by warrants, on May 1st next, of interest for the half-year ending April 30th on their Four per Cent. Mortgage Debenture stock. The transfer books will be closed from April 28th to May 1st both days inclusive.

**ELECTRIC TANNING (GROTH v. THE BRITISH TANNING COMPANY).**—This action was in the list for hearing on Tuesday, before Mr. Justice Charles ; but no one appearing on behalf of the plaintiff, Mr. Bray, who represented the Company, asked that the action might be dismissed with costs, which his Lordship directed should be done.

**LONDON PLATINO-BRAZILIAN TELEGRAPH COMPANY (LIMITED).**—At a Meeting of the Board of this Company on Thursday last, it was decided that, after placing £6,000 to the reserve fund, the Directors will recommend at the forthcoming meeting a dividend of five shillings per share, free of income tax, making with the interim dividend paid in November, a distribution of £4½ per cent. per annum for the year 1890.

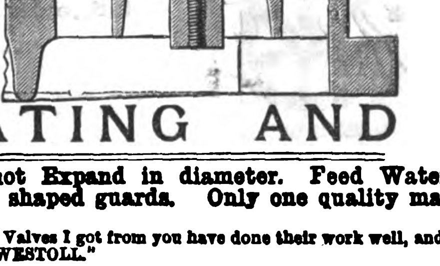
**WEST COAST OF AMERICA TELEGRAPH COMPANY (LIMITED).**—The offices of this Company have been removed from Winchester House to 120, Cannon-street, London, E.C.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY.**—The traffic receipts of this Company for the week ended April 17, 1891, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £4,640.

**WEST INDIA AND PANAMA TELEGRAPH COMPANY.**—At a meeting of the Directors of this Company held on Wednesday it was decided to recommend that, subject to final audit, the following dividends be declared, viz., 6s. per share for the six months to December 31st last on the First Preference shares ; 34s. 6d. per share on the Second Preference shares (*i.e.*, 28s. 6d. balance of arrears and 6s. dividend for the six months to December 31st) ; and 9d. per share on the ordinary shares, and carrying forward £668. The receipts of this Company for the half-month ended April 15th show an increase of £21 as compared with the corresponding period.

NEW VALVE

No Rubber, Percha, or Leather.




One-half the price of Rubber or Metal.

FOR CIRCULATING AND AIR PUMPS.

Unaffected by any Lubricating Oils. Does not Expand in diameter. Feed Water may be worked at any temperature Suitable for any shaped guards. Only one quality manufactured.

"12, John-street, Sunderland, 26th Sept. 1885.

"DEAR SIRS,—In reply to your letter of the 25th inst., the Valves I got from you have done their work well, and ARE AN UNQUALIFIED SUCCESS. I will continue to get them from you as required.—Yours faithfully, JAMES WESTOLL."

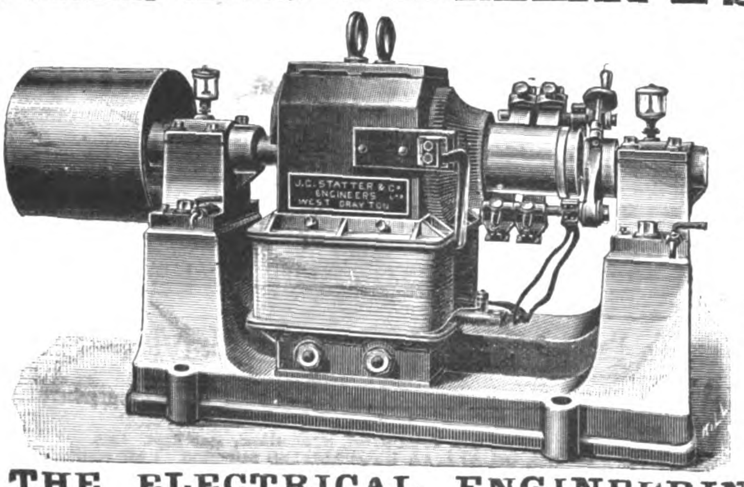
For further Testimony and Prices, apply to MOSSES & MITCHELL, 68-71, Chiswell Street, London.

Digitized by Google

# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name. | Previous Week's Price, April 15. | | Price Wednesday, April 22. | | Rate per Cent. Yielded | Dividend Due. | Business Done During Week Ending April 22. Highest. | Lowest. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **TELEGRAPHS.** | | | | | £ s. d. | | | |
| £1,381,380 | Stock | 15/0 | Anglo-American | 46½ | 46½ | 47 | 48 | 5 19 9 | Jan., Apr., July, Oct. | 47½ | .. |
| £2,809,310 | Stock | 30/0 | Do. Preferred | 84¼ | 85½ | 84½ | 85½ | 6 14 6 | " " | 85½ | 84¾ |
| £2,809,310 | Stock | .. | Do. Deferred | 11 | 11½ | 11 | 11½ | .. | .. | 11⅝ | 11¼ |
| £250,000 | 100 | 4% | African Direct, Telegraph 4% Debentures | 99 | 102 | 99 | 102 | 3 18 5 | January and July .. | 100 | .. |
| 130,000 | £10 | 3/0 | Brazilian Submarine | 11½ | 12 | 11½ | 12 | 6 5 0 | Mar., June, Oct., Dec. | $11\frac{13}{16}$ | 11½ |
| £84,500 | £100 | 5% | Do. 5 per Cent. Bonds | 100 | 103 | 100 | 103 | 4 17 1 | January and July .. | .. | .. |
| £75,000 | £100 | 5% | Do. 5 per Cent. Bonds (2nd Series, 1906) | 103 | 107 | 103 | 107 | 4 13 6 | June and December | .. | .. |
| $7,216,000 | $100 | 7% | Commercial Cable Capital Stock | 108 | 110 | 108 | 110 | 6 7 3 | April and October .. | 108¾ | 108½ |
| 16,000 | 10 | 8/0 | Cuba Submarine | 10½ | 11½ | 10½ | 11½ | 6 19 2 | February and August | 11½ | .. |
| 6,000 | 10 | 10% | Do. Preference 10% | 16½ | 17½ | 16½ | 17½ | 5 14 3 | " " | 17¼ | 16¾ |
| 12,931 | 5 | 2/4¾ | Direct Spanish (£4 paid) | 3¾ | 4¼ | 3¾ | 4¼ | 6 11 9 | April and October.. | 4 | 3⅝ |
| 6,000 | 5 | 10% | Do. Preference 10% | 9 | 10 | 9 | 10 | 5 0 0 | " " | 9⅝ | .. |
| 60,710 | 20 | 3/6 | Direct United States | 10⅛ | 10⅝ | 10⅛ | 10⅝ | 6 15 0 | Jan., Apr., July, Oct. | $10\frac{5}{16}$ | $10\frac{3}{16}$ |
| 400,000 | 10 | 2/6 | Eastern ... xd | 14⅛ | 14⅜ | 14⅛ | 14⅜ | 4 10 5 | " " | 14¼ | 14¼ |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference ... xd | 15¼ | 15¾ | 15¼ | 15¾ | 3 16 2 | " " | 15½ | .. |
| £1,200,000 | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock | 108 | 111 | 108 | 111 | 3 12 1 | May and November | 109½ | .. |
| £200,000 | 100 | 5% | Do. 5 per Cent Debentures, 1899 | 107 | 110 | 107 | 110 | 4 10 11 | February & August | 107¼ | .. |
| 250,000 | 10 | 2/6 | Eastern Extension | 14¾ | 15¼ | 14¾ | 15¼ | 4 13 4 | Jan., Apr., July, Oct. | 15¼ | 15 |
| £320,000 | £100 | 4% | Do. 4 per Cent. Debenture Stock | 105 | 108 | 105 | 108 | 3 14 1 | .. | 107¼ | 106 |
| £91,800 | 100 | 5% | Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900 | 103 | 106 | 103 | 106 | 4 14 4 | January and July .. | 104½ | .. |
| £145,300 | 100 | 5% | Eastern & S. African 5 per Cent. Mor. Deb., 1900 | 103 | 106 | 103 | 106 | 4 14 4 | " " | 103½ | .. |
| 180,227 | 10 | 1/9 | Globe Telegraph and Trust ... xd | 9⅛ | 9⅜ | 9⅛ | 9⅜ | 5 9 4 | Jan., Apr., July, Oct. | 9⅜ | 9¼ |
| 180,042 | 10 | 6% | Do. 6 per Cent. Preference ... xd | 14¾ | 15 | 14¾ | 15 | 4 0 0 | " " | 15 | $14\frac{13}{16}$ |
| 150,000 | 10 | 5/0 | Great Northern | 17½ | 18 | 17½ | 18 | 4 3 4 | Jan., April, and July | 18 | 17½ |
| £15,000 | 100 | 5% | Do. 5 per Cent. Debentures, 1881 | .. | | .. | | .. | January and July .. | .. | .. |
| £230,000 | 100 | 5% | Do. 5 per Cent. Debentures, 1883 | 103 | 106 | 104 | 107 | 5 13 6 | March & September | .. | .. |
| 17,000 | 25 | .. | Indo-European | 41 | 43 | 41 | 43 | 5 16 3 | May and November | 43 | 42¼ |
| 38,348 | 10 | 2/6 | London Platino-Brazilian | 6½ | 7½ | 6½ | 7½ | 5 14 4 | " " | .. | .. |
| £100,000 | 100 | 6% | Do. 6 per Cent. Debentures | 105 | 108 | 105 | 108 | 5 11 1 | March & September | .. | .. |
| 9,000 | 8 | 4/0 | Reuter's | 9 | 9½ | 9 | 9½ | 5 6 10 | April and October.. | 9 | .. |
| 3,381 | £100 Cert. | 6% | Submarine Cables Trust 6% ... x Oct. Coupon | 113 | 118 | 113 | 118 | 5 1 8 | " " | .. | .. |
| 15,609 | 10 | 4/0 | West African Telegraph | 8 | 9 | 8 | 9 | 5 11 1 | January and July .. | .. | .. |
| £290,900 | 100 | 5% | Do. 5 per Cent. Debentures | 98 | 101 | 98 | 101 | 4 19 0 | March & September | 99¼ | 98 |
| 30,000 | 10 | 3/0 | West Coast of America | 2½ | 3½ | 2½ | 3½ | .. | January and July .. | .. | .. |
| £150,000 | 100 | 8% | Do. Debentures 8% 1902 | 92 | 97 | 92 | 97 | .. | June and December | .. | .. |
| 88,321 | 10 | .. | West India and Panama | 2¾ | 3 | 2¾ | 3 | .. | .. | $2\frac{13}{16}$ | 2¾ |
| 34,563 | 10 | 6/0 | Do. 1st Preference 6% | 11½ | 12 | 11½ | 12 | 5 0 0 | May and November | $11\frac{13}{16}$ | .. |
| 4,669 | 10 | £3 | Do. 6 p. c. 2nd Pref. | 11½ | 12½ | 11½ | 12½ | 4 16 0 | " " | .. | .. |
| 64,174 | 15 | 6/0 | Western and Brazilian | 12 | 12½ | 12 | 12½ | 4 16 1 | " " | 12⅝ | 12½ |
| 27,873 | 7½ | 6/0 | Do. 5 per Cent. Cumulative Preferred | 6¾ | 7¼ | 6¾ | 7¼ | 5 4 2 | – | 7 | 6¾ |
| 27,873 | 7½ | 4/6 | Do. 5 per Cent. Deferred | 5¼ | 5¾ | 5¼ | 5¾ | 6 11 7 | .. | $5\frac{9}{16}$ | 5½ |
| £200,000 | 100 | 6% | Do. 6 per Cent. Debs., Series "A" 1910 | 103 | 106 | 103 | 106 | 5 13 2 | February & August | .. | .. |
| £250,000 | 100 | 6% | Do. 6 per Cent. Mort. Debs., Series "B" 1910 | 103 | 106 | 103 | 106 | 5 13 2 | " " | 104 | .. |
| $1,336,000 | $1,000 | 7% | Western Union 7 per Cent. 1st Mortgage | 120 | 125 | 120 | 125 | 5 12 0 | May and November | .. | .. |
| £175,100 | £100 | 6% | Do, 6 per Cent. Sterling Bonds | 100 | 104 | 100 | 104 | 5 15 5 | March & September | .. | .. |
| | | | **TELEPHONES.** | | | | | | | | |
| 224,850 | 14/0 | 0/4½ | Consolidated Telephone Const. & Maintenance. | $\frac{7}{16}$ | $\frac{9}{16}$ | $\frac{7}{16}$ | $\frac{9}{16}$ | .. | May and November | .. | .. |
| 220,000 | £1 | 3½% | Oriental (11s. paid) | ¼ | ⅜ | ¼ | ⅜ | 5 2 11 | Yearly | .. | .. |
| 438,984 | 5 | 2/6 | National | 4¼ | 4½ | 4¼ | 4½ | 6 2 3 | June and December | 4½ | 4¼ |
| 15,000 | 10 | 6/0 | Do. 6 per Cent. Cumulative 1st Pref. | 13 | 13½ | 13 | 13½ | 4 8 11 | " " | 13¼ | .. |
| 15,000 | 10 | 4/9¾ | Do. 6 per Cent. Cumulative 2nd Pref. (£8 pd) | 10 | 10½ | 10 | 10½ | 4 11 7 | " " | .. | .. |
| 209,750 | 1 | ½% | South of England, Ordinary | ⅛ | ¼ | ⅛ | ¼ | .. | – | .. | .. |
| 20,000 | 5 | 2/1 | Do. 6 per Cent. Cumulative Pf. (£3 10s. pd) | 3 | 3½ | 3 | 2½ | .. | .. | .. | .. |
| 58,000 | 5 | 1/0 | United River Plate | 2½ | 3½ | 2½ | 3½ | .. | January and July .. | .. | .. |
| £146,128 | Stock | 5% | Do. 5 per Cent. Debenture Stock | 85 | 95 | 85 | 95 | 5 5 3 | .. | .. | .. |
| £3,200 | 100 | 7% | Do. 7 per Cent. Debentures | .. | | .. | | .. | – | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | | | |
| 19,900 | £5 | .. | Electricity Supply Co. of Spain | 4½ | 5 | 4¼ | 5 | .. | .. | .. | .. |
| 111,000 | 5 | . | London Electric Supply | 2¾ | 2⅝ | 2¼ | 2½ | .. | .. | .. | .. |
| 43,900 | 10/0 | 2/0 | Metropolitan Electric Supply (£9 paid) | 8¾ | 9¼ | 9 | 9½ | 4 5 4 | – | 9⅜ | 9 |
| 7,730 | £5 | .. | St. James' and Pall Mall | 6 | 6¼ | 6 | 6¼ | – | – | .. | .. |
| 42,853 | 5 | .. | Westminster Electric Supply (£4 paid) | 4⅞ | 5⅛ | 4⅞ | 5⅛ | .. | – | 5⅛ | .. |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | | | |
| 63,416 | 3 | .. | Brush Electrical Engineering | 2¼ | 2½ | 2¼ | 2½ | .. | .. | .. | .. |
| 63,416 | 2 | 1/1 | Do. 6 per Cent. Preference | 1⅝ | 1⅞ | 1⅝ | 1⅞ | 6 8 0 | June and December | .. | .. |
| 20,000 | 5 | 3/6 | Crompton and Co., 7 per Cent. Pref. Shares | 5 | 5½ | 4½ | 5½ | 6 16 4 | January and July .. | 5¼ | 5 |
| 17,180 | 5 | 15% 1890 | Edison and Swan United | .. | | .. | | .. | – | .. | .. |
| 45,000 | 10 | 6% | Electric Construction | 5½ | 6½ | 5 | 6 | .. | – | 5⅝ | .. |
| 70,000 | 2 | 10/0 | Elmore's Patent Copper Depositing | 2¾ | 3¼ | 2¾ | 3¼ | .. | – | 3 | 2⅞ |
| 20,000 | 5 | .. | Fowler-Waring Cables (£4 paid) | 2½ | 3½ | 2½ | 3½ | .. | .. | .. | .. |
| 41,600 | 10 | 10/0 | India Rubber, Gutta Percha & Telegraph Works | 18½ | 19½ | 18½ | 19½ | 5 2 7 | February & August | $19\frac{1}{16}$ | .. |
| £200,000 | 100 | 4½% | Do. 4½ per Cent. Debentures, 1896 | 102 | 104 | 102 | 104 | 4 6 7 | March & September | .. | .. |
| 11,334 | £10 | 6/4 | International Okonite Limited Ordinary | 7½ | 8½ | 7½ | 8½ | 11 15 3 | .. | .. | .. |
| 11,334 | £10 | 5/0 | Do, Preference | 9¼ | 9¾ | 9¼ | 9¾ | 8 4 1 | .. | .. | .. |
| 78,949 | 5 | 4/10 | Swan United (£3. 10s. paid) | 4¾ | 5¼ | 4¾ | 5¼ | 6 13 4 | May and November | $4\frac{15}{16}$ | $4\frac{13}{16}$ |
| 37,350 | 12 | 36/0 | Telegraph Construction and Maintenance | 45 | 47 | 45 | 47 | 5 0 0 | March and July..... | 46¾ | 45½ |
| £150,000 | 100 | 5% | Do. 5 per Cent. Bonds, red. 1894 | 102 | 105 | 102 | 105 | 4 15 3 | January and July .. | 104 | .. |
| | | | **RAILWAYS.** | | | | | | | | |
| 60,000 | £10 | .. | City and South London Railway | 5½ | 6½ | 5½ | 6½ | .. | .. | .. | .. |


IMPROVEMENTS IN DYNAMOS




STATTER-BRUNTON
DYNAMO.

The latest design in the market, made with all the advantages of the latest scientific knowledge and the highest mechanical skill.

The woodcut represents our B TYPE DYNAMO. A most efficient machine, working noiselessly, and without sparking or overheating; is highly finished and well proportioned. The output is so rated in our Catalogue that the machines may be worked very much in excess of their stated full output for short periods.

STOCK SIZES UP TO 77 KILOWATTS.
MACHINES BUILT TO 500 KILOWATTS.

THE (STATTER'S) ELECTRICAL ENGINEERING CORPORATION, LIMITED, (UNITED.)
68, Victoria Street, London, S.W. WORKS:—ALLIANCE ENGINEERING WORKS, WEST DRAYTON, NEAR LONDON.


Digitized by Google

# THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 676.—Vol. XXVI. FRIDAY, MAY 1, 1891. Price Fourpence.

## NOTES.

A few interesting facts may be gathered from time to time from the accounts and reports presented, and the statements made at the annual general meetings of electric lighting companies, even if those statistics be withheld which Mr. Crompton invites and which he alone supplies. It was stated some years that on an average each lamp connected to the mains would be used for about two hours a day and this figure was considered ridiculously low. The experience of the Metropolitan Company has shown that each 8 c.p. lamp earns a revenue of about 12s. per annum. This, at 32 watts, is equivalent to 625 hours, or very nearly 1¾ hours per day. This Company, we may add, does business with fairly large customers, since each one has an average of 125 lamps connected.

The establishment of an electric lighting plant at the massive building which contains the offices of the Metropolitan Police is an indication that where light is wanted on a tolerably large scale, it is undoubtedly cheaper to put down the generating plant than to make use of the energy provided by the supply companies. It is true that New Scotland Yard is situated a little too far East to allow of connection with the mains of the Westminster Company, and is out of reach also of the Whitehall station, and therefore would have to depend upon the current from Deptford, but the advantages of the separate plant, which has been erected by Messrs. Drake and Gorham, are very marked. Immunity from breakdown may thus be provided for by spare plant, and the insulation of the circuits is in the hands of the engineer and not at the mercy of the supply company or its customers.

It is difficult to define the exact point at which a private plant can successfully compete with a supply company. There are numerous private houses where the gas engines continue to run, charging the batteries in the morning, although the supply mains pass within a few yards. These little stations have no difficulty in generating a unit for 4d., and it is the trouble, and in some cases the noise, rather than the actual expense, which has induced so many clubs and theatres to take their supply from central stations rather than from their own machinery. The lighting of the Imperial Institute would have been a welcome addition to the load factor of the Kensington and Knightsbridge Company, but it has been decided to provide a separate plant for this huge building also. These large installations are rather apt to make sudden demands upon the central stations unless the switching arrangements are carefully carried out, and much as some of the West End companies long for a few theatres and clubs, the supply of such establishments calls for special attention and alertness on the part of the station attendants.

The value of the point gained by the Kensington and Knightsbridge Electric Lighting Company, in bringing a motion to restrain the Lane Fox Company from issuing threats to their customers and others, does not appear to be of any great or permanent importance. Not long ago a cry was raised, with some justice, that a long forgotten patent was being suddenly sprung upon the users of electric light; and it was urged that, be the patent valid or void, and Mr. Lane Fox an inventor or a thrower out of half-considered guesses, he ought to give fair warning to those from whom he expects to receive royalties. No amount of warning would undo the annoyance caused by the exhumation of the old patent, since batteries have been bought and sold for these ten years past by engineers and private customers in complete ignorance of the existence of any such patent as No. 3988**, of 1878.

A warning was, however, issued, after a considerable delay, not only to supply companies, but to their customers, and the text of it will be found in our Legal Intelligence. It was called a "threat," this being no doubt a legal expression, though it is as difficult to distinguish between a threat and warning in this instance as when the Quaker said, "Have a care, friend, lest thou run thy face against my fist." As is shown by Mr. Lane Fox's letter in another column, the Company "with due diligence" commenced an action; but, as we stated in *The Electrician* of November 14th, p. 27, it was necessary that he himself should be the sole plaintiff. He is entitled, and indeed is in duty bound, to issue proper notices, be they entitled warnings or threats.

At the same time it is, of course, very annoying for supply companies to find that the confidence of their customers is being shaken by these missives, and from their own point of view the Kensington and Knightsbridge Company have scored a point in obtaining an order for an injunction to restrain the continuance of such threats on the part of the Lane-Fox Company.

We publish this week a very able analysis by Lord Rayleigh on the sensitiveness of the Bridge Method when used with periodic currents. Simple as it is to measure resistance with

Digitized by Google

the Wheatstone's Bridge, the theory which indicates the best conditions of tests is very involved, and the complexity becomes very much more pronounced when alternating currents are employed; as not only have the resistances of the six arms to be considered, but the inductance of each one of these arms must be taken into account. Anyone unaccustomed to live in a world of symbols would carefully avoid such an investigation, but Lord RAYLEIGH, no doubt, found it easy enough. Many of the results obtained are simple extensions of those known to hold when steady currents are used, and on this account the meaning of some of the conditions can be easily realised. Thus, SCHWENDLER's rule, that the galvanometer used should have a resistance equal to the parallel resistance of the bridge between the terminals with which it is connected, is true for alternate currents provided we substitute the word impedance wherever the word resistance occurs; and a similar rule of Mr. HEAVISIDE's, with reference to the battery circuit, can likewise be extended. A remarkable characteristic of inductance is that it may be either positive or negative, and may, without sensible alteration of any of the resistances in circuit, be reduced to zero, or any more convenient value, by the addition of suitable condensers or induction coils, or by alterations in the speed of alternation. While, however, it would thus appear that the experimenter has great power of modifying and adjusting his apparatus to favourable conditions, his control is in reality greatly restricted by the magnitude of the capacities and inductances required.

**Cable Extensions.**—A second cable is to be laid between Corsica and the mainland.

**Trunk Wire Extensions in Switzerland.**—It is proposed to connect Lugano, Locarno and Bellinzona by telephone.

**Personal.**—The Secretary of State has appointed Mr. A. A. Campbell Swinton permanent consulting electrical engineer to the Metropolitan Police.

**Berlin.**—The Directors of the Berliner Elektricitatswerke have applied for permission to make considerable extensions in their electric light cable system in Berlin.

**Royal Society.**—Amongst the Papers down for reading yesterday before the Royal Society was one on "The Passive State of Iron and Steel, Part III.," by Mr. T. Andrews, F.R.S.

**Obituary.**—The death is announced of M. Zédé, who died at Marseilles on Sunday night, at the age of 66. M. Zédé was one of the designers of the electric submarine torpedo boat "Gymnote."

**Cement for Leather Belts.**—The following recipe for leather belt cement is due to *La Papeterie*:—Bisulphide of carbon 100 parts, indiarubber 10 parts, essence of turpentine 10 parts, shellac 10 parts.

**Vienna.**—The International Electricity Company now supplies the equivalent of 30,000 eight c.p. lamps from its central station, and it is probable that this will be enlarged so as to supply 40,000 lamps next year.

**Institution of Electrical Engineers.**—A general meeting of the students was held on Friday, April 24th, when a Paper was read on "Alternate Current Motors," by Mr. G. U. Yule. The next meeting will be held on Friday, May 8th.

**Medical Electricity.**—The Grafton College for training nurses and others in medical electricity and massage has recently been started at 35, Fitzroy-square, W., by Mr. H. Newman Lawrence, M.I.E.E., and Dr. Arthur Harries.

**Electro-Harmonic Society.**—The annual meeting of this Society will be held on Tuesday, May 12th, at 4:30, at 28, Victoria-street, London, S.W. Members of the Committee are requested to meet at four o'clock for the election of members and for other business.

**Amsterdam.**—The concession for the electric lighting of Amsterdam has been granted to a local Company called "Electra," and the establishment of a central station and a system of mains for the supply of current equivalent to 40,000 8 c.p. lamps alight simultaneously has been undertaken by the Helios Company of Cologne. The plant will comprise one 160 kilowatt and three 320 kilowatt Zypernowski alternators. The station will be situated about 2¼ miles from the centre of the town.

**Southampton.**—The central station of the Southampton Electric Light Company came into operation on Saturday evening last. The Company have guaranteed to supply the first 50 customers with light gratis for three months. The Harbour Board has decided to light the new pier and the town quay by electricity, and to employ two electric cranes. The contractors to the Southampton Company were Crompton and Co., and the dynamos, accumulators, and mains are all of that firm's manufacture.

**An Acid-resisting Varnish.**—The following patented recipe for an acid-resisting varnish is due to Messrs. Helbig, Bertling, and Reinecke, of Baltimore:—Pour 20lbs. of molten lead into a cast-iron vessel containing about 1 gallon of linseed oil and stir well. After the mixture has cooled, some 17lbs. of lead will be found at the bottom of the vessel. The lead is again melted and the operation repeated. When this has been done about five times the oil attains the consistency of ordinary varnish, and is ready for use.

**Aluminium.**—The works at Hemelingen, near Bremen, which were employed in the manufacture of aluminium and magnesium, have, says *Industries*, now ceased to manufacture the first-named metal. They were using a modified Graetzel-Castner process, but the cost of working was too high, and they could not compete with the large plant at Neuhausen-on-the-Rhine, which works the electrolytic process and utilises the Schaffhausen water-fall. This company has reduced its prices to about a third of what they were a year ago.

**Central Institution.**—A course of lectures, commencing on Monday, May 11th, will be given at this Institution by Prof. Ayrton. These lectures will include "The Elementary Portions of the Theory and Practice of the Electric Distribution of Light and Power with Alternating Currents," "Self and Mutual Induction," "Phase Difference between Currents and Pressures," "Transformers" (Construction, Use and Mode of Testing), "Safety Devices," "High Pressure Mains," "Telegraphy and Telephony." The lectures will be at 3 p.m. on Mondays and Wednesdays.

**Old Students' Association.**—On Friday, the 24th ult., the last of the series of smoking concerts given by the Old Students' Association was held at Masons' Hall Tavern. A most excellent programme was provided, very high-class music being given both vocally, and by such players as Mr. Gatehouse on the violin, while at the same time a most excellent humorous selection was given by Messrs. Keeler and Melrose. A vote of thanks was passed to the Musical Committee at the close of the evening for their successful efforts in getting up such an excellent series of Concerts.

**Interruptions and Repairs of Telegraph Lines**:—

| Line. | Date of Interruption. | Date of Repair. |
|---|---|---|
| Mollendo-Arica-Iquique Cable | March 5 | — |
| Pernambuco-Ceara Cable | ,, 14 | — |
| Santa-Elena-Payta Cable | ,, 31 | April 3 |
| ,, ,, | April 8 | ,, 8 |
| ,, ,, | ,, 9 | ,, 13 |
| Marseilles-Barcelona Cable | ,, 4 | ,, 14 |
| Chorrillos-Mollendo Cable | ,, 6 | ,, 7 |
| Moulmein-Bangkok line | ,, 18 | ,, 22 |
| Saïgon-Bangkok line | ,, 21 | ,, 25 |

**Governmental Regulation of Industrial Enterprises.**—The settlement of the Boy Messengers' case, says *Industries*, is so far satisfactory; but the extent to which the Post Office and other creations of Parliament are interfering to strangle private enterprise is becoming serious enough to justify a drastic re-

Digitized by Google

examination of the whole system. . . . . . It is absurd to regard the Post Office and the Board of Trade as fetiches which must not be touched. . . . . . As regards the Board of Trade, it exists almost wholly for the purpose of preventing other people from conducting their business, or at least for placing as many obstacles in the way of their doing so as possible.

**Rectifying Alternating Current.**—Mr. T. D. Bottome, of Hoosich, New York, has devised an "asymmetrical resistance," which allows a current to pass in one direction but not in the other. It consists of an electrode of aluminium and one of platinum or carbon immersed in a liquid. Owing to the peculiar nature of electrolytic action on aluminium, a non-conducting basic oxide is said to form when the current passes in one direction, and this is decomposed into a soluble sulphate on reversal. All this may be true, but to rectify alternating currents for exciting magnets, &c., by this means, as Mr. Bottome suggests, does not sound hopeful.

**Steep Gradient Electric Traction.**—At Seattle, Wash., a novel method of running electric cars up steep inclines is about to be put into operation. The electric railway there runs up a steep incline about 800ft. long, and it has been found that the motors on the cars are inadequate to surmount it. To overcome the difficulty a small conduit, about 2ft. square, has been constructed, and in this runs a counter-balance car. When an ordinary car is attached to the rope the counter-balance car runs down the hill, but when the passenger car reaches the top of the hill and runs down on the other side, it pulls up the counter-balance, which is now ready to bring up another car.

**Telephone Trunk Wire Extensions.**—The National Telephone Company have arranged to run a direct trunk wire from Glasgow to Dumfries, and thence to Carlisle. The line will be specially constructed to give efficient long-distance speaking, and will be the first telephone line to cross the border. Glasgow and the West of Scotland will then be put in direct communication with the iron districts of Cumberland and Westmoreland, which are already connected with Carlisle, and this will form an important link in the proposed chain of communication between the principal towns and cities of Scotland and England.

**Ether as a Source of Motion.**—Mr. Tolver Preston writes to point out that at the end of the first paragraph of his article in our last issue the passage should read: "Coal must be regarded as a *mere machine* for deriving motion from the ether," and adds—"The old idea of a sort of *quasi* metaphysical 'force' between attracting bodies (assumed to be propagated to a distance without time), which 'force' would be, of course, quite beyond our control, or incapable of modification in any way, has practically received its *quietus* by the late ether (electric) discoveries. When, instead of this supposed mysterious and unalterable 'force,' we have palpable waves and distance action produced by ether disturbance, may we not hope to direct and control it to our advantage?"

**Cologne.**—The municipal central station is rapidly approaching completion, and on April 26th current was sent through the mains for the first time for the purpose of running some alternate-current motors in connection with a lecture of Herr Hegener, Manager of the Municipal Gas and Electric Works. The current was not, however, obtained from the station itself, but from a 10-pole alternator in the show rooms of the Helios Company. The central station alternators are by Ganz and Co., the engines by Sulzer, and the boilers by Steinmüller. The smaller alternators will have an output of 110 H.P., and the larger ones will be of 500 H.P. The foundations are complete, the engines ready, and the dynamos have just arrived. So far over 6,000 (8 c.p.) lights have been applied for.

**Glasgow.**—The Special Sub-Committee of the Town Council on Electric Lighting, after considering the whole subject, have resolved to recommend that the Corporation should undertake the laying down of the necessary works and plant for generating and supplying electricity for private and public lighting within the compulsory area scheduled in the Glasgow Electric Lighting Provisional Order. In the event of the recommendation being approved of by the Town Council, the Electric Lighting Sub-Committee will forthwith invite tenders for the work. It is expected that in the course of the next few days the Electric Lighting Committee will issue the reports they have received from Mr. R. E. Crompton, Prof. Jamieson, and Sir William Thomson.

**Electric Lighting Orders.**—In reply to Mr. S. Balfour, Sir M. Hicks-Beach stated in the House of Commons on Thursday last week that the Board of Trade had no power to revoke a Provisional Order unless the undertakers failed to comply with the requirements of the Order within the prescribed time. In the only case in which the Board of Trade proposed to grant a third Order in a district this Session they had reason to believe that one of the existing companies would not be in a position to comply with the requirements of their Order within the time prescribed thereby. If this should be so, the Board of Trade would, when the proper time arrived, consider any application for the revocation of the Order that might be made to them by the County Council or the Local Authorities.

**Electrolysis Applied to Qualitative Analysis**—At a recent meeting of the Liverpool Section of the Society of Chemical Industry a Paper was read by Dr. Charles A. Kohn, on the "Application of Electrolysis to Qualitative Analysis." Dr. Kohn described a series of experiments he had made on the detection of small quantities of the mineral poisons, antimony, lead, mercury, and copper, taking advantage of the quantitative electrolytic methods of analysis, an account of which he had given to the Society on a previous occasion. The methods were very delicate, clean, and decisive, and likely to be of value in cases of medical and of medico-legal inquiry. Very small quantities of silver and of gold could also be detected electrolytically with ease, and the methods had the further advantage of being made approximately quantitative when desirable.

**Frankfort Exhibition.**—A correspondent writes us to the effect that things are in a rather backward state at Frankfort. A week or ten days ago all that there was to be seen in the Machinery Hall were an Esslingen engine, and a 600 H.P. Suizer engine coupled to a large 40-pole alternator, forming part of the joint exhibit of Ganz and Co., of Budapest, and the Helios Company, of Cologne. The exhibitors are in a bad humour, owing to the Executive Committee having demanded the payment of insurance premiums at the rate of 1·5 per cent., which is generally considered excessive, being ten times that in force for private property.—Plant illustrating Haselwander's rotary current system will be exhibited at the Frankfort Exhibition by Messrs. Lahmeyer and Co.—A Committee has been appointed to make preparations for a three days' Congress of Civic Functionaries to be invited from the chief towns of Germany, Austria-Hungary, Switzerland, Belgium, Holland, Italy, and Scandinavia. The object of the Congress is to consider the application of electric light and power to municipal purposes.

**Telegraphic Extension in Upper Burmah.**—Military necessities gave rise during the year 1890 to telegraphic extensions in Upper Burmah amounting in all to some 375 miles of line. From the point of view of mileage these extensions are of minor importance, but the nature and state of the country through which the lines had to be carried rendered the task one of exceeding difficulty. The longest line constructed was that running from Pauk to Haka, a distance of 195 miles, and the following brief account may give an idea of the difficulties encountered:—One portion of the route was such a sea of mud that four days were consumed in advancing six miles. The lime in the clay attacked the men's feet, and completely disabled many of them. Fever seized the party, and when a station called Achelban was reached everyone was ill, and only 10 men could stand upright. On the 26th November, when the wire had been carried to Gangaw, only 26 debilitated men remained together out of more than 100 who started. By the time the line was finished two officers had died, and seven had been invalided, and out of the hundred odd employés 12 had died and 60 had been invalided.

**Science at South Kensington.**—A memorial is about to be presented to the Marquis of Salisbury expressing a strong opinion that the development and efficiency of the Science Museum and of the Science School and laboratories of the Department of Science and Art at South Kensington will be seriously jeopardised by erecting an Art Gallery upon that

Digitized by Google

portion of the land which was recently purchased by Parliament. The memorialists state that this site is none too large, seeing the progress that is being made in the matter of scientific and technical instruction, to provide for the future requirements of the collections and schools controlled by the Department of Science and Art; and they, therefore, earnestly entreat that another site should be found for the proposed Gallery of British Art. Amongst the signatures already appended to the memorial are those of Sir William Thomson, Lord Rayleigh, Sir Douglas Galton, Mr. W. H. M. Christie (Astronomer Royal), Dr. Hugo Müller, Dr. E. Frankland, Prof. Raphael Meldola, Mr. Shelford Bidwell, Dr. J. H. Gladstone, Prof. W. E. Ayrton, Prof. John Perry, Prof. W. Grylls Adams, Prof. William Crookes, Sir Henry Roscoe, Sir G. G. Stokes, Sir Frederick Bramwell, and Prof. G. Carey Foster.

**Accumulator Cars at Philadelphia.**—According to the *Electrical Engineer* of New York the withdrawal of the accumulator cars which have been running on the Lehigh Avenue Railroad, Philadelphia, from May 1, 1890, to January 16, 1891, was due to the unfavourable character of the line. Only four cars were in regular work, the traffic was subject to great fluctuations, and the track (3·15 miles long) had scarcely a level spot on it, 5 per cent. gradients and sharp curves being frequent. The total weight of the cars when fully loaded was between 9 and 10 tons. Two 116 cell batteries were employed per car, and the mean horse-power required per ton was ultimately reduced to 1·15. Worm and worm wheel gears were employed, the ratio of worm to wheel being 1 to 8. Tests of the gear at speeds equivalent to between 5 and 10 miles an hour of the car showed that the mean efficiency was 82 per cent., with a mean of 12 mechanical horse-power on the axle. The maximum efficiency was 85 per cent. at 550 revolutions of the armatures (equal to about 5½ miles an hour of the car). During the 8½ months that the cars were in operation they carried 336,454 passengers.

**The Paris Electric Lighting Companies.**—The net profits of the Compagnie Parisienne du Gaz amounted last year to close on 1¼ million sterling. Its subscribed capital is 11¼ millions, and it has been 35 years in existence. At the last meeting of shareholders it was announced that the million of additional capital authorised in 1887 had been exhausted, and power was asked to raise another million sterling. These facts, says the *Bulletin International de l'Electricité*, should not surely be lost on those engaged in electrical enterprises. The lighting industry, whether gas or electric, demands incessant additions to capital. A system, as soon as it has passed the period of first establishment, develops so rapidly and so extensively that it is useless to expect the annual profits to cover the additional expenditure entailed. If an old, solidly established company is obliged to borrow, the young electric companies will not be able to avoid doing likewise. It being thus necessary to unceasingly augment the capital of electrical companies on the one hand, while on the other it has to be redeemed within a comparatively brief period (in Paris at the most eighteen years), the conclusion one must come to is that in Paris either the area of operations must be strictly limited, or the concessions must be prolonged.

**Electric Light Cables.**—Under this title the India Rubber, Gutta Percha, and Telegraph Works Company, of Silvertown, have recently brought out a very readable pamphlet, advocating, it is needless to say, the employment of rubber cables on the frequently reiterated ground that other kinds of insulated conductors will be found "more expensive in the long-run." Useful hints are given with regard to the erection of overhead wires, the laying of underground mains, and the testing of electric-light mains. The Board of Trade regulations in connection with overhead conductors are embodied in the pamphlet and somewhat criticised. It is pointed out that a minimum size of conductors should be specified, and that although care is taken to ensure that an insulator of the proper thickness shall be employed, no test of its resistance is specified. The danger of shocks from electrostatic charges when the bearer wires are insulated as laid down by the rules is pointed out, and it is suggested that if the rule is adhered to it would be a good thing to break the bearer wires up into sections and attach them separately, as by this means the discharge received would be limited to the charge on a single section. Attention is also drawn to the excessive wind-pressure allowance of 50lb. per square foot.

**The Comparative Cost of Arc and Sunbeam Lamps.**—At a meeting of the South Wales Institute of Engineers, Mr. Polyblank gave, says *Engineering*, some interesting particulars of his experience with arc and sunbeam lamps at Swansea Docks. He finds that a 2,000 c.p. 10-ampere arc with two 11 mm. carbons 12in. long, burns 12 hours. The cost of such a lamp, working from sunset to sunrise throughout the year, or about 4,374 hours, was as follows:—

| | £ | s. | d. |
|---|---|---|---|
| Carbons per annum, at £5. 5s. 1,000 | 5 | 14 | 7 |
| Coal—8 tons per lamp, at 14s. | 5 | 12 | 0 |
| Labour—cleaning lamps, changing carbons and globes, one man to every 20 lamps = 3d. per lamp per day | 4 | 12 | 0 |
| Making a total of | 15 | 18 | 7 |

per lamp per annum, or £3. 12s. 10d. per 1,000 hours.

The average length of life of a 500 c.p. sunbeam lamp, Mr. Polyblank's experience shows to be about 1,500 hours, though some break after only 400 hours' work. The cost of working was as follows:—

| | £ | s. | d. |
|---|---|---|---|
| Renewal of lamps, three per annum at 22s. each | 3 | 6 | 0 |
| Coal—12 tons per annum at 14s. | 8 | 8 | 0 |
| Labour—in changing lamps three per annum, say | 0 | 5 | 0 |
| Making a total cost of | 11 | 19 | 0 |

per lamp per year, or £2. 14s. 8d. per 1,000 hours.

The lamps when first put up took 10 amperes at 100 volts, but after the lapse of from 800 to 1,000 hours, the current is reduced to 8·5 amperes. The globes blacken somewhat, but not so seriously as might be imagined.

**The Electrolytic Preparation of Chlorate of Potassium.**—For the past ten months the manufacture of chlorate of potassium by the Gall-Montlaur electrolytic process has been successfully carried out at Vallorbes. The daily output now amounts to one ton of refined chlorate. According to *La Lumière Electrique*, M. Lunge states that one H.P. day = one kilogramme of potassic chlorate, hence a daily production of one ton requires 1,000 H.P. The process is based on the transformation of a 25 per cent. solution of chloride of potassium (KCl) at a temperature of from 45°C. to 55°C., into chlorate ($KClO_3$) by the action of the chlorine and potassium liberated by electrolysis. The chlorate is precipitated, collected, washed, dried, and purified. One of the preliminary difficulties was the selection of suitable connections for the electrodes, since the slightest trace of certain metallic oxides in the solution arrests the process. The vats are 270 in number (half being in use at one time), rectangular in shape, and arranged so as to permit of the rapid handling of a volume of liquid amounting to 11,000 gallons per diem. A porous diaphragm separates the kathodes from the anodes, the former being of iron and the latter of platinum (four mils thick). The solution is kept at the proper temperature by the current itself. Power is obtained from the falls of the Orbe, which can supply 2,500 H.P. At present there are installed at the generating station 10 150-H.P. Riether turbines, and 10 105-kilowatt Thury dynamos. The generating plant is at the foot of a mountain, the works themselves being 330ft., and the reservoir 230ft. above the station. This arrangement has the two-fold advantage of obtaining a great head of water and of removing the machinery out of reach of the fumes given off in the process. The hydrogen liberated at the kathode amounts to 3,530 cubic feet per ton of chlorate turned out, and as this large volume of gas escapes into the air, carrying with it a certain amount of chloride of potassium, the vicinity of the works is coated with a thick, white saline deposit of a highly erosive character. With ample water-power available, the electrolytic process can undersell the chemical process, although at present only 400 tons per annum is being being produced by it as against 8,000 tons by the older method. Some 5,000 tons of this total is produced by the works of the Chemical Union. The electrolytic process is cleaner, simpler, quicker, leaves no residue, and needs no coal for mere heating purposes.

Digitized by Google

## ELECTROMAGNETIC THEORY.—IX.

BY OLIVER HEAVISIDE.

(Continued from page 722.)

§ 53. In order to clearly understand the sense in which motion of a charge through a medium, or motion of the medium itself, or of both together with respect to fixed space, is to be understood, and of the part played therein by the motional electric and magnetic forces, it will be desirable to give a few illustrative examples of such a nature that their meaning can be readily followed from a description, without the mathematical representation of the results. It does not, indeed, often happen that this can be done with profit and without much circumlocution. In the present case, however, it is rather easier to see the meaning of the solutions from a description, than from the formulæ.

In the first place, let us start with a single charge $\rho$ at rest at any point A in an infinite isotropic non-conducting dielectric —ether, for example—which is also at rest. Under these circumstances the stationary condition is one of isotropic radial displacement from the charge at A according to the inverse-square law, and there is nothing to disturb this distribution.

Now, if the whole medium and the charge itself are supposed to have a common motion (referred to an assumed fixed space, in the background, as it were), no change whatever will take place in the distribution of displacement referred to the moving charge. That this should be so in a rational system we may conclude from the relativity of motion (the absolute motion of the universe being quite unknown, if not inconceivable) combined with our initial assumption that the electric flux (and the magnetic flux not here present) represent states of the medium, which may be carried with it just as states of matter are carried with matter in its motion. But as the charge, and with it the displacement, move through space as a rigid body without rotation, the changing displacement at any point constitutes an electric current, and therefore would necessitate the existence of magnetic force, if we treated the first law of circuitation in its primitive form, referred to a stationary medium. Here, however, the motional magnetic force, which is (§§ 44, 49) the vector-product of the displacement and the velocity of the medium, comes into play, and it is so constructed as to precisely annul all magnetic force under the circumstances, and leave the displacement (referred to the moving medium) unaffected; or, in another form, it changes the law of circuitation (curl $\mathbf{H} = \mathbf{J}$) referred to fixed space, so as to refer it in the same form to the moving medium.

The result is $\mathbf{H} = 0$, and $\mathbf{D}$ moves with the medium.

Similar remarks apply to other stationary states. They are unaffected by a common motion of the whole medium and the sources (or quasi-sources), and this result is mathematically obtained by the motional electric and magnetic forces.

§ 54. But the case is entirely altered if the charge and the medium have a relative translational motion.

Start again with charge and medium at rest, and the displacement stationary and isotropically radial. Next, introduce the fact (the truth of which will be fully seen later) that the medium transmits all disturbances of the fluxes through itself at the speed $(\mu c)^{-\frac{1}{2}}$, which call $v$; and let us suddenly set the charge moving in any direction rectilinearly through the medium at this same speed, $v$. The question is, what will happen?

A part of the result can be foreseen without mathematical investigation; the remainder is an example of the theory of the simplest spherical wave given by me in "Electromagnetic Waves." Let A (in Fig. 1) be the initial position of the charge when it first begins to move, and let AC be the direction of its subsequent motion. Describe a sphere of radius $AB = vt$; then, at the time $t$ the charge has reached B. Now, from the mere fact that the speed of propagation is $v$, it follows that the displacement outside the sphere is undisturbed. It is clear that there cannot be any change to the right of B, because the charge has only just reached that place, and disturbances only travel at the same speed as it is moving itself. Similar considerations applied to the expanding sphere through this charge at every moment of its passage from A to B will show that no disturbance can have got outside the sphere. The radial lines, therefore, represent the actual displacement, as well as the original displacement, though of course, in the latter case, they extended to the point A.

We have now to complete the description of the solution. There is no displacement whatever inside the sphere BEDF. The displacement emanating from the charge at B, therefore, joins on to the external displacement over the spherical surface. We can say beforehand that it should do so in the simplest conceivable manner, by the shortest paths. On leaving the pole B it spreads uniformly in all directions on the surface of the sphere, and each portion goes the shortest way to the opposite pole D. But it leaks out externally on the way, in such a manner that the leakages are equal from equal areas. The displacement thus follows the lines of longitude.

This completes the case so far as the displacement is concerned. But the spherical surface constitutes an electromagnetic sheet, and corresponding to the displacement there is a distribution of coincident induction. This induction is perpendicular to the tangential displacement, and therefore follows the lines of latitude. Its direction is up through the paper above A (at E for example), and down through the paper below A (at F for example). The tangential displace-

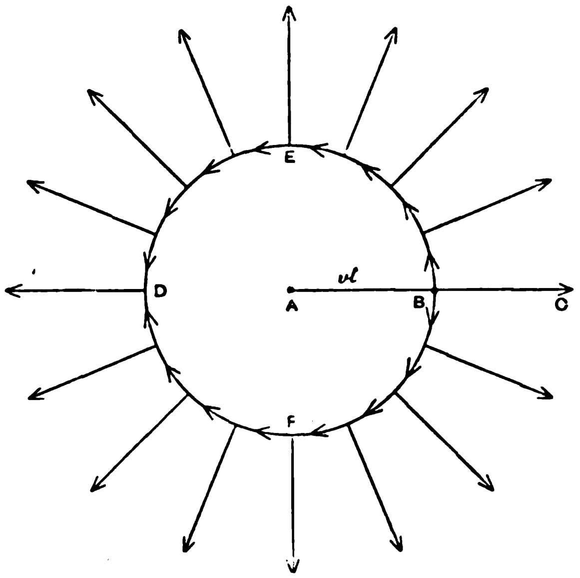



Fig. 1.

ment and induction surface-densities (or fluxes per unit area of the sheet), say, $D_0$ and $B_0$, are connected by the equation

$$B_0 = \mu v D_0,$$

or,
$$D_0 = cvB_0.$$

Or, if $E_0$ and $H_0$ be the equivalent forces got by dividing by $c$ and by $\mu$ respectively, then, since $\mu c v^2 = 1$,

$$H_0 = cvE_0,$$
$$E_0 = \mu v H_0.$$

Or, expressing the mutual directions as well,

$$\mathbf{H}_0 = \mathrm{V}\mathbf{v}\mathbf{D}_0,$$
$$\mathbf{E}_0 = \mathrm{V}\mathbf{B}_0\mathbf{v};$$

where $\mathbf{v}$ is the vector velocity of the electromagnetic sheet at the place considered. These last are, in fact, as we shall see later, the general equations of a wave-front or of a free wave, which though it may attenuate as it travels, does not suffer distortion by mixing up with other disturbances.

Now, as time goes on, the charge at B moves off to the right, the electromagnetic sheet simultaneously expanding. The external displacement, therefore, becomes infinitesimal; likewise that on on the D side of the sphere. Practically, therefore, we are finally left with a plane electromagnetic sheet moving perpendicularly to itself at speed $v$, at one point of which

is the moving charge, from which the displacement diverges uniformly in the sheet, following, therefore, the law of the inverse first power (instead of the original inverse square), accompanied by a distribution of induction in circles round the axis of motion, varying in density with the distance according to the same law, and connected with the displacement by the above equations. In the diagram, AB has to be very great, and the plane sheet is the portion of the spherical sheet round B, which is then of insensible curvature.

§ 55. Having thus turned the radial isotropic displacement of the stationary charge into a travelling plane distribution, let us suddenly reduce the charge to rest. We know that after some time has elapsed, the former isotropic distribution will be reassumed; and now the question is, how will this take place?

Let B in Fig. 2 be the position of the charge at the moment of stoppage and after. Describe a sphere of radius $vt$, with B for centre; then the point C is where the charge would have got at time $t$ after the stoppage had it not been stopped, and the plane DCE would have been the position of the plane electromagnetic sheet. Now, the actual state of things is described by saying that:—

(1). The plane sheet DCE moves on quite unaltered, except at its core C, where the charge has been taken out.

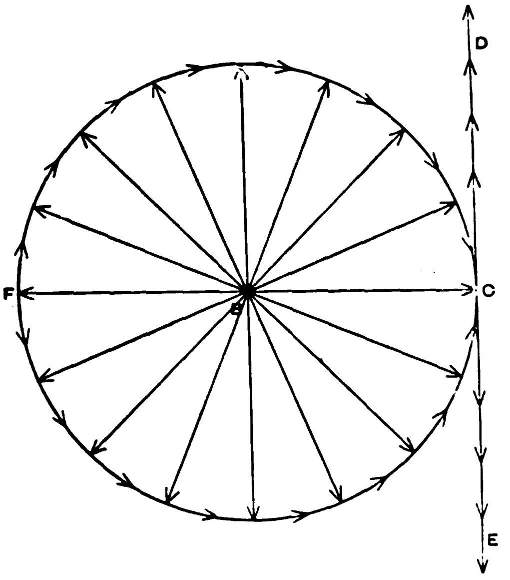



Fig. 2.

(2). The stationary radial displacement of the charge in its new position at B is fully established within the sphere, without any induction.

(3). The internal displacement joins itself on to the external in the plane sheet, over the spherical surface, by leaking into it and then following the shortest route to the pole C. That is, the tangential displacement follows the lines of longitude.

(4). The induction in the spherical sheet is oppositely directed to before, still, however, following the lines of latitude, and being connected with the tangential displacement by the former relations.

In time, therefore, the plane sheet and the spherical sheet go out to infinity, and there is left behind simply the radial displacement of the stationary charge.

§ 56. Now, return to the case of § 54, and referring to Fig. 1, suppose it to be the charge that is kept at rest, whilst the medium is made to move bodily past it from right to left at speed $v$, so that the relative motion is the same as before. We must now suppose B to be at rest, the charge being there originally, and remaining there, whilst it is A that is travelling from right to left, and the spherical surface has a motion compounded of expansion from the centre A and translation with it. Attending to this, the former description applies exactly.

The external displacement is continuously altering, and there is electric current to correspond, but there is no magnetic force (except in the spherical sheet), and this is, as before said, accounted for by the motional magnetic force.

The final result is now a stationary plane electromagnetic sheet, as, in fact, described before in § 45, where we considered the displacement and induction in the sheet to be kept up steadily by electric and magnetic forces impressed by the motion.

Now stop the motion of the medium, without altering the position of the charge, and Fig. 2 will show the growth of the radial stationary displacement, as in § 55, as it is in fact the same case precisely after the first moment.

We can in a similar manner treat the cases of motion and stoppage of both charge and medium, provided the relative speed be always the speed $v$, however different from this may be the actual speeds.

§ 57. From the two solutions of §§ 54, 55 (either of which may be derived from the other) we may deduce a number of other interesting cases.

Thus, let initially a pair of equal opposite charges $+\rho$ and $-\rho$ be moving towards one another, each at speed $v$ through the medium (which for simplicity we may consider stationary) each with its accompanying plane electromagnetic sheet.

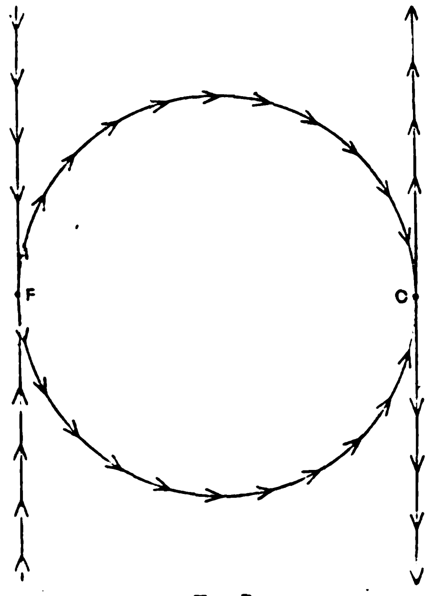



Fig. 3.

When the charges meet the two sheets coincide, the two displacements cancel, leaving none, and the two inductions add, doubling the induction. We have thus, momentarily, a mere sheet of induction.

Now, if we can carry the charges through one another, without change in their motion, the two sheets will immediately reappear and separate. That is, the plane waves will pass through one another, as well as the charges.

But if the charges cancel one another continuously after their first union, a fresh case arises. It is, given a certain plane sheet of induction initially, what becomes of it, on the understanding that there is to be no electrification?

The answer is, that the induction sheet immediately splits into two plane electromagnetic sheets, joined by a spherical sheet, as in Fig. 3. For it is the same as the problem of stoppage in § 55 with another equal charge of opposite kind moving the other way and stopped simultaneously, so that there is no electrification ever after. Touching the sphere at the point F in Fig. 2 is to be placed the additional plane wave, and the internal displacement is to be abolished. That is to say, in Fig. 3 the displacement converges uniformly to F in the plane sheet there, then flows without leakage to the opposite pole C along the lines of longitude, and there diverges uniformly in the other plane sheet. Each displacement sheet has its corresponding coincident induction, according to the former formulæ.

Digitized by Google

They all move out to infinity, leaving nothing behind, as there is no source left.

§ 58. Similarly, let there be a pair of coincident or infinitely close opposite charges, with no displacement, and let them be suddenly jerked apart, each moving at the speed of propagation of disturbances. The result is simply a single spherical wave, without plane appendages, and without leakage of the displacement. The charges are at opposite poles, at the ends of the axis of motion, and the displacement just flows over the surface from one to the other symmetrically. There is the usual induction $B_0 = \mu v D_0$ to match.

Fig. 3 also shows this case, if we leave out the plane sheets and suppose the positive charge to be at F and the negative at C.

After a sufficient time, we have practically two widely separated plane electromagnetic sheets, although they are really portions of a large spherical sheet.

Now, imagine the motion of the two charges to be reversed; if we simultaneously reverse the induction in the spherical sheet, without altering the displacement, it will still be an electromagnetic sheet, but will contract instead of expanding. It will go on contracting to nothing when the charges meet. If they are then stopped nothing more happens. But if the charges can separate again, the result is an expanding spherical electromagnetic sheet as before.

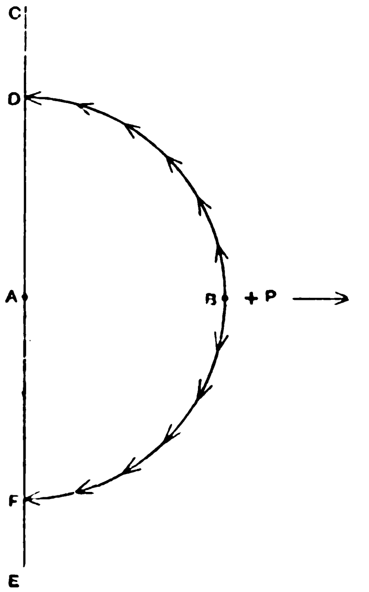



Fig. 4.

§ 59. If, in the case of colliding plane sheets with charges, § 57, they be of the same name, then, on meeting, it is the induction that vanishes, whilst the displacement is doubled. That is, we have momentarily a plane sheet of displacement.

If the charges be kept together thereafter, this plane sheet splits into two plane electromagnetic sheets joined by a spherical sheet. At the centre of the last is the (doubled) charge $2\rho$, which sends its displacement isotropically to the surface of the sphere, where it is picked up and turned round towards one pole or the other. The equator of the sphere is the line of division of the oppositely flowing displacements. The displacement gets greater and greater as the poles are neared, the total amount reaching each pole being $\rho$ (half the central charge), which then diverges in the plane sheet touching the pole.

The final result, when the waves have gone out to infinity, is, of course, merely the stationary field of the charge $2\rho$.

§ 60. If a charge be initially in contact with a perfectly conducting plane, and be then suddenly jerked away from it at the speed $v$, the result is merely a hemispherical electromagnetic shell. The negative charge, corresponding to the moving point-charge, expands in a circular ring upon the conducting plane, this ring being the equator of the (complete) sphere.

This case, in fact, merely amounts to taking one half of the solution in § 58, and then terminating the displacement normally upon a conductor.

In Fig. 4, A is the original position of $\rho$ on the conducting plane CAE, and when the charge has reached B the displacement terminates upon the plane in the circle DF.

Instead of a plane conducting boundary, we may similarly have conical boundaries, internal and external (or one conical boundary alone), with portions of perfect spherical waves running along them at the speed $v$.

If the two conical boundaries have nearly the same angle, and this angle be small, we have a sort of concentric cable (inner and outer conductor with dielectric between), of continuously increasing thickness. The case of uniform thickness is included as an extreme case; the (portion of the) spherical wave then becomes a plane wave.

§ 61. The nature of a spherical electromagnetic sheet expanding or contracting at speed $v$, when it is charged in an arbitrary manner, may also be readily seen by the foregoing. So far, when there has been electrification on the sheet, it has been a solitary point-charge or else a pair, at opposite poles. Now, the general case of an arbitrary distribution of electrification can be followed up from the case of a pair of charges *not* at opposite ends of a diameter, and each of these may be taken by itself by means of an opposite charge at the centre or externally, so that integration does the rest of the work. When there is a pair of equal charges of opposite sign we do not need any external or internal complementary electrification, but we may make use of them argumentatively; or we may let one charge leak outward, the other inward, and have the external and internal electrification in reality. The leakage should be of the isotropic character always. But the internal electrification need not be at the central point. It may be uniformly distributed upon a concentric sphere. This, again, may be stationary, or it may itself be in motion, expanding or contracting at the speed $v$. The external electrification, too, may be on a concentric spherical surface, which may be in similar motion. The sheets, too, may be of finite depth, and arbitrarily electrified, so that we have any volume-distribution of electrification moving in space in radial lines to or from a centre, accompanied by electromagnetic disturbances arranged in spherical sheets.

There is thus a great variety of ways of making up problems of this character, the nature of whose solutions can be readily pictured mentally.

Two charges, $q_1$ and $q_2$, for example, on a spherical sheet. One way is to put $-q_1$ and $-q_2$ at the centre, and superpose the two solutions. Or the charges $-(q_1$ and $q_2)$ may be put externally, with isotropic leakage. Or part may be inside, and part outside. Or we may have no complementary electrification at all, but lead the displacement away into plane waves touching the sphere.

Only when the total charge on the spherical sheet is zero can we dispense with these external aids (which to use depending upon the conditions of the problem); then the displacement has sources and sinks on the sheet which balance one another. The corresponding induction is always perpendicular to the resultant tangential displacement, and is given by the above formula, or $\mathbf{B}_0 = \mu V \mathbf{v} \mathbf{D}_0$, where $\mathbf{D}_0$ is the tangential displacement in the sheet (volume density × depth).

One case we may notice. If the density of electrification be uniform over the surface, there is no induction at all. That is, it is not an electromagnetic sheet, but only a sheet of electrification, without tangential displacement, and therefore without induction.

So, with a condenser consisting of a pair of concentric shells uniformly electrified, either or both may expand or contract without magnetic force. This is, however, not peculiar to the case of motion at speed $v$. Any speed will do. But in general, if the speed be not exactly $v$, there results diffused disturbances. The electromagnetic waves are no longer of the same pure type.

*(To be continued.)*

Digitized by Google

## THE MAGNETIC CIRCUIT OF TRANSFORMERS: CLOSED VERSUS OPEN.

BY S. EVERSHED.

(*Concluded from page 757.*)

§ **78.** So much for the theory of idle current supply by condensers. It is too soon to expect any practical results of importance, but there is no reason to expect any insurmountable difficulties in making large condensers capable of withstanding 2,000 volts or more. Meanwhile it may be useful to give a rough calculation of the probable dimensions of a condenser to supply one ampere at 2,000 volts with a frequency of 100 ∿. According to our formula,

$$K = \frac{C}{2\pi E F} = \frac{1}{2\pi \times 2{,}000 \times 100} = \cdot 8 \text{ microfarad.}$$

This must be converted into electrostatic units before we can determine the size, number, and thickness of the dialectric films. One microfarad is equal to $1 \times 10^{-15}$ C.G.S. (magnetic) units, and to convert this into static units it must be multiplied into $v^2$, or $(3 \times 10^{10})^2$, so that

$$\begin{aligned} \cdot 8 \text{ microfarad} &= \cdot 8 \times 10^{-15} \times 9 \times 10^{20} \\ &= \cdot 8 \times 9 \times 10^{5} \\ &= 7{\cdot}2 \times 10^{5} \text{ electrostatic units.} \end{aligned}$$

§ **79.** If each film has an area of 1,000 square cms. (roughly one square foot), and a thickness of ·05cms., and if we further assume the dielectric constant to be about twice that of air, the capacity per film will be

$$\frac{2 \times 1{,}000}{4\pi \times \cdot 05} = 3{,}200 = \cdot 032 \times 10^{5}.$$

and $\frac{7{\cdot}2}{\cdot 032} = 225$ nearly enough, so that it would require 225 films of dielectric to supply one ampere. If the conducting plates are half the thickness of the films the total thickness of the condenser will be nearly 17cms. Such a condenser would go into a box 14in. by 14in. by 8in., but this is the size wanted to supply one 10 H.P. open transformer—No. 2 as a Hedgehog required about ·9 ampere—and a fair output for a central station would mean from 50 to 100 such condensers, but even then the space occupied by them is not a very serious matter. Of course, a dielectric may be discovered, a very thin film of which would suffice to withstand 2,000 volts; but it is reasonable to suppose that in the fierce race for the best covering for high-tension mains all the really serviceable materials have already been unearthed. It is curious that one of the best materials from a mechanical point of view, turns out to be about the worst electrically; in seeking for a strong dielectric one naturally expects to find glass a thoroughly satisfactory material. It is usually supposed to be capable of standing enormous electrical stresses, though so far as the writer is aware no determinations of the potential differences required to pierce glass of given thickness and composition have ever been published, and he can therefore only quote from results noticed by himself while using a large induction coil. The coil terminals being connected to glass Leyden jars, it was noticed that when the latter were giving sparks some three or four inches in length they would usually burst after a short time, although a jar here and there would successfully stand the enormous force. The glass of these jars was about ·5cm. thick, and taking a four-inch spark to represent 100,000 volts, we may conclude that 200,000 volts per cm. is certainly very close to and probably beyond the breaking stress for the glass of which these particular jars were composed. Taking this figure as a guide, a glass film ·015cm. thick would be at its breaking point with 3,000 volts, or say 2,000 effective volts from an alternate current circuit. Allowing a factor of safety of 4, the films would require to be about ·06cm. thick. The dielectric "constant" for glass is one of those puzzling quantities which are only called constant because it would be so extremely convenient if they were so. The specific inductive capacity for glass is given by Fleming Jenkin (Electricity and Magnetism) as 1·9, while Dr. Hopkinson found values ranging from 6·7 to 9·9. The true constant might be expected to be equal to the square of the refractive index for infinitely long light waves, and the index for the glass used in Hopkinson's determinations is given as ranging from 1·5 to 1·6 (Fleming's "Alternate Current Transformer," Vol. I, p. 345). These figures indicate the value 2·5 as the electric constant required by Maxwellian theory. It seems probable that the large discrepancy between this value and those observed by Dr. Hopkinson is due to something akin to electrolytic conduction, in which case we should expect glass to ultimately break down from decomposition even supposing it able to stand without cracking, the rise of temperature due to the local conduction currents in it. Evidently glass has too complex a composition for use in alternate current condensers.

§ **80.** Since writing the above Mr. Swinburne has described the progress made by Mr. Bourne and himself in the search for dielectrics, in a short Paper read at the Physical Society. The best results have been obtained from paper saturated with some hydrocarbon oil, and probably condensers made on some such lines will ultimately come into general use. One small difficulty not apparently noticed by Mr. Swinburne in the course of his experiments is that most hydrocarbon oils contain traces of the acids used in refining, and this naturally tends to diminish their specific resistance. Solid hydrocarbons on the other hand, while excellent in their insulating quality are liable to crack, and any discontinuity in the dielectric film is fatal. We may take it for granted then, that condensers are quite feasible. Their cost is another matter altogether and one which time alone can settle.

§ **81.** We are now in a position to give some sort of answer to the question we set out to discuss, namely, which are the more economical, closed or open transformers? Perhaps the best way of putting the conclusions arrived at before the reader will be simply to consider the annual cost of the power wasted in the cores of the typical transformers which have served as examples in these Papers. Take the case of a supply company running a 600 kilowatt station. According to the figures adduced by Mr. Crompton, in his celebrated Paper on Central Station Lighting (*Journal* Soc. Tel. Eng., Vol. XVII., p. 361), the total cost of the plant, inclusive of mains and transformers, would be about £60,000. Suppose for the sake of argument we assume Mr. Crompton's coefficient to be nearly two, and put the capital outlay at £100,000 for the 600 kilowatt plant. The maximum transformer capacity must be about 1,000 h.p., and we may conveniently divide this into 100 transformers of 10 h.p. each. If the Ravenshaw transformer is used with its original winding, the core waste will amount to 9·6 B.T. units per diem, or 3,500 units per annum per transformer. It is impossible at present to obtain reliable information as to the actual running expenses of alternate current plants but it has been stated at about fourpence per unit delivered to the consumer; but in reckoning the cost of waste power it is clear that we must only take the coal and oil consumption into account, the only appreciable saving to be effected by a diminution in waste power being in cost of materials. Wages and fixed charges remain as before. Probably one penny per unit is a reasonable sum to allow in the case of waste power. At this rate 3,500 units will cost about £15; that is to say, the Company will virtually spend £1,500 per annum in heating the cores of its transformers. This, let it be remembered, is a fixed charge depending solely on the design and average size of the transformers, and not at all on their useful output. They may run at full load continuously from one year's end to another, and the engineers of the company may point with pride to the 95 per cent. efficiency of their converters, but the waste goes on just the same and the company which succeeded in cutting down the whole of the core waste would add nearly 1½ per cent. to its dividend.

§ **82.** Replace the transformers by the No. 2 closed modification, wasting 3·94 units per diem or just under £6 per annum; the waste in 100 such transformers will be £600 per annum, as against £1,500 for the original transformers, a clear gain of £900 per annum. But there is the additional capital outlay in copper. The saving in running expenses is effected by putting something like 180lbs. more copper in the coils adding

Digitized by Google

perhaps £25 to the price of each converter, so that for an additional outlay of £2,500 a saving of £900 per annum is effected. Evidently a good investment. Will it pay to convert No. 2 into a Hedgehog like Fig. 15? So far as the transformers themselves are concerned it certainly will. No. 2 as an open transformer with small Hedgehog ends (Fig. 15), wastes 1·94 units per diem in its core, to which the constant $C^2R$ waste for exciting current must be added, bringing the whole constant waste up to 2·14 units costing £320 per annum for 100 such transformers. This is an additional saving of £280, compared with the same transformers with closed magnetic circuits. Of course one cannot be sure of this saving unless the idle current is supplied by condensers, so that the light load may be taken by a portion of the station plant fairly well loaded. It should be noticed that transformer No. 2 would certainly cost less to build with an open than with a closed magnetic circuit, so that although £280 seems hardly worth saving by itself, the saving in capital outlay is an additional advantage. What that saving would be it is impossible to say, as manufacturers of electrical plant do not publish their prime costs and list prices are generally meaningless. The whole point really turns on this: To effect any appreciable saving by means of open transformers condensers must be used. Inclusive of condensers can they be supplied at the same cost as transformers with closed cores? If that question is decided in favour of open magnetic circuits there would still be the extra complication and liability to breakdowns introduced with condensers to be taken into account. A single disaster with the condensers would probably more than wipe out the whole annual saving in the transformers.

§ **83.** Since an open transformer is economical by reason of the small amount of iron in its core, why not take the next step and use no iron at all? The dimensions of a coreless transformer are

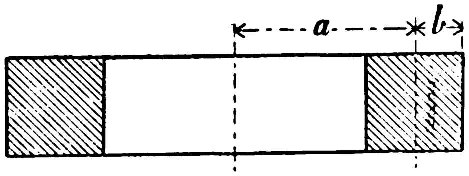



Fig. 25. Section through circular coil forming primary and secondary windings of 10 h.p. coreless transformer. 1/10 full size.

easily calculated if we assume some convenient shape for the coils. Suppose we design a coreless transformer which shall require the same weight of copper as No. 2 (either open or closed) and work with the same resistance drop, namely 2·8 per cent.; the problem then reduces itself to finding the size of a bobbin on which to rewind the coils used in No. 2, and as we want to keep down the exciting current to its smallest possible value, we must evidently wind the wire so that the product of induction due to unit current into the number of turns on the coil (in short L) is a maximum. A solution of this problem has been given by Gauss but it will be better to work it out here independently.

The self induction in a coil whose average diameter is large compared with the cross sectional area of the winding is approximately:—

$$L = 4\,\pi\,N^2\,a\left(\log_e \frac{8\,a}{R} - 2\right), \quad . \quad . \quad . \quad (1)$$

where N is the number of turns of the coil, $a$ is the average radius and R the average distance of the wires from each other (geometrical mean distance). We may take the cross section of the bobbin as being square, as shown in Fig. 25. The area of section is $4\,b^2$, one-half of which may be taken to represent insulation, the remainder being available for copper. In calculating for minimum exciting current we have only to deal with the primary coil, the copper of which will have a cross section equal to $b^2$. Its volume is known, for as we have 240lbs. of copper on No. 2 we may assume that we shall use 120lbs. on the primary, or the volume will be

$$V = 6055 \text{ cc.}$$

The primary and secondary being supposed to be well mixed will each cover the whole cross section, so that the geometrical mean distance of the primary winding from itself will be

$$R = \cdot447 \times 2\,b = \cdot894\,b.$$

§ **84.** From these equations we are able to eliminate N and $a$ from (1) for

$$a = \frac{V}{2\,\pi\,b^2}$$

and

$$N^2 = \frac{r\,b^4}{\rho\,V}$$

where $\rho$ is the specific resistance of copper, and $r$ is the resistance of the primary, which must be 7·6 ohms. to make the full load-drop equal 2·8 per cent. as before. Substituting the values of $N^2$ and $a$ so determined, we get

$$L = \frac{2\,r\,b^2}{\rho}\left(\log. \frac{4\,V}{\cdot894\,\pi\,b^3} - 2\right), \quad . \quad . \quad . \quad (2)$$

so that

$$\frac{d\,L}{d\,b} = \frac{2\,r}{\rho}\left\{2\,b\,(\log. 4\,V - \log. \cdot894\,\pi - 3\log. b - 2) - 3\,b\right\}.$$

The right-hand side vanishes if $b = 0$, which is an impossible but obvious solution, and the maximum we are seeking occurs when $\frac{d\,L}{d\,b}$ is made to vanish by writing

$$\log. 4\,V - \log. \cdot894\,\pi - 3\log. b - 2 - \frac{3}{2} = 0 \quad . \quad . \quad (3)$$

solving (3) for $b$ we find $b =$ 6·38 cms.

and, therefore, $a = 23·7$ „
R = 5·7 „
N = 1100 turns.

With these values we can determine the induction threading the coil due to one ampere, for

$$L = B_{10} N,$$

where $B_{10}$ is the induction for 10 amperes (*c.g.s.* unit), and putting real values into (1) we find

Induction per ampere = 49,500 thoms *

If the coil is run at 2,000 volts, at a frequency of 70 ∿, the exciting current will be given by the equation

$$B' = 49{,}500\ C' = \frac{2{,}000 \times 10^8}{4{\cdot}4 \times 1{,}100 \times 70},$$

from which C′ = 12 amperes,

or

$$C = \frac{12}{\sqrt{2}} = 8{\cdot}5 \text{ amperes.}$$

§ **85.** Of course, no one would dream of working with an exciting current more than twice as great as the full load current which for 10 h.p. is 3·75 amperes. To obtain a reasonable exciting current we may either use more copper or raise the frequency, and we will adopt the latter expedient, for there being no core there is no reason for running at a low frequency, at least so far as the transformer is concerned. Neither is there any reason to reduce the exciting current below that required for No. 2 as a Hedgehog, namely, ·9 ampere. The exciting current being inversely proportional to the frequency, we must raise the latter to:—

$$F = 70\ \frac{8{\cdot}5}{\cdot9} = 660 \ \text{∿ per second.}$$

this is far higher than anything yet adopted in practice, and at such a frequency eddy currents in every part of the system from alternator to transformers would be a serious item. But the whole of the exciting current is idle in a coreless transformer, and if it is supplied by a condenser we may arrange the frequency so that the condenser used for No. 2 would serve for the coreless transformer, for the idle current output of a condenser is directly proportional to the frequency. To find the appropriate frequency to fit the condenser required by No. 2 we have first the following data:—

Condenser supplies ·9 ampere at 70 ∿

It therefore supplies $\frac{\cdot9}{70}$ „ at 1 ∿

* One *thom* = one "magnetic line of force." B throughout this investigation stands for *total* induction.

Digitized by Google

Or current supplied by condenser at frequency F is:—

$$C = \frac{\cdot 9}{70} F \quad . \quad . \quad . \quad . \quad . \quad . \quad (1).$$

Also, as we have seen the frequency needed to make the exciting current equal to ·9 ampere was 660∿, so for a current C it must be

$$F = 660 \frac{\cdot 9}{C} \quad . \quad . \quad . \quad . \quad . \quad . \quad (2).$$

Eliminating C we have

$$F^2 = \sqrt{660 \times 70}$$

and $F = 215$ ∿ per second,

and therefore $C = 2{\cdot}76$ amperes.

§ **86.** The frequency just found is by no means excessive although somewhat higher than is now generally considered advisable. The efficiency of the coreless transformer is very high in spite of the large exciting current. At full load it is as follows:—

| | | |
|---|---|---|
| Output | 7,500 | watts. |
| $C^2R$ for exciting current | 58 | ,, |
| $C^2R$ for load | 212 | ,, |
| | 7,770 | |

$$\text{Efficiency} = \frac{750}{777} = 96{\cdot}5 \text{ per cent.}$$

and on the time load assumed throughout these articles its efficiency works out thus—

| | | |
|---|---|---|
| Output | 24,000 | watt hours |
| 24 hours' $C^2R$ for exciting | 1,390 | ,, ,, |
| 6 hours' $C^2R$ for load | 360 | ,, ,, |
| | 25,750 | |

$$\text{All day efficiency} = \frac{240}{258} = 93 \text{ per cent.}$$

§ **87.** Coreless transformers have many advantages. They are necessarily less wasteful than any other form of converter, they are far simpler to build, the trouble of insulating the coils from the core vanishes with the core, and the power wasted is so small that the transformer would keep perfectly cool. The 10 H.P coreless transformer just described would occupy a space of about 2 feet diameter and 6 inches deep, and it is difficult to imagine a safer arrangement than such a bobbin placed in an earthenware pan filled with oil and closed by an oil-tight lid. There are some disadvantages, perhaps serious ones; the high frequency leads to difficulties in designing alternators, and all eddy current effects would be nine times as great at three times the frequency and this may easily become a serious matter. Some trouble also would probably arise from the induction due to the load currents in the primary and secondary coils unless the windings were thoroughly mixed. The engineers of a company which had an eye to good dividends in spite of competition might be expected to overcome all these obstacles, though it is in the last degree unlikely that any directors will sanction an increase in capital outlay for the sake of a moderate saving in working expenses, until they have to supply energy at fourpence a unit or lose their trade. When that millennium arrives, and it most certainly will, the directors will worry the engineers. In the meantime it is clear that the condenser is the key of the whole question. If condensers are practicable, open cores for transformers will supersede closed magnetic circuits, and both may have to give place to the coreless transformer.

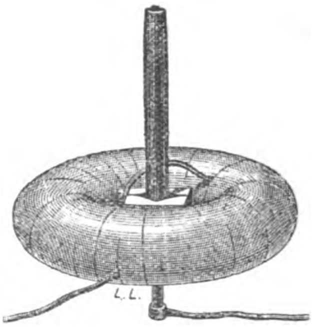
**A Submarine Cable Museum.**—According to the *Oesterreichisch-Ungarische Post*, Herr Schachner, superintendent of the Zara telegraph section, possesses an interesting collection of submarine cable samples which he has been twenty years collecting. It consists chiefly of lengths obtained when new cables were laid or old cables were repaired. The collection comprises specimens of gutta-percha, Hooper, and india-rubber cables. Examples of standard joints and cable apparatus, not to mention shells and marine animals, are also to be found in this museum. In every case where the defects of a cable were due to the injury done by the sea bottom, samples of the same are exhibited side by side with the cable injured.

## EXPERIMENTS WITH THE ELECTRIC ARC.

In *La Lumière Electrique* of April 25th, M. E. Raverot, referring to the experiments of Mr. Stanley, jun. (*The Electrician*, March 27th), in connection with a rotating arc, and to the application of that phenomenon made by Mr. J. D. F. Andrews (*The Electrician*, April 3rd), describes some attempts of his own to construct a continuous current electric candle on the same principle.

M. Raverot devoted his attention solely to the construction of continuous current candle to work under normal conditions of current and voltage. The diameter of the central carbon varied from 3 to 8 millimetres, and the maximum distance between the inner and outer carbons was 2mm. The directing solenoid was of the shape shown in the accompanying Figure. It consisted of a coil of 2·5mm. copper wire. It was used sometimes alone, and sometimes with a short iron tubular core When sufficient care was taken to obtain accurate centrality, no difficulty was experienced in securing satisfactory rotation of the arc. With regard to a suitable material for insulating the two carbons it was, however, quite otherwise. With air as the insulator it was practically not possible to easily obtain accurate centrality with the dimensions employed. This point is, however, an important one, because even without a solenoid and using a solid insulator, the arc always takes the curved shape and does not spread in a sheet between the carbons.

As a solid insulator it was natural to try first of all the well-known mixture of plaster and baryta which constituted the columbium of the Jablochkoff candle. This mixture, however, proved to be too fusible in the case of the



Continuous Current Candle with Rotating Arc.

continuous-current candle with the rotating arc. Perhaps it was not sufficiently baked, but it seems more probable that its inefficiency was due to the conditions of cooling, which are quite different to those which usually obtain. The following result affords an additional reason for so thinking:—On becoming acquainted with the dimensions given by Captain Gregory Ignatiev, for his annular candle in *La Lumière Electrique*, Vol. XXIV., p. 365, an attempt was made to reproduce it. The result was that the central carbon became incandescent from one end to the other. It seemed, therefore, that the arrangement of C. Binks described in *La Lumière Electrique*, Vol. XI., p. 203, was the one to follow. In this the central carbon is positive, and the two carbons are separated by refractory insulating substance. Ignatiev reversed this arrangement, and even proposed to use air only as the insulating medium.

M. Raverot is of opinion that the desired substance will be found to be one of the refractory oxides of the earthy metals, such as aluminium, magnesium, chromium, or zirconium, but as the use of these involves some manufacturing difficulties he experimented with porcelain, and he points out that upon the volatility of the refractory substance chosen depend the diameters and sizes of the carbons and the importance of the directing solenoid. Fine plaster, moulded and well baked, gave a practical result, and continuous-current candles, taking 12 amperes and 55 volts, were constructed for a private installation.

The excellent working of most modern arc lamps diminishes the interest of the continuous-current candle, but M. Raverot, nevertheless, thinks that a good solution of the problem would still meet with favour.

Digitized by Google

## FARADAY'S INSULATED ROOM.

The following communication has been sent us by Mr. F. C. Webb, together with a copy of his Paper from the *Philosophical Magazine* :—

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Sir William Thomson, in his interesting lecture on Electric and Magnetic Screening, alludes to Faraday's celebrated experiments with an insulated room.

I also performed an experiment with an insulated room, which I think deserves notice on such a subject.

Faraday electrified the *outside* of the room, and found no effect on electrometers, &c., *inside*.

I electrified the *in*side of the room, and found no effect on electrometers *out*side. Now, this would not in itself appear, at first sight, very important. But I performed my experiments in 1869, at Keyham Dockyard, to prove the truth of important theories I had published in 1860.

Up to that date all text-books alluded to the "earth as the great reservoir of electricity," and when any electricity disappeared it was always conveniently consigned to "the earth." I fought against the earth and the text-books for many a year, but not even my experiment of 1869 has kept the poor old earth from being maligned as a receiver of stolen goods.

Now, I appeal to you, Sir, when a plain, practical man takes advantage of Her Majesty's Dockyard, &c., in the pursuit of pure scientific truth, should not the results find a place in the books and papers connected with the subject?

I enclose you a copy of my article "On an Electrical Experiment with an Insulated Room," excerpt from the *Phil. Mag.* of September, 1872.—Yours, &c.

F. C. WEBB.

The following extract from the Paper describes the very interesting experiment :—

"The room was about 8ft. by 9ft. and about 8ft. high. The floor was of wood, and the sides of wooden framework covered with calico and with pieces of tinfoil pasted about it to make it a good conductor. It had a door and two windows of wire gauze. A small table was placed in it, and a frictional electrical machine was placed on this. The room was suspended by four double parts of half-inch round gutta percha band to a wooden frame, the floor being about 4ft. from the ground. The gutta percha was covered with paraffin; and the whole room was tested for insulation with five hundred Daniell's elements with a delicate astatic Thomson's reflecting-galvanometer, and gave no perceptible loss. A Peltier electrometer was placed on the ground outside; and a wire from the brass knob of this was connected to the gauze of the window. The table was connected with the tinfoil that was pasted about the surfaces of the room, so that when the rubber or prime conductor was connected to the table it was in connection with the sides of the room. Thus arranged, the machine acted to all appearance exactly the same as in an insulated room. When the rubber was connected to the table, on turning the glass disc the prime conductor was charged so as to give off sparks the same as when the room was uninsulated; and the conductor was completely discharged when touched to the insulated room. Not the slightest effect was produced on the electrometer, even when sparks were flashing from the prime conductor to the wire gauze of the windows to which the wire from the electrometer was attached. Connecting the room to the earth made no difference. A sphere about a foot in diameter was then charged when the room was insulated, and then handed out by an insulating handle, when the electrometer immediately diverged to about 50 degrees, showing that the outer surface of the room had become negative. On taking the sphere back into the room, the electrometer fell to zero."

It is evident that equal and opposite quantities of electrification were produced, and there was no reason why the electrometer outside should give any indication. The experiment of passing a charged ball out of the room is a very pretty proof of the immediate result of disturbing the balance of opposite electrifications. It appears probable that the machine would not have worked indefinitely, and that the results were due to the capacity of the room. For if the room be reduced to a minimum, or abolished, it is well known that a mere machine well insulated will not work. Our correspondent is not quite accurate in saying that he electrified the inside of the room. Faraday's "ice-pail" experiment is so well known to every student that we need not describe it here. Suffice it to say that any attempt to give a charge to the interior of a conductor can only result in electrification of its exterior.

## MEETINGS OF SCIENTIFIC SOCIETIES, &c.

**FRIDAY, May 1st.** (To-night).

ROYAL INSTITUTION.

*5 p.m.* Annual Meeting.

*9 p.m.* Evening Discourse. "Hawks and Hawking." By J. E. HARTING, F.L.S.

INSTITUTION OF MECHANICAL ENGINEERS.

*7.30 p.m.* Ordinary General Meeting.

**SATURDAY, May 2nd.**

ROYAL INSTITUTION.

*3 p.m.* Afternoon Lecture. "The Dynamo." By Prof. SILVANUS P. THOMPSON, D.Sc.

**MONDAY, May 4th.**

ROYAL INSTITUTION.

*5 p.m.* General Monthly Meeting.

SOCIETY OF ENGINEERS.

*7.30 p.m.* Ordinary Meeting. Paper to be read: "Modern Coal Gas Manufacture." By C. C. CARPENTER.

**TUESDAY, May 5th.**

INSTITUTION OF CIVIL ENGINEERS.

*8 p.m.* Ordinary Meeting. Paper to be read with a view to discussion: "On Railway-Train Lighting." By WILLIAM LANGDON. At this meeting the monthly ballot for members will be taken, and after the adjournment at 9 p.m., the President and Council will hold a reception in the library.

**WEDNESDAY, May 6th.**

ROYAL SOCIETY.

*9 p.m.* Annual Conversazione.

SOCIETY OF ARTS.

*8 p.m.* Ordinary Meeting. Paper to be read: "The Sources and Applications of Borax," by E. L. FLEMING.

**THURSDAY, May 7th.**

ROYAL INSTITUTION.

*3 p.m.* Afternoon Lecture. "Recent Spectroscopic Investigations," by Prof. DEWAR, F.R.S.

INSTITUTION OF ELECTRICAL ENGINEERS.

*8 p.m.* Ordinary General Meeting. Papers to be read: (1) "On some Effects of Alternating Current Flow in Conductors having Capacity and Self-induction," by Dr. J. A. FLEMING. (2) "Some points connected with Mains for Electric Lighting," by W. H. PREECE, F.R.S.

CHEMICAL SOCIETY.

*8 p.m.* Ballot for Election of Fellows, and Papers to be read.

**FRIDAY, May 8th.**

INSTITUTION OF CIVIL ENGINEERS.

*7.30 p.m.* Students' Meeting. Paper to be read: "Malta Dockyard Caisson." By J. WALTER BROWN, Stud. Inst. C.E.

ROYAL INSTITUTION.

*9 p.m.* Evening Discourse. "Liquids and Gases." By Prof. W. RAMSAY, F.R.S.

**SATURDAY, May 9th.**

ROYAL INSTITUTION.

*3 p.m.* Afternoon Lecture: "The Artificial Production of Cold." By H. GRAHAM-HARRIS, M. Inst. C.E.

*** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

**Magnetic Screening.**—In a recent number of *Nature*, J. J. Borgman, of St. Petersburg, describes a neat lecture experiment in connection with magnetic screening. A Lecher's tube is put, by means of two cork rings, into another large (4 cm. diam.) glass tube, with a crane on one end. Holding the tube in one hand, and approaching it to a wire in which electrical waves are produced, a continuous illumination is to be seen in the Lecher's tube. This remains even if the large tube is filled with water. But if the tube is filled with dilute sulphuric acid the light disappears. When the crane is opened, and the acid flows out, the light is seen again, but only in that part of Lecher's tube which is not surrounded with the acid. The light in the Lecher's tube penetrates but very little below the level of the acid in the surrounding tube,

Digitized by Google

# The Electrician.

Published every Friday, Price Fourpence; Post Free, Fourpence Halfpenny
Editorial, Publishing, and Printing Offices:
SALISBURY COURT, FLEET ST., LONDON, E.C.
*Telephone No.* 2714. *Telegrams:* "ELECTRICIAN NEWSPAPER, LONDON."

*All Letters relating to Subscriptions, Advertisements and other business matters should be addressed to the Publisher, "*THE ELECTRICIAN,*" Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to "*THE ELECTRICIAN*" Printing and Publishing Company, Limited, and be crossed "Coutts and Co." All other letters to be addressed to the Editor.*

*All letters intended for insertion in "*THE ELECTRICIAN,*" or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

"THE ELECTRICIAN" *is published every Friday morning, in time for the morning mails. Subscribers should receive their copies by the first post on Friday morning.*

"THE ELECTRICIAN" *is on sale at the railway bookstalls throughout the Kingdom on Friday morning, and can be obtained of all Booksellers and Newsvendors; or direct from the Publishing Offices as above.*

*New Volumes of "*THE ELECTRICIAN*" commence in May and November.*

## SUBSCRIPTION RATES.

The rates for Subscriptions to "THE ELECTRICIAN" are as follows:—

| | 3 months s. d. | 6 months. s. d. | 12 months. s. d. |
|---|---|---|---|
| For the United Kingdom | 5 0 | 10 0 | 19 6 |
| For Foreign Parts and Colonies:— Within Postal Union | 6 6 | 12 6 | 24 0 |
| For Aden, Borneo, Ceylon, China, India, Japan, Java, Labuan, Mozambique, New Caledonia, Persia, Philippine Islands, Siam, Transvaal, and Zanzibar | 7 6 | 14 6 | 28 0 |



## TO ADVERTISERS.

"THE ELECTRICIAN" *offers exceptional advantages to Advertisers.*
**It has by far the largest circulation of any English Electrical paper, and circulates all over the World.**

*Particulars relating to Advertisements will be promptly forwarded on application to the Offices as above.*

TRADE ADVERTISEMENTS *intended for the current issue must reach the Offices not later than First Post on Thursday morning. Renewals of expiring advertisement orders and alterations to standing advertisements should be in the Publisher's hands by Wednesday at latest. No alteration can be made in Wrapper advertisements after Wednesday evening.*

SMALL PREPAID ADVERTISEMENTS *(for Rates see page xvii.) are accepted up to 4 p.m. on Thursday.*

## TECHNICAL PRINTING.

"THE ELECTRICIAN" PRINTING AND PUBLISHING COMPANY (LIMITED) *inform Electricians, Electric Light Engineers, &c., that they make a specialty of Technical Printing, and have a large Staff thoroughly acquainted with Electro-Technology. They can, therefore, promise Accuracy and Despatch in the Printing of Electro-Technical Literature, &c.*

## THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. (Royal 8vo.)

*Early in each year is issued "*THE ELECTRICIAN*" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. The DIRECTORY was established in 1883, and the 1891 Edition, published on the 23rd February, 1891, consists of 900 pages of printed matter. The names and addresses of all persons engaged in the Electrical Industries at home and abroad may be relied upon as accurate. Useful Tables and Electrical Formulæ, and information specially compiled for this work are given, together with popularly-written Biographical Notices of the leading Electricians, Electrical Engineers, &c., accompanied in many cases by Portraits.*

*The issue for 1891 is ready, and should be ordered at once. Price 5s., post free 5s. 9d. Abroad postage extra. Full particulars on application.*

## ELECTRICAL BOOKS AND PUBLICATIONS

*All Books, Newspapers, and other publications, dealing with Electrical and kindred subjects, can be ordered direct of "*THE ELECTRICIAN*" Printing and Publishing Company, who are proprietors of the well-known "*ELECTRICIAN*" Series of Standard Electrical Works, and are agents for all the leading publishing houses at home and abroad.*


## CONTENTS OF THE CURRENT NUMBER.


NOTES ... 777
Electromagnetic Theory, IX. By Oliver Heaviside. Contin. Illustrated ... 781
The Magnetic Circuit of Transformers: Closed versus Open. By S. Evershed. Concluded. Illustrated ... 784
Experiments with the Electric Arc. Illustrated ... 786
Faraday's Insulated Room ... 787
Meetings of Scientific Societies 787
ELECTRIC SHOCKS ... 788
Reviews ... 789
New Metropolitan Police Buildings. Illustrated ... 790
On the Sensitiveness of the Bridge Method in its Application to Periodic Electric Currents. By Lord Rayleigh. Illustrated ... 791
Notes on the Design of Multipolar Dynamos. By W. B. Esson. *Discussion.* Illus... 793
Presentation to Sir W. Thomson 796
On Imparting Electric Charges by Friction. By Ed. Riecke. 796
Legal Intelligence ... 797
American Notes ... 798
CORRESPONDENCE—
Twisted Telephone Wires—A. R. Bennett ... 798
The Lane Fox Patents—St. G. Lane Fox ... 799
Trade Notes and Notices ... 799
PATENT RECORD ... 800
COMPANIES' MEETINGS, &c.—
The Indo-European Telegraph Company ... 800
Metropolitan Electric Supply Company (Limited) ... 801
Reuter's Telgram Company Limited ... 803
Elmore's Foreign and Colonial Patent Copper Depositing Company (Limited) ... 804
Brazilian Submarine Telegraph Company (Limited). 804
The Kensington and Knightsbridge Electric Lighting Company, Limited ... 804
Submarine Cables Trust ... 804
City Notes, &c. ... 805
Companies' Share List ... 806


## NOTICE.

**The present Number of "THE ELECTRICIAN" completes Volume XXVI. With next week's Number will be issued (gratis) the Index to the Volume.**

**READY NEXT WEEK.**

**Volume XXVI. of "THE ELECTRICIAN," price 12/6; post free, 13/6.**

**NOW READY.**

**Cases for binding Volume XXVI., price 2/0, post free, 2/3.**

## ELECTRIC SHOCKS.

When Major CARDEW confessed that the Paper which he presented to and partly read before the Institution of Electrical Engineers last week was somewhat dry, none of his audience were disposed to disagree with him, but as the author of the next Paper did not care about beginning to read it at ten minutes to nine, he proceeded to open the discussion, and rather skilfully withdrew the attention of the meeting from the actual topic—"A Few Calculations on Electrical Shocks from Contact with High-Pressure Conductors"—and discussed shocks in general and in particular. The short but lively discussion contrasted not only with the heavy mathematics which it followed, but the levity with which the subject was treated jarred strangely with the sad results to which allusion was naturally made. It is possible, however, to be witty about dismal matters and to laugh about pain, without joking at the sufferings of others or treating the subject in a callous style. This being so, the discussion was all too brief, and was worthy of being adjourned, if only it could have been carried on without becoming a mere recital of disasters. The dangers of engineering operations are pretty well understood, and the degree of danger which attaches to various hazardous occupations is well known. Architects are sometimes surprised to learn from insurance offices that their profession

Digitized by Google

is fraught with divers perils, since they may be called upon in the execution of their duties to climb ladders and may often stand in jeopardy of falling bricks. On the other hand, it was the magnitude of the works at the Forth Bridge, and not any special hazard in the operations, which gave a certain prominence to the hospital which was provided there. Taking the number of men into account, it was found that there was no extraordinary danger in their work, and the provision which was made merely sufficed for those casualties which are inseparable from any constructive undertaking of the same kind. Within the past ten years there have been fatal accidents at the well-known electrical works at Lambeth, but it is extremely satisfactory to learn that while many hundreds of high pressure dynamos have been turned out, not a single death has been caused by electricity, since those which have unfortunately occurred have been due to the accidents which must from time to time take place in any engineering establishment. It must be remembered that it is only during the testing of dynamos that any risk can arise, and the testing is part of the duties of the skilled staff, who, of course, know exactly where the danger lies. As far, then, as manufacture is concerned, it is proved by the experience of this firm who practically first introduced high-pressure dynamos into this country—and their experience is confirmed by that of many other manufacturers—that the precautions which are practically dictated by comfort suffice in the most complete manner for the protection of life.

The overhead wires which recently spread over the West End in all directions from the Grosvenor Gallery seemed, not only to the public, but to many engineers, to be as dangerous as they were ugly; but they will soon be a matter of past history, and the accidents attributable to them are singularly few. With the double system of distributing mains which the London Electric Supply Corporation are laying, there will be no occasion to make joints on live conductors, and the "ring mains" employed by the Metropolitan Company also avoids any difficulties of this kind. The narration by Mr. ADDENBROOKE of his perilous exploit in jointing a new branch to an overhead wire charged with 2,400 volts, perched in mid-air on a rubber-covered bracket as he worked, held his audience in suspense, and as an anti-climax Major CARDEW observed that, according to the calculations contained in his Paper, and set forth geometrically upon the black-board, a careless workman who both gave and received a shock by touching a stick of solder held by Mr. ADDENBROOKE altered the phase angle of the voltage and reduced the pressure by perhaps one-third.

We are not much nearer the solution of the question as to the magnitude of the shock which will prove fatal, and it is becoming very apparent that no more accurate answer is to be expected than could be given to an inquiry as to the exact height from which a man must fall to ensure killing him. A distinct advance is made in recognising that the effects of the shock do not depend merely on the pressure. It is obvious that the mere voltage of the spark which may be taken with no discomfort whatever from a frictional or influence machine is very considerable, but the current is infinitesimal; and even from such a source as an ordinary induction coil the quantity of electricity is extremely small. The varying resistance due to the condition of the skin in different individuals, and the variation at different times with the same person, is well known. The degree of discomfort and of pain experienced by different patients, though not as yet to be expressed in the C.G.S. system, has been sufficiently determined to enable some estimate to be made of the most extreme limit of safety. Numerous experiments have been carried out with ordinary continuous current machines, with alternating currents, and with batteries. The currents have been measured with more or less accuracy in milliamperes, and a rough notion has been arrived at of the point where discomfort begins and of the point where the pain is insupportable. Experiments have also been made with the discharge of Leyden jars and induction coils, but these do not throw much light on the subject. The element of time has been disregarded in most of these observations, and this is probably an important factor in determining the effects of a strong current through the body. The millicoulombs are probably as much more worthy of consideration than the milliamperes, as the milliamperes are of more consequence than the volts. The capacity of the human body is altogether too small to produce any appreciable condenser current into and out from it, and actual conduction need only be considered.

We cannot here enter into the physiological details of the matter, as there is at present very little more to go upon than the barest hypotheses. The information given by experts is of a very negative character. They say that the body does not act like an ordinary conductor, that the current does not act as a powerful or tetanic stimulus to the nerves, they tell us that we must not mention electrolysis of the tissues, but they always have plenty of generalities to bring forward. If there be any electrolytic action its effects would be sensible only at the parts in contact with the conductor. But the tissues have been examined for accumulations of gas, which might be evolved in the capillary vessels, but none has been found. The physiological question of electrotonus is complicated enough for small laboratory currents, but, for all practical purposes, the effect of a strong current, whether momentary or prolonged and acting on either nerve or muscle, may be described in plain English as a shock. When physiologists have something definite to tell us, they may be able to give a more scientific word, but the word "shock" used in this sense is comparable to a mechanical or an emotional shock, since the magnitude at which either of these shocks becomes fatal is as ill defined as that of an electric shock.

## REVIEWS.

**Coal and What We Get from It.** RAPHAEL MELDOLA, F.R.S. Romance of Science Series, S.P.C.K., London, 1891.

This little book contains little that directly concerns the electrical engineer, but much that may fill him with envy; for he uses coal for the purpose of obtaining energy. He succeeds in getting about one-fifteenth of it in a useful form, and has nothing more than ashes and clinkers as a waste product. The gas engineer, on the other hand, could, in some cases, give away his gas and yet make a profit out of the gas-liquor, the coke, and the tar. Smelly oils, gaudy dyes, essences, spirits, photographic developers, and a host of other things are produced by the modern chemist from coal tar. This book gives a very clear idea of the general nature of these compounds, the history of their discovery, and briefly describes some of the processes of manufacture. From a rough computation of the index it appears that some 300 different substances are discussed by the author.

**Screws and Screw-making.** (Britannia Company, Colchester, 1891.)

Many treatises are ill-disguised advertisements, but this book, which, to be commended for its honesty, is an excellent work on screw-making, containing numerous tables and formulæ, a reprint of the British Association reports, illustrated with the Britannia Company's tools, and winding up with a full catalogue of their goods. The tables are very complete, 17 pages are devoted to a table of change-wheels for cutting screws of various pitches in both inches and millimetres. It is the most complete book that we have seen on the subject.

Digitized by Google

## NEW METROPOLITAN POLICE BUILDINGS.

The whole of the new Metropolitan Police Offices at New Scotland Yard have been fitted with the electric light by Messrs. Drake and Gorham as contractors, with Mr. A. A. Campbell Swinton as consulting engineer. There are about 1,100 lamps at present fixed, and the total number will eventually be about 1,250. Every effort has been made to render this installation as complete and perfect as possible, and it is believed that every possible contingency which could produce a failure of the light has been provided against. The engine house has been excavated in the yard between the main building and Whitehall, and the whole of the generating plant has been placed well away from the offices.

The steam plant consists of three "Lancashire" boilers by Davey, Paxman and Co., each 22ft. 6in. × 6ft. diameter, each containing two flues 2ft. 3in. diameter with three circulating tubes and Paxman's patent strengthening and expansion joint. The heating surface of each boiler is 480 sq. ft., and the three boilers are capable of evaporating from 6,000 to 8,000lb. of water per hour.

The chimney shaft is 12 sq. ft. in sectional area, and is carried up to a height of 80ft., the lower 40ft. being lined with fire-brick. The steam is conveyed to the engine-room by a duplicate system of steam-pipes divided by nine valves which enable any length to be cut out of circuit as required, and provides for the continuation of the working in the event of a failure of the steam pipe at any point. The feed-water heater is of a special type, consisting of a tank into which the feed water is admitted by a ball valve, the water being blown into a spray by the exhaust steam from the engines which enters immediately under the ball valve.

A bye-pass is provided to carry the exhaust direct to the chimney, and thereby the amount of steam entering the heater can be varied, and the temperature of the water can be regulated from cold to boiling as required.

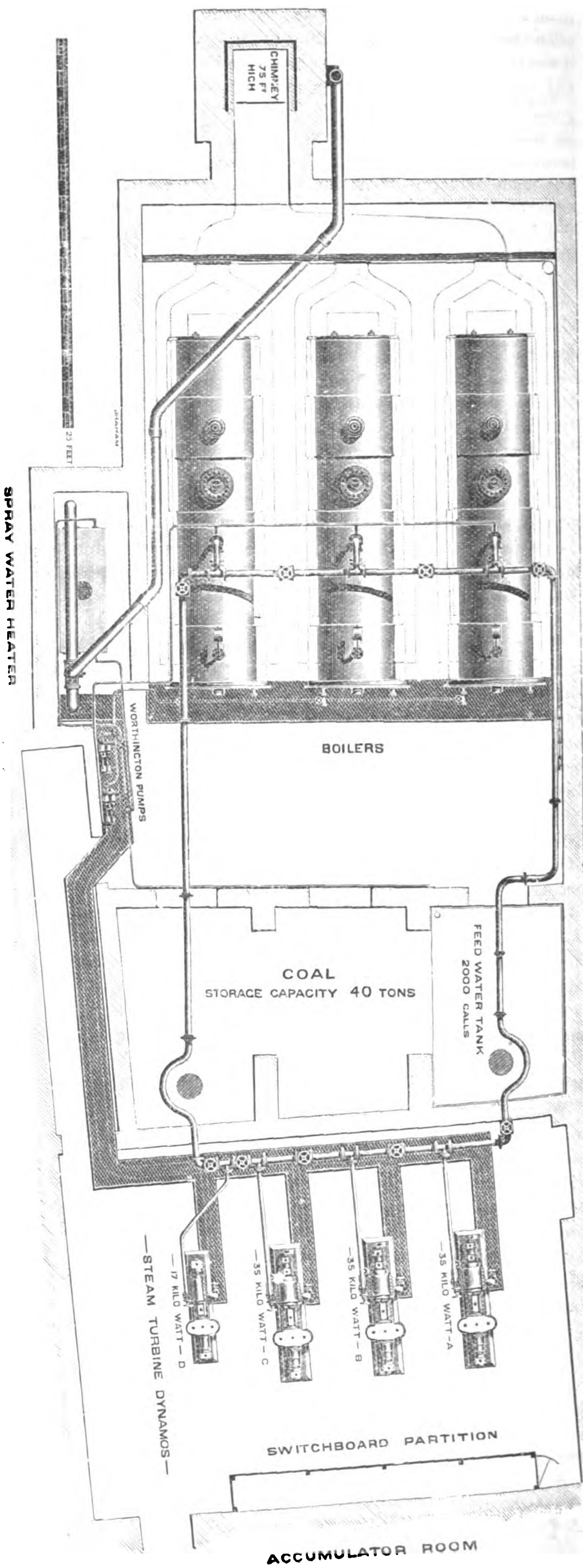
Two "Worthington" steam pumps are so arranged as to draw water from the feed-water heater, or direct from the mainfeed-water tanks, which contain 2,000 gallons of water, and are so connected that either pump can feed any one of the boilers at will.

The current is obtained from four of the new "Parsons" steam turbines and shunt-wound dynamos, three of these being capable of giving an output of 35 units each, and a smaller generator giving an output of 120 amperes × 130 volts for the charging of accumulators. These machines differ chiefly from the older forms of "Parsons" generators, in that they run at a lower speed; and the turbines are on the radial flow principle, instead of parallel, as previously. They are also fitted with a new form of variable expansion electrical governor, which secures additional economy at light loads, and is designed to maintain a constant E.M.F. under all conditions.

The accumulators consist of 106 cells, capable of discharging at a rate of 120 amperes for nine hours for the supply of 200 lamps of 16 c.p. each. The main distributing switchboard is placed 2ft. 6in. from the wall, and doors provide access to the back of the partition, so that all the connections at the back and front can easily be inspected at any time.

The lamp circuits from the main building are brought to a special distributing board fitted with cross connections, and Drake and Gorham's patent ring contact switches, the design permitting both positive and negative connections to be shifted from any one of the sources of generating power to another instantaneously. The ordinary lighting for the building is supplied direct from the steam turbine dynamos, which supply a perfectly steady light, the extremely sensitive automatic governor keeping the E.M.F. constant within a very small percentage.

The battery is charged from the smaller generator during the day, and except in cases of emergency, is used only for



the night service after 10 p.m., and for any few lamps required in dark places during the daytime.

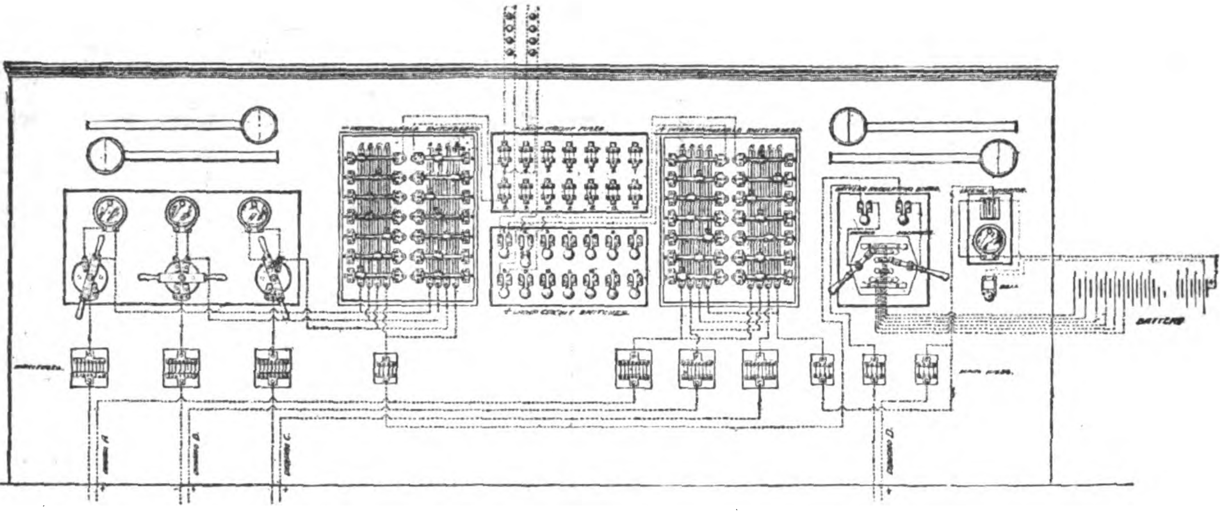
The voltmeters are of the "Cardew" pattern, made with specially large dials, so that the voltage may be seen at a glance from any point in the engine-room.

The wiring of the main building has been carried out so as to obtain the greatest security and immunity from failure of the light, a number of small mains being run from the distributing board in preference to large conductors.

Every alternate lamp throughout the building is supplied from a different circuit, so that in the event of a breakdown only half the lights would be extinguished. Throughout the passages the casing is let in flush with the face of the plaster, conductors braided with white cotton, are carried to each lamp on the face of the concrete ceilings, and supported with eyelets bushed with ebonite. This arrangement enables the position of the light to be shifted at any time without difficulty, and provides one solution of the extremely difficult problem of running the branch wires in modern fireproof buildings in which no lath and plaster is used.

In order to ensure economy, a separate switch has been provided for every individual lamp throughout the rooms and offices.

The generating plant also provides electrical power to the printing office, where the Police reports and notices are now all printed by a machine worked by an electric motor.



Main Distributing Switchboard for putting any Circuit in connection with any Dynamo. Fitted throughout with Drake and Gorham's Patent Ring Contact Switches.

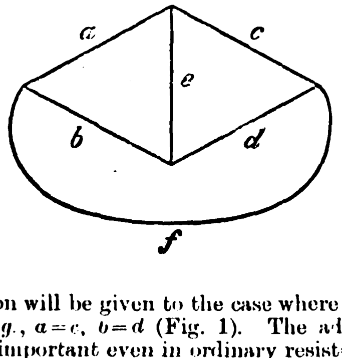
so as to render the conductors accessible without being an eyesore. The branch conductors are carried to small distributing fuse boxes, with glass fronts, placed over the doors in the different offices, from which point special vulcanised twin

New Scotland Yard is, it is believed, the first Government office lighted entirely and exclusively with the electric light. The whole installation is now practically complete, and the new illuminant is giving general satisfaction to the occupants.

## ON THE SENSITIVENESS OF THE BRIDGE METHOD IN ITS APPLICATION TO PERIODIC ELECTRIC CURRENTS.*

BY LORD RAYLEIGH.

The most favourable conditions in the ordinary measurement of resistance have been investigated by Schwendler† and by O. Heaviside.‡ It is here proposed to treat the problem more generally, so as to cover the application to conductors endowed with self-induction, or combined with condensers. The receiving instrument may be supposed to be a telephone, which takes the place of the galvanometer employed in ordinary testing. In the conjugate "battery" branch a periodic electromotive force of given frequency is the origin of the currents.




Special attention will be given to the case where the branches are equal in pairs, *e.g.*, $a=c$, $b=d$ (Fig. 1). The advantages of this arrangement are important even in ordinary resistance testing, and in the generalised application are still more to be insisted upon. By mere interchange of $a$ and $c$ and combination of results, the equality of $b$ and $d$ can be verified independently of the exactitude of the ratio $a : c$.

If any element in the combination, for example $a$, be a mere resistance, the difference of potentials at its terminals (V) is connected with the current, $x$, by the relation

$$V = ax.$$

We have, however, to suppose that $a$ is not merely a resistance or even combination of such. It may include an electro-magnet,* and it may be interrupted by a condenser. So long as the current is strictly harmonic, proportional to $e^{ipt}$, the most general possible relation between V and $x$ is expressed by

$$V = (a_1 + ia_2)\,x,$$

where $a_1$ and $ia_2$ are the real and imaginary parts of a complex coefficient $a$, and are functions of the frequency $p/2\pi$. In the particular case of a simple conductor, endowed with inductance L, $a_1$ represents the resistance, and $a_2$ is equal to $p$ L. In general, $a_1$ is positive; but $a_2$ may be either positive, as in the above example, or negative. The latter case arises when a resistance, R, is interrupted by a condenser of capacity C. Here $a_1 = R$, $a_2 = -1/pC$. If there be also inductance L,

$$a_1 = R, \qquad a_2 = pL - 1/pC.$$

Since the parts of $a^2$ may be either positive or negative, there is nothing to hinder its evanescence by compensation. In the above combination of an electromagnet and condenser compensation occurs, when $p^2LC=1$, that is, when the natural period with terminals connected coincides with the forced period. The combination is then equivalent to a simple resistance†; but a variation of frequency will give rise to a positive or negative $a_2$.

The case of two electro-magnets in parallel is treated in my Paper on "Forced Harmonic Oscillations‡; and other combinations have

* Abstract of Paper read before the Royal Society, January 17, 1891.

† "On the Galvanometric Resistance to be Employed in Testing with Wheatstone's Diagram," *Phil. Mag.*, Vol. 31, p. 364, 1866.

‡ "On the Best Arrangement of Wheatstone's Bridge for Measuring a given Resistance with a given Galvanometer and Battery," *Phil. Mag.*, Vol. 45, p. 114, 1873.

* An electro-magnet here denotes a conductor with sensible inductance. Iron may be present if the range of magnetisation be small.—*Phil. Mag.* March, 1887.

† "Theory of Sound" § 46, Macmillan, 1877.

‡ *Phil. Mag.*, May, 1886

Digitized by Google

been discussed by Mr. Heaviside and myself. But the above examples will suffice to illustrate the principle that the relation of V to $x$ is one of proportionality, and may be expressed by the single complex symbol $a$. We fall back at any time upon the case of mere resistance by supposing $a$ to be real. In like manner $b$, $c$, $d$, $e$, and $f$ are symbols expressing the electrical properties of the remaining branches.

In all electrical problems the generalised quantities $a$, $b$, &c., combine just as they do when they represent simple resistances. Thus, if $a$, $a'$ be two complex quantities representing two conductors in series, the corresponding quantity for the combination is $a+a'$. Again, if $a$, $a'$ represent two conductors in parallel, the reciprocal of the resultant is given by addition of the reciprocals of $a$, $a'$. For, if the currents be $x$ and $x'$, corresponding to a difference of potentials V at the common terminals,

$$V = a\,x = a'\,x',$$

so that

$$x + x' = V\,(1/a + 1/a').$$

If $\psi_1$, $\psi_2$, $\Psi_1$, $\Psi_2$ represent respectively the currents and electromotive forces in the battery and telephone branches of the bridge, it follows that $\psi_1$, $\psi_2$ are linear functions of $\Psi_1$ and $\Psi_2$, and, conversely, $\Psi_1$, $\Psi_2$ may be regarded as linear functions of $\psi_1$ and $\psi_2$. We may therefore set

$$\left.\begin{aligned}\Psi_1 &= A\,\psi_1 + B\,\psi_2\\ \Psi_2 &= B\,\psi_1 + C\,\psi_2\end{aligned}\right\} \quad \ldots\ldots \quad (1),$$

the coefficient of $\psi_2$ in the first equation being identical with that of $\psi_1$ in the second by the reciprocal property. The three constants A, B, C are in general complex quantities, functions of $p$.

If $\Psi_2 = 0$,

$$B\,\psi_1 + C\,\psi_2 = 0,$$

and

$$\psi_2 = \frac{B}{B^2 - A\,C}\,\Psi_1 \quad \ldots\ldots \quad (2).$$

In like manner, if we had supposed $\Psi_1 = 0$, we should have found

$$\psi_1 = \frac{B}{B^2 - A\,C}\,\Psi_2 \quad \ldots\ldots \quad (2);$$

showing that the ratio of the current in one branch to an electromotive force operative in the other is independent of the way in which the parts are assigned to the two branches.

We have now to determine the constants A, B, C in terms of the electrical properties of the system. If $\psi_2$ be maintained zero by a suitable force $\Psi_2$, the relation between $\psi_1$ and $\Psi_1$ is $\Psi_1 = A\psi_1$. In our application, A therefore denotes the (generalised) resistance to an electromotive force in the battery branch, *when the telephone branch is open*. This resistance is made up of $f$, the resistance in the battery branch, and of that of the conductors $a+c$, $b+d$ combined in parallel. Thus,

$$A = f + \frac{(a+c)\,(b+d)}{a+b+c+d} \quad \ldots\ldots \quad (4).$$

In like manner,

$$C = e + \frac{(a+b)\,(c+d)}{a+b+c+d} \quad \ldots\ldots \quad (4').$$

To determine B, let us consider the force $\Psi_2$ which must act in $e$ in order that the current through it ($\psi_2$) may be zero, in spite of the operation of $\Psi_1$. We have $\Psi_2 = B\,\psi_1$. The total current $\psi_1$ flows partly along the branch $a+c$, and partly along $b+d$. The current through $a+c$ is

$$\frac{\dfrac{1}{a+c}}{\dfrac{1}{a+c}+\dfrac{1}{b+d}}\,\psi_1 = \frac{(b+d)\,\psi_1}{a+b+c+d} \quad \ldots \quad (5).$$

and that through $b+d$ is

$$\frac{(a+c)\,\psi_1}{a+b+c+d} \quad \ldots\ldots \quad (6).$$

The difference of potentials at the terminals of $e$, supposed to be interrupted, is thus

$$\frac{c\,(b+d)\,\psi_1 - d\,(a+c)\,\psi_1}{a+b+c+d};$$

or

$$B = \frac{bc - ad}{a+b+c+d} \quad \ldots\ldots \quad (7).$$

By (4), (4′), (7) the relationship of $\Psi_1$, $\Psi_2$ to $\psi_1$, $\psi_2$ is completely determined.

The problem of the bridge requires the determination of the current $\psi_2$, as proportional to $\Psi_1$, when $\Psi_2 = 0$, that is, when no electromotive force acts in the bridge itself, and the solution is given at once by simple introduction into (2) of the values A, C, B from (4), (4′), (7).

If there be an approximate balance, the expression simplifies. For $bc - ad$ is then small, and $B^2$ may be neglected relatively to AC in the denominator of (2). Thus, as a sufficient approximation in this case, we have

$$\psi_2 : \Psi_1 = \frac{\dfrac{ad - cb}{a+b+c+d}}{\left\{e + \dfrac{(a+b)\,(c+d)}{a+b+c+d}\right\}\left\{f + \dfrac{(a+c)\,(b+d)}{a+b+c+d}\right\}} \quad . \quad (8)$$

in agreement with the equation used by Mr. Heaviside for simple resistances.

The form of (8) enables us at once to compare the effects of increments of resistance and inductance in disturbing a balance. For let $a\,d = b\,c$, and then change $d$ to $d + d'$ where $d'_1 + i\,d'_2$. The value of $\psi_2/\Psi_1$ is proportional to $d'$, and the amplitude of the vibratory current in the bridge is proportional to Mod $d'$, that is to $\sqrt{(d'^2_1 + d'^2_2)}$. Thus $d'_1$, $d'_2$ are equally efficacious when numerically equal.

The next application that we shall make of (8) is to the generalised form of Schwendler's problem. When all else is given, how should the telephone, or other receiving instrument, be wound in order to get the greatest effect?

If by separation of real and imaginary parts we set

$$e = e_1 + i\,e_2 \qquad \frac{(a+b)\,(c+d)}{a+b+c+d} = r_1 + i\,r_2 \quad \ldots \quad (9)$$

the factor in the denominator of (6) with which we are concerned becomes

$$e_1 + r_1 + i\,(e_2 + r_2)\,;$$

and the square of the modulus is given by

$$\text{Mod}^2 = (e_1 + r_1)^2 + (e_2 + r_2)^2 \quad \ldots \quad (10).$$

In this equation $e_1$, $r_1$ are essentially positive, while $e_2$, $r_2$ may be either positive or negative. If $e_1$ and $e_2$ are both at disposal, the minimum of (10), corresponding to the maximum current, is found by making

$$e_1 = 0, \qquad e_2 = -r_2 \quad \ldots \quad (11).$$

But this is not the practical question. As in the case of simple resistances, what we have to aim at is not to render the current in the bridge a maximum, but rather the *effect* of the current. Whether the receiving instrument be a galvanometer or a telephone, we cannot in practice reduce its resistance to zero without at the same time nullifying the effect desired. We must rather regard the space available for the windings as given, and merely inquire how it may best be utilised. Now the effect required to be exalted is, *cæteris paribus*, proportional to the number of windings ($m$); and, if the space occupied by insulation be proportional to that occupied by copper, the resistance varies as $m^2$. So also does the inductance; and accordingly, if the instrument be connected to the bridge by leads sensibly devoid of resistance and inductance,

$$e_1 + i\,e_2 = m^2\,(\epsilon_1 + i\,\epsilon_2) \quad \ldots\ldots \quad (12),$$

where $\epsilon_1$, $\epsilon_2$ are independent of $m$. The quantity whose modulus is to be made a minimum by variation of $m$ is thus

$$\frac{e_1 + i\,e_2 + r_1 + i\,r_2}{m} = \frac{r_1 + m^2\epsilon_1 + i\,(r_2 + m^2\,\epsilon_2)}{m}\,;$$

and we have

$$\text{Mod}^2 = \frac{(r_1 + m^2\epsilon_1)^2 + (r_2 + m^2\epsilon_2)^2}{m^2}$$

$$= (r_1^2 + r_2^2)\,m^{-2} + 2\,(r_1\epsilon_1 + r_2\epsilon_2) + (\epsilon_1^2 + \epsilon_2^2))m^2.$$

This is a minimum by variation of $m$ when

$$m^4 = \frac{r_1^2 + r_2^2}{\epsilon_1^2 + \epsilon_2^2},$$

or

$$\text{Mod}\,(r_1 + ir_2) = \text{Mod}\,(e_1 + ie_2) \quad \ldots\ldots \quad (13).$$

We may express this result by saying that to get the best effect the instrument must be so wound that its *impedance* is equal to that of the compound conductor $r_1 + ir_2$. If for any reason the inductances can be omitted from consideration, then the resistance of the instrument is to be made equal to $r_1$, in accordance with Schwendler's rule.

The case of the "battery" branch may often be treated in like manner. As Mr. Heaviside has shown, if a number of cells are available for ordinary resistance testing, they should be combined so that their resistance is equal to that ($s_1$) of the corresponding combination of wires in parallel. Periodic currents may be conceived to arise from the rotation of a coil in a magnetic yield of given strength. If the space occupied by the windings of the coil be supposed to be given, their number $m$ will be determined by the condition of equal impedances. Thus, if

$$\frac{(a+c)\,(b+d)}{a+b+c+d} = s_1 + is_2 \quad \ldots \quad (14),$$

$$\text{Mod}\,(f_1 + if_2) = \text{Mod}\,(s_1 + is_2) \quad \ldots \quad (15).$$

in analogy with (13).

Digitized by Google

The above is the solution of the problem, if the coils of the sending and receiving instruments represent the whole of their respective branches, and are limited to occupy given spaces. The inductances and resistances cannot then be varied independently. But there would often be no difficulty in escaping from this limitation. The inclusion of additional resistance, external to the instrument, can only do harm; but the case is otherwise with inductance, positive or negative. If the inductance of the instrument added to $r_2$, or to $s_2$, be positive, the total inductance may be reduced to zero by the insertion of a suitable condenser, and this without material increase of resistance. If the inductance be already negative, the remedy is not so easily carried out; but, theoretically, it is possible to add the necessary inductance without sensible increase of resistance. The greater the frequency of vibration, the more feasible does this course become. We may, therefore, without much violence, suppose that the inductances of two branches can be reduced to zero without additional resistance. Thus,

$$e_2+r_2=0, \qquad f_2+s_2=0 \quad . \quad . \quad . \quad . \quad (16);$$

and the condition of maximum efficiency of the transmitting and receiving coils is then given by Schwendler's rule,

$$e_1=r_1, \qquad f_1=s_1 \quad . \quad . \quad . \quad . \quad . \quad (17).$$

These suppositions form a reasonable basis for further investigation; but conclusions founded upon them will be subject to re-examination, especially in extreme cases.

We may now introduce a simplification by supposing the branches of the bridge are equal in pairs

$$a=c, \qquad b=d$$

and find the best arrangement of resistances, &c., so as to make a maximum the value of $\psi_2/\Psi_1$, or the ratio of the current produced in the telephone branch to the electromotive force acting in the battery branch.

In the first place, suppose there is no inductance in any arm of the bridge, so that simple resistances alone are dealt with. By substitution in the above equations and applying (13) and (15) we can obtain

$$\psi_2/\Psi_1=\frac{d_1-b_1}{8b_1(a_1+b_1)} \quad . \quad . \quad . \quad . \quad . \quad . \quad (18).$$

Here $a_1$ is still at disposal, and we see that according to (18) it ought to be diminished without limit. This conclusion does not harmonise with one obtained by Mr. Heaviside.* It must be observed, however, that $a_1=0$ is unpractical, involving, as it does, $s_1=0$, $f_1=0$. Even according to (18) there is little to be gained by diminishing $a_1$ below, say, $\frac{1}{2}b_1$. In this case

$$a_1=\tfrac{1}{2}b_1, \qquad e_1=r_1=\tfrac{3}{4}b_1, \qquad f_1=s_1=\tfrac{3}{8}b_1 \quad . \quad . \quad (19).$$

Such an arrangement as (19) may be recommended for practical use.

When $b_1$ is large, there may be advantage in taking $a_1$ relatively smaller than in the above example. In such cases we approach the limiting condition of things, and have approximately

$$e_1=r_1=\tfrac{1}{2}b_1, \qquad f_1=s_1=2a_1 \quad . \quad . \quad . \quad . \quad . \quad (20)$$

$$\psi_2/\Psi_1=\frac{d_1-b_1}{8b_1^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad (21)$$

And the smallness of $f_1$ in comparison with $b$, may sometimes be a convenience.

The next remark that has to be made is that, even when the conductors, $b$ and $d$, to be compared are endowed with sensible inductances (positive or negative), the problem may still, theoretically, be brought under the above head. Suppose, for example, that $b$, $d$ represent nearly equal electro-magnets. Their inductances may be compensated by the introduction (in series) of suitable equal condensers into these branches, so that $b$ and $d$ are reduced to $b_1$ and $d_1$. If then we assume $a$ to be a simple resistance ($a_2=0$), the solution is as before. Two objections may here be raised. First, on the theoretical side it has not been proved to be advantageous to assume $a_2=0$; and, secondly, the introduction of extraneous condensers †, even with interchange, into the branches to be accurately compared may be a complication unfavourable to success.

We will now suppose that

$$e=e_1+ie_2=r_1-ir_2, \qquad f=f_1+if_2=s_1-is_2 \quad . \quad . \quad . \quad (22).$$

It can then be shown that

$$\psi_2/\Psi_1=\frac{d-b}{16}\,\frac{s_1+is_2}{br_1s_1} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (23);$$

and the question before us is how to make the modulus of the second fraction on the right a maximum by variation of $a$.*

Consideration of this expression shows that the sensitiveness may theoretically become infinite by suitable choice of $a_2$, the inductance component of $a$. The investigation is not particularly satisfactory as it leads to conditions of test which it is impossible to realise. It is, however, useful in showing in what direction we must tend in the search for sensitiveness. In practice $a_1$ cannot be reduced indefinitely, and we may inquire the best value of $a_2$ for a given value of $a_1$.

The required relation is denoted by the equation

$$a_1^2+a_2^2=\frac{a_1(b_1^2+b_2^2)}{b_1}$$

under which circumstances it is found that

$$\text{Mod.}\,\psi_2/\Psi_1=\frac{\text{Mod.}\,(d-b)}{16b_1\sqrt{a_1b_1}}$$

independent of $b_2$.

The consideration of a few numerical cases shows that when $a_2=o$ there is little to be gained by further reduction of $a_1$; but when $a_2$ is suitably chosen, the gain may be worth having. The use of $a_2$ may be advantageous, even when the subject of measurement is a mere resistance. The sign of $a_2$ is immaterial.

So far as the general theory is concerned, it is a matter of indifference whether the indicating instrument be in the branch $e$, or in $f$. The latter corresponds to the connections in De Sauty's method of testing condensers by means of the galvanometer. In practice, more space would probably be available for the coils of a transmitting instrument than of the receiving instrument, at least, if the latter be a telephone; and this would tell in favour of choosing that branch for the transmitter which should have the larger time constant (L/R).

To get an idea of the relative capacities, resistances, and inductances involved, we must assume a particular pitch. A frequency suitable for telephonic experiments is 1,000 per second, for which $p=2{,}000\,\pi$. Thus, if the value of $a_2$ for a condenser of capacity C, and for an inductance L, and that of $a_1$ for a resistance R, are all numerically equal,

$$\text{R}=2{,}000\,\pi\,\text{L}=\frac{1}{2{,}000\,\pi\,\text{C}}.$$

If R be 1 ohm, equal to $10^9$ C.G.S., the corresponding capacity is $1{\cdot}6\times10^{-13}$ C.G.S., equal to 160 microfarads, and the corresponding inductance is $1{\cdot}6\times10^5$ C.G.S., equal to ·00016 henry. Again, if C be one microfarad, equal to $10^{-15}$ C.G.S., R is 160 ohms, and L is ·025 henry.

In the preceding calculations $e$ and $f$ are supposed to be adjusted to the values most favourable to the effect in the receiving instrument. A question, which arises quite as often in practice, is how to make the best of given instruments. The full answer is necessarily somewhat complicated; for there could be no objection to the insertion of a condenser, for example, if the sensitiveness could be improved thereby. Suppose, however, the transmitting and receiving branches to be fully given, so that $e$ and $f$ are known complex quantities, the only question to be considered is as to the most suitable value of $a$, assumed to be equal to $c$.

For this purpose it will be found necessary to make the modulus of

$$(a+b+2e)\left(\frac{1}{a}+\frac{1}{b}+\frac{2}{f}\right) \quad . \quad . \quad . \quad . \quad . \quad (24)$$

a maximum by varying $a_1$ and $a_2$.

The required condition is expressed by the equation

$$a^2=\frac{b+2e}{2/f+1/b} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (25).$$

In taking the square root, the ambiguity must be so determined as to make $a_1$ the real part of $a$, positive equation (25), coincide with that obtained by Mr. Heaviside for the case where all the quantities are real.

## NOTES ON THE DESIGN OF MULTIPOLAR DYNAMOS.†

BY W. B. ESSON.

DISCUSSION.—(AUTHORISED ABSTRACT.)

Prof. S. P. THOMPSON said he regretted that Mr. Esson had used the word "volume" for something which was not of the nature of *volume*, and he thought that the meaning assigned to it was not the *ampere-turns* on the armature, but twice that number. The formulæ for the theoretical load limit given seemed incorrect owing to neglect of leakage. Speaking of the comparison of the two and four-pole machines shown in Figs. 3 and 4 (reproduced on next page), he said a better comparison would have been obtained by

* *Loc. cit.*, p. 120, "In conclusion, if, to measure a certain resistance, the best resistances for the galvanometer, battery, and the three sides, $a$, $b$, $c$, were required, then we should have to make $a=b=c=d=e=f$."

† The use of condensers or electro-magnets in the branches $e$ and $f$ stands, of course, upon a different footing.

* These conditions require no attention in galvanometric testing with steady currents, being satisfied by $p=0$, independently of the nature of the instrument.

† Paper read before the Institution of Electrical Engineers, April 9, 1891.

Digitized by Google

considering Fig. 4 to be a two-pole machine with a double magnetic circuit, both the top poles being N (say) and the two bottom ones S. The surface of the two armatures would still be the same, and so far as he could see, their limiting outputs would remain unaltered. It was thus not a question of the number of poles, but of the number of magnetic circuits. Again, on slip 3 relations between the "volume of current" and the diameters of ring and drum armatures were given, but no mention as to whether these were intended to apply to machines with single or double magnetic circuits was made. In his (Prof. Thompson's) opinion it would have been better to

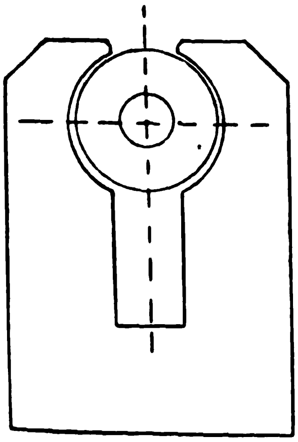


Fig. 3.

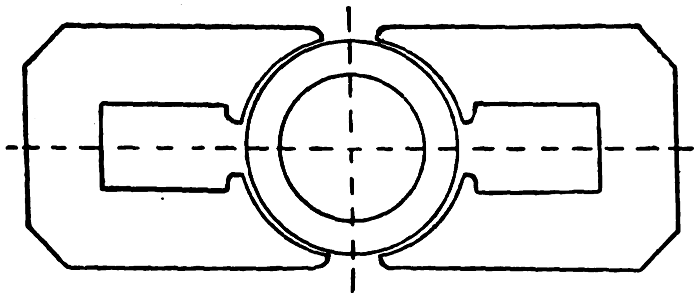


Fig. 4.

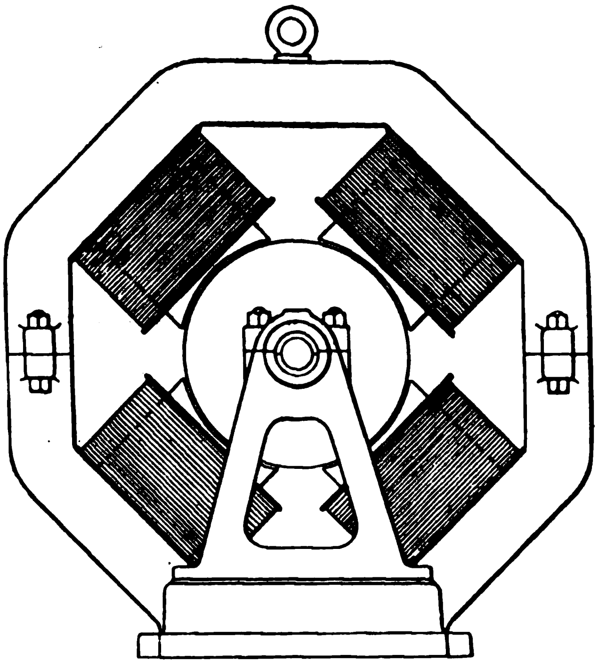


Fig. 6.

distinguish between the two types, for he believed the proportions should be different, and that an armature working in a double circuit field could safely carry a greater current than when in the field of a single magnet. Referring to "cross-induction," he remarked that some years ago he suggested that pole-pieces should be laminated, or have air-spaces parallel to the lines of force, in order to counteract the weakening of the field near the trailing horns. As regards the proportions of iron and copper in the magnets of direct and alternate current multipolar dynamos, he thought a more modern type of alternator should have been chosen, for the amount of copper was prodigious. In c nclusion, he thanked the author for the many good things contained in the Paper, and said the data there given would be very useful in designing machines.

Mr. KAPP, speaking of the laminated pole-pieces mentioned by Dr. Thompson, said Mr. Joel adopted a similar plan in 1885, with the idea of getting more corners on his magnet, and consequently obtaining a greater magnetic pull. He himself had also designed multipolar machines with a deep slot in the middle of each pole-piece, and found that the armature reactions were halved thereby. Referring to magnetic circuits of four-pole machines he did not agree with Mr. Esson that a field of the Elphinstone-Vincent type (Fig. 4) was more efficient than the symmetrical Gramme field shown in Fig. 6 (reproduced below), and thought that the author's conclusions might be due to wrought iron being wholly used in the one, and mostly cast iron in the other. Taking the same material he (Mr. Kapp) found that of the three kinds of four-pole magnets shown in Figs. A, 4, and 6, the first or "Ironclad" form (Fig. A) was the heaviest and required most wire whilst the last (Fig. 6) was lightest and required the least wire. In comparing bi-polar machines with multipolar ones, he pointed out that it was necessary to make the armatures of the latter machines larger in order to obtain sufficient space between adjacent pole-pieces. This, together with the fact that only shallow armature cores are needed, makes the ventilation of multipolar machines very much better than bi-polar ones. This point, he thought, had been overlooked by the author: although Mr. Esson's formulæ for the "volume of current," carried by armatures, agreed fairly well for well-designed machines, it must not, he said, be used indiscrimi-

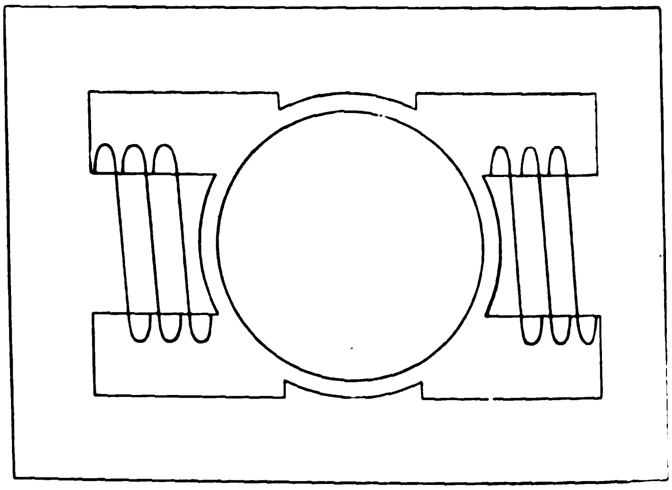


Fig. A.—"Ironclad" Four-Pole Field Magnet.

nately, and if a larger armature be made with a view to increasing the "volume" of current, the field-magnets must also be increased.

Mr. F. V. ANDERSEN remarked that Mr. Esson's formulæ for the load which could be safely carried by armatures without sparking did not include the number of commutator segments. He thought that increasing the number of such segments tended to diminish sparking, and inquired whether sparking could not be prevented by this means.

The further discussion of the Paper was adjourned to the 16th inst.

### Thursday, April 16th.

Mr. F. V. ANDERSEN supplemented his former remarks by saying that in considering the question of sparklessness in dynamos account should be taken of the lead of the brushes, for very large currents could be collected without much sparking if the lead was not limited to a small angle Mr. Esson's formula for the limiting currents was doubtless true if the brushes be at the polar tips; this, however, meant a considerable lead, and a change of, say, 10 per cent. in the load would necessitate the readjustment of the brushes. Now, for central station work, it was desirable that machines should have a very small lead, and this could be obtained by having long powerful fields. Referring to the cost of multipolar machines, he said that their chief characteristics were short fields and shallow armature cores. There was, however, no difficulty in making two-pole machines with short fields provided large lead was permissible or the maximum load decreased as the limbs were shortened. He, therefore, considered that there was no gain in splitting up the constructive material to form multipolar fields.

Mr. HOUSMAN greatly appreciated Mr. Esson's term "volume of current," but thought the fact that it meant twice the ampere turns should have been made more clear. The whole of the author's argument in favour of multipolar machines, he said, depended on the length of the air space necessary to prevent sparking being generally greater than that required for the copper. As regards the relations of "volume of current" and output to the diameter of armature, he thought that for equal rise of temperature the "volume" $v$ was proportional to diameter to the power three-halves, $d^{\frac{3}{2}}$, hence the output for the same circumferential velocity would vary as $d^{\frac{5}{2}}$. Under the same conditions of circumferential speed and induction, the loss by hysteresis varies as $d^2$, and consequently the rise of temperature due to this loss was the same for all sizes of armature. Foucault current losses, however, varied as $d^3$, and in general these were much greater than those due to hysteresis. In practice he had observed that the maximum safe output for a given armature was reached when the sum of the hysteresis and Foucault current losses was about equal to the losses in the conductors. The rapidity with which heating due to Foucault currents increased with the diameter, prevented the output varying in so great a

Digitized by Google

ratio as $d^3$, and as a rule it increased in a ratio somewhere between $d^2$ and $d^3$. Referring to the limiting non-sparking load, he said that Mr. Swinburne's hypothesis (on which the author bases his arguments), which says that the self-induction of an armature coil is small, and therefore only a weak field is required to effect sparkless reversal, was not justified. The coefficient of self-induction of an armature section, as measured by a ballistic galvanometer placed in circuit with a coil wound close to a disconnected section, he found to be very considerable; and, by passing various currents through the latter, the zero variation of the coefficient with armature current had been ascertained. From the coefficients so determined he had calculated the strengths of field necessary to effect reversals, and by measuring the field round the armature had determined the non-sparking lead for various currents. These calculated values agreed fairly closely with those found by actual trial; and in the case of a small air-space dynamo, a field of 3,000 C.G.S. units was necessary to produce sparkless commutation, the maximum field being 7,000. To further investigate how far Mr. Swinburne's hypothesis was correct, he had run a dynamo at half load with different brushes, the first set covering one commutator segment, and the next bearing only half a segment. In the latter case the lead required was much greater than in the former. If the hypothesis was correct, a very small change of lead should double the field; but in practice the additional lead was considerable. The difficulty of variable lead could, as was well known, be got over by using "commutating magnets" or "reversing pole pieces." Those shown in Mr. Swinburne's Paper on "Armature Reactions" were quite inadequate as regards size, for in practice they had to be much more substantial. As a rule, the number of series turns on these "commutating magnets" was about ·75 times the effective armature turns for single-magnet machines, and for double magnet machines 1·25 times the effective turns. On the question of efficiency, he said that multipolar machines could not compete with two-pole ones, for the weight of iron was not diminished in so great a ratio as the increase in number of poles, and hence both the hysteresis and Foucault current losses for a given output were greater in multipolar maches. Neither would the magnets be so light as stated in the Paper, and the economy obtained by having all the winding on one magnetic circuit was all in favour of the two-pole type. A difficulty, however, was met with in large two-pole machines, owing to the energy stored up in a single section of a large machine when a strong current is passing being very great, and this caused considerable trouble, but he thought it might be overcome by subdividing the winding.

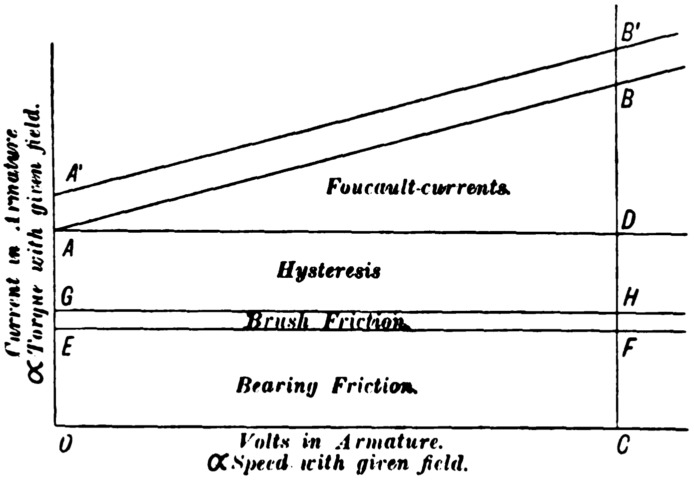



Fig. B.

Mr. SWINBURNE said, Mr. Esson should be congratulated on bringing forward a subject that had never before been systematically discussed. In England, engineers had settled down into making a regular type of two-pole single magnet drum machines; and on the Continent, even small machines were made with a large number of field magnets without any obvious reason. On the subject of prevention of sparking, he said Mr. Esson had hinted that because his (Mr. Swinburne's) formulæ were calculated, they might be inaccurate, and had, therefore, given empirical formulæ for maximum output without sparking, taken from the practice of various makers. These he said, were often misleading, because, perhaps, none of the machines taken were near their sparking point. His own formulæ were founded on experiment and observation, as well as calculation. As far as efficiency was concerned a small number of poles was advisable, but the limiting output for a two-pole drum was about 100 kilowatts, whereas a four-pole drum would give several hundred kilowatts without sparking. Mr. Esson had, he thought, not dwelt sufficiently on two of the chief advantages of having more than two poles. A four-pole drum armature had very simple end-connections, could be perfectly ventilated, and was easily accessible for repair and inspection. The proper ventilation of large machines he considered to be of the first importance. The coupling up of multipolar armatures was, he said, to be condemned most strongly. Considering a large machine with its armature so coupled and supposing the bearings to wear a little, he pointed out that a very small eccentricity would decrease the lower air-gap and increase the upper gap by one per cent.; this means that in an armature having a loss of two per cent., the bottom half would do double work, thus involving great waste of power and heating. This objection, he believed, had not been urged before, but it was very serious in large machines. The armature conductors should therefore be in series or connected partly in series and partly in parallel as suggested by Fritsche.

Mr. HOUSMAN explained his method of analysing Foucault current and hysteresis losses in dynamo armatures by running them as separately-excited motors without load, and observing the volts and amperes required at different speeds. The results when plotted give an inclined straight line A B (Fig. B), from the position of which the Foucault losses may be determined. Friction and hysteresis are not separated in the initial diagram, but the former may be determined by other experiments. The results obtained with various exciting currents show that a certain excitation gives a minimum total loss.

Mr. A. T. SNELL thought the term "volume of current" would be very useful as a name for a quantity often used by designers. His own experience as regards "volume" and diameter agreed with the formulæ given by the author, and the ratio of the constants ·048 and ·072 in formulæ (5) and (6), for the output of cylinder and drum armatures were in the same ratio as the coefficients ·01 and ·015, given by himself about two years ago. He did not agree with the Esson that the output of an armature was independent of the number of poles, for he found that the output could be considerably increased by using four poles instead of two. This he illustrated by the following table, which expresses results obtained from two machines in which the air-gaps, speed, and heating were about the same:—

| Machine. | Diameter of armature. | "Volume of current." | Volts. | Amperes. | Watts. |
|---|---|---|---|---|---|
| Two-pole ... | 60 cms. | 26,600 | 700 | 70 | 50,000 |
| Four-pole ... | 60 „ | 14,700 | 250 | 300 | 75,000 |

The advantages of four-pole machines generally he considered due to the air-gaps, magnets, and cross-magnetising forces being small, whilst the peripheral velocity for a given speed of the shaft could be large. This last was of great importance in direct driven machines. Their disadvantage was that they usually had a large magnetic density in the iron and air-space, but the latter could be obviated by spreading out the polar extremities.

Mr. MILLER remarked that in the case of dynamos for the transmission of power, the design was influenced by the voltage of the machine, for there was a limit to the difference of potential that could safely and conveniently be used between commutator sections of ordinary construction. For example, a machine to give 2,000 amperes and 50 volts could best be made multipolar; but not so one for 2,000 volts and 50 amperes. In the latter case it would not be advisable to concentrate the volts in a fourth or sixth of the circumference. On the question of the utility or otherwise of cross connections in multipolar machines between sections which theoretically should be at the same potential, he said, that in practice the evil consequences of various inequalities were minimised thereby. In his opinion, based on experience, the extra expense of cross connections was well worth incurring, for they produced a distinct diminution in sparking. He also said that Mr. Esson had not even mentioned unipolar machines, presumably because he considered they were worthless. This, he thought, was a mistake. One of the chief faults usually attributed to them, viz., that there was a great fall of volts between no load and full load, did not exist if they were properly designed.

Mr. CROMPTON said the information contained in the Paper would be very useful to engineers. Some speakers had implied that there was no gain in making multipolar machines. This he thought was not correct, for his firm had constructed large four-pole machines quite as efficient as the two-pole type, with an economy of 40 per cent. in material. He then directed attention to the small losses in the armatures of two-pole machines as shown on a diagram illustrating his Paper, read recently before the Institution of Civil Engineers, and he doubted whether the losses in multipolar machines could be got equally small if the armature circuits were connected in parallel instead of in series. Fritsche's windings, as had been pointed out by Mr. Swinburne, could be employed satisfactorily in multipolar armatures. In his opinion no machine lends itself so well to the production of high voltages as the multipolar type.

The discussion was adjourned to the 23rd inst.

THURSDAY, APRIL 23RD.

Mr. MORDEY read a communication from Mr. W. B. Sayers.

Mr. ESSON, he pointed out, had made no mention of slotted armatures in his Paper, although many of the results contained in it could, by suitable modification, be applied to them. A mistake made by nearly all designers in considering this kind of machine was to assume that they required much less magnetising power than ordinary smooth core machines. It was clear, however, that the ratios of the magnetising forces of the back and cross turns respectively on the armature to those on the magnet must have limiting values irrespective of the air-space, which values could not be exceeded without giving rise to great distortion of field and serious sparking. Short air-space machines had the disadvantage of a large induction in the armature at light loads, and the drop of volts with increase of current was serious. To make slotted armature machines satisfactory they should have the same air-space as those with smooth cores, that space being reckoned from the top of the iron projections. A slotted armature had, therefore, to be slightly larger than a smooth-cored one for a given output. The *sine quâ non* of a good slotted armature machine was that the sum of the areas of the teeth under a pole piece was not less than the section of the core. The coils of these machines being nearly surrounded by iron had a greater self-induction, and, therefore, more lead was usually required to prevent sparking. The advantages of such armatures were that they combined positive driving and large clearance with considerable immunity from injury when removed for inspection or repair. To apply Mr. Esson's formulæ for the "volume of current" to slotted armatures

Digitized by Google

the air-space should be reckoned from the tops of the projections. Obviously, the radial depth of the core must be measured from the bottom of the slots. Speaking of Prof. Thompson's remarks on the comparison of Fig 4, considered as a two and a four-pole machine, he said that if correctly reported, he (Prof. Thompson) had apparently overlooked the fact, that for a two-pole machine the radial depth of the armature core would require to be doubled, and if used as shown, the E.M.F. as a two-pole machine would not be much increased, but the external current would be halved.

Mr. ESSON, in his reply to Prof. Thompson's objections to the expression "volume ofurrent," said it was to avoid the confusion which had arisen from using "ampere turns" that he used the word "volume." The ampere turns on any armature were $\frac{w\,C}{p}$, where $w$ was the number of wires counted all round the outside, C the total current, and $p$ the number of poles; and the fraction of this which produced the cross field was $\frac{\phi\, p}{360}$. This gives $\frac{w\,C}{p}\,\frac{\phi}{360}$ as the cross-magnetising ampere turns, and for simplicity he wrote it $\frac{v\,\phi}{360}$, where $v$ represented $\frac{w\,C}{p}$. Respecting the comparisons of a double magnet two-pole machine with a four-pole one, he said that the best comparison all depended on the size of the machine. Even if it were so large that it was desirable to make it of the four-pole type, there was still the alternative that it might be made two-pole, if the double horseshoe were practically split where the like poles abutted together. It would, he said, be a mistake to compare a small two-pole machine with a four-pole one, since a single magnet where it could be used was better; and it was only when the air-gap necessary to prevent sparking was greater than that needed for the copper that a multipolar machine was to be preferred. Speaking of the ratio of copper to iron in the machines shown in Figs. 1 and 2, he pointed out that this ratio might be anything, depending on the efficiency of the machines. Mr. Kapp had contended that the four-pole Gramme field was lighter than the double horseshoe shown in Fig. 4, when the same materials were used; this he thought was a mistake, for owing to the greater length of yoke in the former, the weights were as 4 to 3. With reference to the relation between the temperature and peripheral velocity of armatures, he had no very precise data, but from some preliminary experiments he believed that connection was approximately represented by $C^0 = \frac{W\;330}{\cdot 0005\;V\,S}$ where $C^0$ was the rise in degrees centigrade, W the watts expended, V the velocity in feet per minute, and S the surface in square centimetres. He agreed with Mr. Andersen that increasing the number of sections diminished sparking, but he had wished to emphasise the fact that if the load exceeded a given value no non-sparking position could be found for the brushes: this was true whatever the number of sections. He had then pointed out that in no actual machine did the load exceed half the limiting value. As regards Mr. Swinburne's remarks, he said he had no desire to hint that because the formulæ were calculated they were wrong. On the contrary, the calculations were most valuable, but the equations could only indicate relations and not absolute values, and one had to go to practice to obtain data. He entirely agreed with Mr. Crompton about the economy of material effected by making multipolar machines, for his own experience showed the saving to approach very closely the 40 per cent. mentioned by Mr. Crompton.

## PRESENTATION TO SIR WILLIAM THOMSON.

On "graduation day" at Glasgow University last week, the following address was presented to Sir William Thomson by the students of the University:—

To Sir William Thomson, Knight, LL.D., D.C.L., M.D., President Royal Society, Past President Royal Society of Edinburgh, Past President British Association, Past President Institute of Electrical Engineers, Grand Officer of the Legion of Honour, France; Knight of the *Ordre Pour le Merite* of Germany, Commander of the Order of Leopold of Belgium, Foreign Associate of the French Academy.

From the Students of Glasgow University.

DEAR SIR: In name and in behalf of the students of Glasgow University we beg to tender you our most sincere and cordial congratulations on the occasion of your election to the most honourable position which the sphere of British science affords—the presidency of the Royal Society—now for the first time held by a Scotch Professor. We recognise with feelings of pleasure and pride your unexcelled qualifications to fill this distinguished office, and to uphold its noblest traditions. We are satisfied that of all the brilliant names upon the presidential roll from the foundation of the society none will be held in brighter or more enduring remembrance than your own.

We would avail ourselves of this opportunity to give expression to our warm esteem and unaffected admiration for you in your more immediate relation to us. During your long tenure of the Chair of Natural Philosophy in the University you have won the affection of your students by your uniform courtesy and kindness, as you have gained their respect by your rare gifts as a scientist and a scholar. Your fame has attracted students from all parts of the world to your class-room and laboratory. You have in no small degree assisted the prosperous development of our ancient university, and added lustre to its name.

We would also recall your services to the cause of university reform, your work upon the University Commissions of recent years; and we would gratefully remember your exertions to bring about the present disposition of the surplus funds of the Exhibition of 1851, in the benefits of which our own university will share.

In regard to the wider aspects of your scientific work, we could not presume to refer in detail to the world-famous inventions, discoveries, and speculations which have placed you in the foremost position among living men of science. These achievements, splendid in themselves, and of inestimable practical importance, have met with well-merited recognition from our Queen and Government, as not only of national but of universal interest and value.

We would, in conclusion, express the heartfelt hope that you may long enjoy health and vigour to continue your labours for the advancement of science and the good of humanity.

University of Glasgow, April 24, 1891.

Sir William Thomson, who was received with cheers, in acknowledging the address, said,—Gentlemen of the Students' Representative Council and students whom you represent, I thank you all most warmly, most cordially, for your great kindness in presenting me with this address. It is, indeed, as you have said, an honour to have been elected to the presidency of the Royal Society. It is an honour which I feel deeply, an honour which entails very serious responsibilities and duties. The pleasure of receiving it is enhanced in no small degree, I can assure you, by what you have done for me this day. The sense of the weight of duty entailed by such a position is greatly lightened, indeed, by the feeling that you sympathise with me in it, by feeling that you have looked upon this position in which I have been placed as being interesting to yourselves. And I must lastly say this—if you will allow me to thank you as one of yourselves for it—that while you have shown sympathy with me I wish to express my sympathy with you. I have been a student of the University of Glasgow for 55 years to-day, and I hope to continue a student of the University as long as I live.

## ON IMPARTING ELECTRIC CHARGES BY FRICTION.*

BY ED. RIECKE.

Some experiments on the electrification imparted by rubbing were published by Riess in the year 1876. The author has attempted to extend the results then obtained.

The rubbing bodies were generally rectangular or square plates, provided in the middle with vulcanite handles. The substances rubbed were principally flannel and silk, in the form of strips 83 cm. long and 11 c.m. (33½in. × 4½in.) wide, stretched in several layers on glass plates. The electroscope was a simple gold leaf electroscope placed in a metal box provided with two openings through which a lamp and lens served to project an image of the gold leaves in order to determine their divergence. This was then reduced to absolute electrostatic units.

Experiments with vulcanite plates and flannel showed that with strokes repeated in exactly the same way a weak charge at first appeared, which soon increased and finally reached a constant value. With regard to the dimensions of the rubber, it appears that the maximum density of electrification produced by rubbing is smaller the larger is the surface of the rubbing body. Whether the rubbing is done longitudinally or laterally is of little importance.

The maximum electric density $\epsilon$ for a surface of five square centimetres is given in the following table:—

| Plates. | Rubbed on Wool. | Rubbed on Silk. |
|---|---|---|
| Sealing wax | $\epsilon = 5{\cdot}70$ | $\epsilon = 5{\cdot}40$ |
| Shellac | 5·57 | 5·12 |
| Sulphur | 5·48 | 5·39 |
| Vulcanite I. to III. | 4·82 | 4·43 |
| Amber I. and II. | 4·60 | 4·40 |
| „ III. and IV. | 4·18 | 4·11 |
| Vulcanite IV. to VI. | 3·90 | 3·80 |
| Glass I. and II. | ... | 3·18 |
| „ III. and IV. | 2·65 | 2·90 |

From this we see that all bodies which, when rubbed on wool and silk, become negatively electrified, give with wool a greater electric density than with silk. Glass, which under the same conditions becomes positively electrified, gives with silk a greater density. If the rubbing bodies are arranged in order of the densities excited, the order is the same both for wool and silk (shellac and sulphur only changing places). The maximum density for most of the bodies was obtained by rubbing nearly the same length, but in the case of glass a length four times as great was required, and a 2·5 per cent. gradient has been mounted without difficulty.

* *Wied. Ann.*, Vol. XLII.

Digitized by Google

# LEGAL INTELLIGENCE.

## The Kensington and Knightsbridge Electric Lighting Company (Limited) v. The Lane Fox Electrical Company (Limited).

This was a motion before Mr. Justice Sterling on Friday last, by the plaintiff Company asking for an injunction to restrain the defendant Company from threatening the plaintiffs, their customers, or any other person or persons with legal proceedings, or liability in respect of any alleged infringement of certain letters patent claimed by the defendants to have been assigned to them. The letters patent related to an invention of which Mr. St. George Lane Fox, an electrical engineer, was the author. He was the registered owner of the patent, but he had by an agreement, dated July 31, 1890, agreed to assign it to the defendant Company, of which he was the Managing Director and a large shareholder. On November 15, 1890, he had commenced an action against the plaintiff Company to restain them from infringing his patent, but the plaintiff Company had not yet put in their defence. On February 21, 1891, the defendant Company sent the following letter to Messrs. John Barker and Co., of Kensington :—

"We understand that your house is being supplied with electric light by the Kensington and Knightsbridge Electric Supply Company, which Company, as you are doubtless aware, is now being sued for damages for infringement of our patented system of electric distribution. We have been advised that you, as one of the users of the said system, are liable for the infringement. We beg, therefore, to caution you of the fact, and to offer you an indemnity upon the terms contained in the enclosed circular. These terms, however, are to be considered as withdrawn if not accepted by the 28th inst."

The circular referred to in this letter was to the effect that the Lane Fox Electrical Company (Limited), by whom all Mr. Lane Fox's patents for this system of electric light distribution were stated to be held, were prepared to grant licences for the use of the system on certain terms therein set out. A similar communication had been sent by the defendant Company to numerous other customers of the plaintiff Company, and it was against this course of action that the present motion was directed. It was said, on behalf of the defendant Company, that it had been decided that where an action had been commenced before the threats were made, an injunction to restrain the threats would not be granted ; and here such an action had been brought. It was necessary to bring the action in Mr. Lane Fox's name, the patent being vested in him, but the defendants were the real owners in equity. The question turned upon the construction of section 32 of the Patents, &c., Act, 1888, which provides that :—

"Where any person, claiming to be the patentee of an invention, by circulars, advertisement, or otherwise, threatens any other person with any legal proceedings or liability in respect of any alleged manufacture, use, sale, or purchase of the invention, any person or persons aggrieved thereby may bring an action against him, and may obtain an injunction against the continuance of such threats, and may recover such damage (if any) as may have been sustained thereby, if the alleged manufacture, use, sale, or purchase to which the threats related was not in fact an infringement of any legal rights of the person making such threats. Provided that this section shall not apply if the person making such threats with due diligence commences and prosecutes an action for infringement of his patent."

Mr. Graham Hastings, Q.C., and Mr. Wallace were for the plaintiff Company ; and Mr. J. C. Graham for the defendants.

Mr. JUSTICE STIRLING said, that no doubt the letter complained of contained a threat. The defendant Company claimed by the circular to have acquired the rights of the patentee of the invention, and were therefore within the definition of the Act. By the Act any person aggrieved might bring an action against any one uttering threats. The plaintiff Company were undoubtedly persons aggrieved, and might bring an action against any person whose "legal rights" were alleged to be infringed. But here the defendant Company had no legal rights, for Mr. Lane Fox had only agreed to assign his rights to them. Therefore the defendant Company, the persons making the threats, were simply entitled in equity to an assignment of the patent upon certain terms not disclosed. That the defendant Company were not entitled to sue was clearly shown by the fact that Mr. Lane Fox had brought an action in his own name. The constitution of the Company was somewhat remarkable. The capital consisted of 100 £1 shares, which were deemed to have been fully paid up, and Mr. Lane Fox might have good reason for not wishing to clothe them with the legal title so as to enable them to sue in respect of an infringement. There was only an equity here, to enforce which the Company would have to bring an action against Mr. Lane Fox. Then did the proviso apply ? The action was not brought by the persons making the threats, but by the legal owner of the patent, Mr. Lane Fox, and damages for the threats could only be recovered from this Company with a nominal capital of £100. Consequently an order must be made for an injunction to restrain the continuance of such threats.

## Latimer Clark, Muirhead, and Co. v. Westminster Electric Supply Corporation.

In the Queen's Bench Division, on Monday, the case of Latimer Clark, Muirhead, and Co. (Limited) *v.* Westminster Electric Supply Corporation (Limited) came before Mr. Justice Hawkins and a special jury. This was an action brought by the plaintiff Company against the defendant Company to obtain specific performance of a contract and damages for an alleged breach, and an injunction restraining the defendant Company from having the work performed by other contractors. The defendant Company denied that they made the contract. They further said that the alleged agreement was delivered by them to their solicitors as an escrow only upon the terms that it should not take effect or be operative or enforceable until the fulfilment of the following condition—namely, that the plaintiff Company, or one or more of the Directors thereof, forthwith subscribed for 3,333 shares of £5 each in the defendant Company, and that neither the plaintiff Company nor any Directors thereof had ever subscribed for the shares.

Sir C. Russell, Q.C., and Mr. Pollard appeared for the plaintiff Company, while the Attorney-General, Mr. Moulton, Q.C., and Mr. Shaw represented the defendant Company.

Sir C. RUSSELL, in opening the case for the plaintiff Company, said his clients were a limited company, carrying on the business of electrical engineers, and that the principal shareholders in the Company had previously carried on a similar business as a private partnership for a considerable number of years. The defendant Company was originally a small concern with a small capital, and in 1889 they were ambitious enough to desire to apply to Parliament for power to supply with electricity important districts in the city of Westminster, including Mayfair, Belgravia, and Pimlico. Being a small company it was necessary that they should go before the authorities in a position to effectively carry out the powers they were seeking, and, accordingly, two gentlemen—Mr. Brown Martin and Mr. Wallace—applied to the Directors of the plaintiff Company for their assistance in two directions. In the first place, they asked that the plaintiff Company should place at their disposal such technical assistance as might be required for the preliminary inquiry which took place before a Provisional Order was granted ; and secondly, they inquired whether the plaintiff Company would construct the necessary works in the event of their obtaining the Provisional Order. The plaintiff Company agreed to give the defendant Company the necessary assistance, and the defendant Company entered into a contract to give the plaintiff Company work to the extent of £100,000. That contract was deposited with the defendant Company's solicitors, Messrs. Fowler, upon the one condition that the Directors of the defendant Company went to allotment in reference to the new capital they were seeking to raise for the purpose of carrying out the works. The plaintiff Company rendered all the necessary assistance, and the defendant Company went to allotment. Now the defendant Company were seeking to import a new condition into the contract with the view of shuffling out of the bargain. Under the contract the plaintiff Company were to supply all the necessary machinery for the proposed central station at Westminster, to design and arrange the details of a complete system of distribution to suit the requirements of the district, to execute all the engineering works of the Company until the installation was at work, to prepare a preliminary estimate of the whole cost of the work, and to supply and work all the engines, machinery, mains, and appliances at a fair market value. The defendant Company now desired to say that the contract was conditional on the plaintiff Company subscribing for 3,333 £5 shares, and that, as they did not do so, they (the defendant Company) were entitled to cancel the contract. He (the learned counsel) submitted that if any of the Directors of the plaintiff Company agreed to subscribe capital in a certain event it was a separate and independent agreement, and had nothing whatever to do with the contract now sued upon, and that this was practically an undefended action.

Mr. WM. MURDOCK, secretary of the plaintiff Company, then gave evidence.

Mr. JOHN MUIRHEAD, a Director of the plaintiff Company, stated that his Company agreed to assist the defendant Company, and did so. The contract was entered into and sealed on December 5, 1889. When the contract was handed to Messrs. Fowler there was no such condition as that alleged by the defendant Company, namely, that the plaintiff Company or that individual Directors were to subscribe for 3,333 shares of £5 each in the defendant Company. In cross examination, witness said he accompanied Mr. Latimer Clark to the offices of the defendant Company on December 2, 1889. He never heard of any proposal that the plaintiff Company should subscribe. On December 2nd Mr Stratton asked Mr. Latimer Clark if he were ready with a subscription of £16,000, and Mr. Latimer Clark replied in the affirmative. Mr. Stratton then said, "Very well ; I will put you down for £16,000 in case of need." He was not told as early as November, 1889, that if a contract was given to the plaintiff Company they would have to subscribe £25,000. He could not remember having heard anything said about the plaintiff Company subscribing for shares in the defendant Company until December 2nd. It was arranged that £20,000 should be paid to him out of the first moneys coming from the contract, in order that he might meet any claims in connection with the subscription to the defendant Company. That £20,000 was for the purpose of bringing out the Company in a perfectly different way.

Mr. LATIMER CLARK gave corroborative evidence. In cross-examination, witness said he believed the defendant Company were attempting to get out of the bargain. On December 2, 1889, he was informed that the defendant Company had arranged with Messrs. Crompton to take shares to the extent of about £8,000. He was not present at the offices of the defendant Company on December 5th. He had no recollection of Mr. Wallace informing him on that date that the plaintiff Company would have to subscribe £16,000. He did not remember Mr. Wallace saying that the Directors of the defendant Company would seal the contract subject to the subscription for the shares, or that the contract would be left with Mr. Fowler until the plaintiff Company had subscribed £16,000.

Mr. F. MUIRHEAD having also given corroborative evidence,

The further hearing of the case was adjourned till Tuesday.

TUESDAY, APRIL 28TH.

On the hearing of the case being resumed on Tuesday morning,

The ATTORNEY-GENERAL said he should have to submit at the end of the case that his lordship was bound to direct judgment for the defendants. In all probability his lordship would think it more convenient that the whole of the evidence should be taken before he dealt with the point of law.

Digitized by Google

On the suggestion of Mr. Justice Hawkins, the parties and their respective counsel had a conversation, and in the result

The ATTORNEY-GENERAL said he was glad to be able to inform his lordship that an amicable settlement had been arrived at. It had been arranged that the defendant Company should pay to the plaintiff Company the sum of £4,000, to include everything.

Judgment for the plaintiff Company for £4,000 was entered accordingly.

## AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *April* 20, 1891.

**The Telephone in Mexico.**—At the annual meeting of the Mexican Telephone Company, held this week, it was reported that there are at the present time in the City of Mexico 759 subscribers that use this Company's system, and elsewhere, in its territory 364 subscribers, making in all 1,123. The monthly rental is from $5.00 to $6.00. The gross receipts for the past year were $76,000; the net receipts being over $26,000. This Company has applied for a renewal of its charter, and promises, should this be granted, to substitute iron poles and 1½in. cables in the streets in place of the present wires and wooden poles; and, also, to pay 50 cents per month per pole, and to give the municipality free fire-alarm wires on the same poles. In four years there has been an increase of 214 subscribers.

**Municipal Lighting in Massachusetts.**—The committee on manufactures of the Massachusetts Legislature, this week reported five Bills giving the right to five separate cities in that Commonwealth to establish and maintain electric light plants to do city lighting. A petition of the Mayor and Common Council of Boston for the same privilege was reported upon adversely by the committee.

**A Dynamo Telegraph Plant.**—At the new quarters of the Western Union Telegraph Company, in St. Louis, Mo., an extensive plant of small dynamos for furnishing current for electric circuits is now being installed. Three Rice automatic engines of 15 H.P. each are used for driving the generators, of which there are 15. Each engine drives a line shaft to which five dynamos are connected. Eleven of the generators are wound for 70 volts pressure at a speed of 1,250 revolutions. Two are wound for 30 volts, and two for five volts each. The generators, which are built by the "C. and C." Motor Company, are to be run in series of five each, two series to be run at a time, and three to be held in reserve. The field magnets of each series are energised by a shunt from the brushes of the last machine in the series. By tapping each series at points between the machines five different potentials varying from 70 to 350 volts can be supplied. The 30-volt and 5-volt machines supply the local currents. The exact potential required for any line is obtained by inserting in the circuit the necessary resistances, which consist of incandescent lamps placed in series.

**Thomson-Houston Annual Report.**—The annual meeting of the stockholders of the Thomson-Houston Electric Company was held in Middleton, Conn., on Monday of this week. The report made to the stockholders shows that the growth in the company's business, from the time of its organisation in 1883, has been as follows:—

| | | | |
|---|---|---|---|
| 1883 | $426,987.97 | 1887 | $2,335,594.80 |
| 1884 | 700,470.46 | 1888 | 4,435,902.23 |
| 1885 | 983,996.05 | 1889 | 8,222,789.12 |
| 1886 | 1,405,041.74 | 1890 | 10,617,661.67 |

On January 1, 1891, there were in the United States alone nearly 1,000 substantial companies using the system of the Thomson-Houston Electric Company. According to carefully prepared tables, this is about three times the number of local companies using the system of the next largest company engaged in the manufacture of electrical apparatus. If to the above are added the lighting and power stations of the companies working in alliance with the Thomson-Houston Electric Company, the number reaches 1,500, or more than double the aggregate of those using the apparatus of all other systems in the country. The total common stock of the Company already authorised and issued is $6,000,000, and of Preferred stock $4,000,000. The Company has branch offices in eleven different cities in the United States, through which the business of the different sections of the country is transacted. There is at present no section of the country that is not under the immediate and careful supervision of some one of these offices. The balance-sheet shows that the profits for the year have been upwards of $3,000,000. A statement is given showing the number and capacity of the local companies using the Thomson-Houston electric lighting system in the United States, which is as follows:—

| | No. of Companies. | No. of Arc Lamps. |
|---|---|---|
| January 1, 1883 | 5 | 365 |
| ,, 1884 | 31 | 2,478 |
| ,, 1885 | 59 | 5,867 |
| ,, 1886 | 100 | 13,227 |
| ,, 1887 | 171 | 21,840 |
| ,, 1888 | 303 | 36,936 |
| ,, 1889 | 419 | 51,621 |
| ,, 1890 | 587 | 68,203 |
| ,, 1891 | 755 | 87,131 |

Of these about 500 companies are operating both arc and incandescent plants, and employ between 600,000 and 700,000 incandescent lights of the Thomson-Houston manufacture. More than 150 lines of electric railways are in operation or under contract, aggregating over 2,000 cars, as a result of less than three years' operation of this department. The following named gentlemen were elected Directors of the Company for the ensuing year:—Henry A. Pevear, Chas. A. Coffin, Jos. N. Smith, Benj. F. Spinney, Chas. B. Newhall, Jefferson Coolige, S. Endicott Peabody, Elihu Thomson, and Fred. P. Fish.

## CORRESPONDENCE.

### TWISTED TELEPHONE LINES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: From some of the conclusions of your article of April 17th on this subject I must strongly dissent.

The author, founding, apparently, on some Midland Railway experiments, pronounces against the efficiency of the "cross" as compared with the "twist." He also states that the French section of the London-Paris telephone line, although not silent, is far superior to the majority, indeed, to almost all of the telephone lines in this country, other than those erected by the Post Office.

These statements show that the author, whoever he may be, is by no means conversant with what has been done in Great Britain—I won't say England—in the matter of telephone trunk lines. The first assertion may form a subject for controversy; the second is simply untrue.

In December, 1887, I contributed to one of your contemporaries* an article which dealt somewhat exhaustively with the merits of the "cross" versus the "twist," the data being furnished by an experience then about three years old. The lapse of nearly four more years enables me to emphatically confirm the conclusions then arrived at. In one particular only has it been found desirable to modify the plan then illustrated and recommended. In lieu of the crossings being gutta-percha covered wires, arranged so as not to touch the poles or arms, these have for some years been bridges made up of several strands of uncovered hard copper wire, one bridge straight, the other arched either under or over the straight one, both being too stiff to admit of accidental disarrangement. As stated in the article, silence with loops crossed as recommended, is perfect, however great the disturbance. The 19-mile loop, with crossings every 12 spans, referred to as having been erected in 1884, and which was the first copper trunk line erected by a telephone company, still continues to work well. It runs from Dundee to Arbroath, parallel with, and in some cases almost touching, the poles of the Dundee-Arbroath Joint Railway, which carry the London-Aberdeen Wheatstone Automatic and other heavy circuits, the induction from which is so heavy that conversation

* Metallic Circuits for Telephone Lines. *Electrical Review*, December 2, 1887.

Digitized by Google

between Dundee and Arbroath on a single wire can only be carried on during lulls in the telegraphing. Since 1887 many much longer and perfectly silent crossed lines have been erected. In fact, I, who can claim to have had at least, as much experience with telephone trunk lines as any other engineer, have never put up a twisted line, nor can I conceive under what circumstances it would be necessary or desirable to do so. The constant twist, like the crossing at every pole mentioned as having been carried out on the Midland Railway, is a superfluity—an excess of precaution only comparable to the perpetual carrying of an open umbrella to guard against an occasional shower of rain. Everybody knows that two or more single wires may be run side by side on the same arm for about a mile without overhearing becoming perceptible. An uncrossed loop can be run for a much greater distance than this, probably ten or twelve miles, alongside a single wire, because overhearing in the loop results from the differential action of the single on the two wires of the loop, and it takes a long run to raise this difference to an equality with the direct action between two adjacent singles a mile long. Crossings every ten miles will kill all overhearing, and will generally be sufficient to neutralise telegraphic induction also. But the crossing must be properly done. I am aware that the Northern District Telephone Company in Northumberland, and the National Telephone Company in Lancashire, tried crossing with unsatisfactory results, but it was because the conditions necessary to observe were either not understood or were disregarded. Similarly, twisted loops that are not silent in respect to each other, and on which telegraphic induction is always present, have been erected in different parts of the country. But this is not the fault of the "twist" any more than the other was the fault of the "cross." Both are thoroughly efficient when properly done.

The drawbacks of the "twist" are chiefly (1) greater first cost; (2) unsightliness; (3) greater liability to faults; (4) greater difficulty in finding faults; (5) the re-arrangement of routes of twisted loops is a complicated operation which cannot economically be carried out without interrupting communication. These objections have been amply confirmed by observations extending over a series of years; especially have the greater liability to faults—about 6 to 1—and the difficulty of finding and removing them been demonstrated.—Yours, &c.,

A. R. BENNETT.

[We have invited Mr. Bennett to support the assertions made in his letter by some description of the faults to which he alludes, but he only informs us that contacts, according to his experience, are the great bugbears of the twist system.—ED. *E.*]

## THE LANE-FOX PATENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I shall be much obliged if you will allow me, through your columns, to offer a few observations for the purpose of explaining the report of the action of the Kensington and Knightsbridge Electric Light Company *v.* the Lane-Fox Electrical Company, which appeared in *The Times* of last Saturday. This report, although accurate as far as it goes, is calculated to convey, to anyone unacquainted with the history of the matter, a very misleading conception of the actual state of the case.

Briefly stated, the facts are as follows:—The patent in dispute covers the method of electric light distribution now very generally in use, and which is known as the "direct supply system." This patent was, until quite recently, held by the Brush Electric Light Company, and was the subject of litigation between that Company and the Edison-Swan Electric Light Company. Before, however, the case came into court a settlement was arrived at between the two Companies, whereby the Edison-Swan Company acknowledged the validity of the patent, and accepted a licence from the Brush Company. What the precise terms of this licence may be I have not been able to ascertain.

Suffice it to say, that inasmuch as it raised questions between the Brush Company and myself, a new agreement was entered into between us, by which the patent was made over to me subject to this Edison-Swan licence (the benefit of which was retained by the Brush Company), and also to a licence to the Brush Company itself. In this way I became entitled to royalties accruing from the use of the patent by the trade generally, with the above exceptions. I not unnaturally concluded that the patent, having been acknowledged by two such important firms as the Edison-Swan Company and the Brush Company, and that having the strong support of by far the most eminent scientific and legal authorities of the day (including Sir William Thomson, President of the Royal Society, Dr. Silvanus Thompson, Prof. Perry, Mr. W. H. Preece, Mr. Latimer Clark, Sir Richard Webster, Mr. Fletcher Moulton, and many others), it would be generally acknowledged by the various infringers, without any further dispute. Accordingly a limited company was formed, with the nominal capital of £100, for the purpose of holding the patent, and of apportioning certain interests therein. Instead, however, of honourably accepting the position, a movement was started in the trade, at the instigation of the Kensington and Knightsbridge Company, for organising an opposition to the patent. After all our conciliatory overtures with this trade combination had failed, an action was started against the Kensington and Knightsbridge Company, in the joint names of myself and my Company, and for this action we retained the services of the Attorney-General and Mr. Moulton, Q.C., from both of whom I had a general retainer of long standing. Now the Kensington and Knightsbridge Company holding also a general retainer (though of long subsequent date to my own) for these same counsel, claimed their services against us, because, according to the rules which govern these matters, my prior retainer was invalidated by the fact of my Company being made party to the suit. The consequence was that, in order that we might continue to have the services of these counsel, the original action had to be withdrawn, and a new one instituted in my own name alone. These facts will explain how it came about that we were placed in the rather curious position indicated in the report of the proceedings before Mr. Justice Sterling.—Yours, &c.,

ST. G. LANE-FOX.

66, Victoria-street, S.W., April 28, 1891.

## TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

"THE ELECTRICIAN"

**ELECTRICAL TRADES' DIRECTORY & HANDBOOK for 1891.**

The 1891 edition of our well-known Directory and Handbook is ready, price 5s., postage extra. The book consists of over 900 pages, and has entailed this year a heavy amount of work. The HANDBOOK DIVISION contains a mass of most useful information. The DIRECTORY DIVISION consists of 430 pages, and contains a very carefully compiled Alphabetical and Classified List of Firms and Persons engaged in the Electrical and Allied Trades in all parts of the world. This Division has been corrected up to date, and the book is thoroughly reliable, the very numerous changes which take place at the beginning of the year being incorporated. By the aid of this Directory, makers of Electrical Machinery, Apparatus, Instruments, Fittings, Sundries, Novelties, and other goods, may safely communicate direct with probable customers without the annoyance and great expense consequent upon using books which are mere lists of Members of Scientific Societies repeated again and again. The Colonial and Foreign Division of this Directory will be found extensive and reliable. *Orders should be forwarded at once.*

In the course of a few weeks "The Electrician" Company will publish "THE ELECTRICIAN" PRIMERS in two volumes, price per volume 2s. paper covers, 2s. 6d. cloth.

CUTTRISS, WALLIS, AND CO. (LIMITED).—As we notified in our last issue, the business of Messrs. Cuttriss and Co., Elmwood Electrical Works, Leeds, has, in conjunction with that of Mr. E. C. Wallis, of Bond-place, Leeds, been transferred to a limited liability company, under the above title, and in a circular issued by the new Company it is notified that the amalgamation is in consequence of a large increase of business in both firms. The circular adds that the new Company will largely increase their manufactures, and that they are in a position to undertake all classes of installation work, &c.

Digitized by Google

LYON'S LIQUID RESISTANCE.—The General Electric Co. inform us that they have been appointed sole licensees and manufacturers of the liquid resistance described in our last issue.

ANOTHER EXHIBITION.—Yet another exhibition purporting to represent the electrical, engineering, ironmongery, and other trades, is being held at the Agricultural Hall this week.

SCIENTIFIC APPLIANCE MANUFACTURING COMPANY (LIMITED), (IN LIQUIDATION).—A meeting is to be held at 26, Ludgate-hill, London, E.C., on May 25th, at six p.m., for an account of the winding up.

FIRE AT MESSRS. FOWLER, LANCASTER AND CO.'S.— A fire occurred on Wednesday at this Company's show rooms, which resulted in considerable damage to a number of electroliers and brackets, and a large stock of switches, &c., were destroyed. We regret to learn that only part of the damage is covered by insurance. We are pleased, however, to find that this will not in any way interfere with Messrs. Fowler, Lancaster and Co.'s business, and that they are in a position to execute orders with their usual promptitude.

ELECTRICAL ENGINEERING CORPORATION (LIMITED).—At a meeting held on the 23rd ult. resolutions were passed winding up this Company voluntarily, and appointing Mr. F. W. Pixley, 24, Moorgate-street, London, E.C., the liquidator.

CROSSLEY'S "OTTO" GAS ENGINES.—We have received from Messrs. Crossley Bros. some printed particulars of the latest type of their well-known gas engines, from which we learn that 15,000 of these engines are in use in Great Britain and Ireland for driving all kinds of machinery, &c. The machinery at Messrs. Crossley's large works, at Openshaw, is driven by their gas engines, indicating about 300 H.P.

ELECTRO-METALLURGICAL COMPANY (LIMITED). — Resolutions have been passed that this Company be voluntarily wound up, and that Mr. J. J. B. Arter, 26, Waterloo-street, Birmingham, C.A., be the liquidator.

# PATENT RECORD.

## APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

April 13, 1891.

6,276. G. W. BLANCHARD. London. Electric locking devices for the gear wheels of motors of electric cars (or carriages).

6,292. H. W. MILLER. London. An improved form of insulator for use with electrical current.

6,298. J. WODICKA. Crouch Hill. Improvements of armatures of dynamo-electric machines and motors.

6,318. N. MITCHELL. London. An improvement relating to medico-electric batteries.

April 14, 1891.

6,347. G. T. TUGWELL and E. A. MITCHELL. Brighton. Improvements in alternating current transformers.

6,372. R. VARLEY, jun. London. Improvements in electric time calls.

6,378. C. J. VAN DEPOELE. London. Improvements in and relating to electric motors.

6,397. C. LANGDON-DAVIES. London. Improvements in phonophoric telegraphy.

6,402. A. T. COLLIER. London. Improvements in microphonic or telephonic transmitters.

April 15, 1891.

6,474. W. GRITTEN and J. LANG. London. Improvements in materials or compounds to be used as substitutes for wood, vulcanite, ebonite, and the like, in the manufacture of articles such as electrical insulators, cells for electrical accumulators, boxes, door handles, toys, and other articles of the like kind.

6,485. A. T. GRAVIER. London. Improvements in dynamo-electric and electro-dynamic machines.

6,489. W. R. PRYKE. London. A combined ceiling switch, cut-out, and ceiling rose for electric incandescent lamps.

6,492. C. BARTER. London. An improved holder and shade for electric glow lamps.

6,502. J. VON DER POPPENBURG. Berlin, Germany. Improvements in galvanic batteries.

April 16, 1891.

6,517. C. M. DORMAN and R. A. SMITH. Manchester. Improvements in electric light switches.

6,559. J. M. NICOL. London. Improved electric bell push.

April 17, 1891.

6,614. H. M. TAYLOR. Edinburgh. Taylor's patent automatic electric bell signals for the prevention of collisions and accidents in foggy weather, or through engine drivers running past danger signals.

6,633. F. TEAGUE. Improvements in or relating to electric meters

6,655. J. C. FULLER and G. FULLER. London. Improvements in supports for telegraph insulators.

6,660. S. Z. DE FERRANTI. London. Improvements in the method of distribution of electrical energy, and in apparatus incidental thereto.

April 18, 1891.

6,677. D. T. PIOT. London. Improvements in the construction of magneto-electro medical.

6,730. W. M. MORDEY. London. Improvements in dynamo-electric machines.

## SPECIFICATIONS PUBLISHED.

1890.

4,791. DOUGLAS. Measuring electrical currents. (Price 8d.)

5,540. HIGGINS. Electrical measures. (Price 8d.)

5,916. BONNE (Actien Gesellschaft Mix and Genest). Electric bell, &c. (Price 6d.)

5,926. PITT (Atherton). Electrical conductors, &c. (Price 8d.)

6,266. MARX. Electrolysis. (Price 8d.)

6,631. AIRD. Electrical curative apparatus. (Price 8d.)

6,667. FRAGER. Electric meter. (Price 8d).

7,456. DE BROUCHERE and ANSPACH. Applying electricity to produce water pressure, &c. (Price 8d.)

7,511. IMMISCH. Brush for dynamos, &c. (Price 8d.)

7,513. WISE (Schoop). Secondary batteries. (Price 6d.)

8,116. BINSWANGER and FRANKE. Electrical switches. (Price 6d.)

8,153. HOLMES. Electric accumulators. (Price 6d.)

8,174. RICHARD, J. and F. Electrical transmitting apparatus. (Price 8d.)

8,477. BEEVOR. Electric switches. (Price 8d.)

8,854. DESRUELLES and CHAUVIN. Measuring electrical energy. (Price 8d.)

1891.

1,007. FERRARIS. Separating ores, &c., by electricity. (Price 6d.)

1,279. WILEY and OTHERS. Electric railway signals. (Price 8d.)

1,425. BOULT (Roberts). Storage batteries. (Price 8d.)

3,336. LAKE (Lemp and another). Electrically welding, &c. (Price 8d).

3,495. DORMAN and SMITH. Electric switch. (Price 6d.)

3,609. HARTMANN and BRAUN. Electricity meters. (Price 6d.)

3,673. SIEBOLD. Electric arc lamps. (Price 8d.)

# COMPANIES' MEETINGS & REPORTS.

## The Indo-European Telegraph Company (Limited).

The twenty-fourth ordinary general meeting of the members of this Company was held at Winchester House, 50, Old Broad-street, on Tuesday last, under the presidency of Mr. J. Herbert Tritton.

The MANAGING DIRECTOR (Mr. W. Andrews) read the notice convening the meeting, and the Company's seal was affixed to the register of shareholders.

The report and accounts were taken as read.

The CHAIRMAN: Gentlemen, you will observe that the receipts of the Company show an augmentation, omitting shillings and pence, of £5,518 over those of 1889, the gross take for the year 1890 being £113,807. The gross expenses are £57,901, being a decrease of £1,338 on those of 1889. As regards maintenance expenses there is an increased payment of interest upon £2,000 owing to the appreciation in the value of the rouble. The Company's payments have all along been made upon the basis of roubles, and of late the Company has had to pay more per rouble than before, the value being higher per £ sterling; but for this the reduction in the maintenance expenses would have been larger by this £2,000. There is also a loss on commercial account of £428, arising from the same increased value of the rouble. Notwithstanding this adverse circumstance, the outcome compares favourably with last year. We place £10,000 to the reserve, recommend the payment of a dividend which makes up 10 per cent. for the year, and carry forward £4,168, as against £2,039 for 1889. The Company has again expended considerable sums in the improvement and strengthening of the line, and in removing a considerable length from the highroad to the railway, where it is more protected from disturbance. The Indian traffic of this Company, and the Eastern Company, has shown more elasticity during 1890, there being an increase, as compared with 1889, in the gross of £9,904, and in the Company's total of £2,739. It is, however, still to be remarked that the income from this source has not yet reached the amount of receipts in 1885, the year preceding the reduction of the tariff, the gross being less by £55,876, and this Company's total by £13,494 than in that year. Taking the year 1886, in which year the reduction came into force on the 1st July, the gross receipts from Indian traffic are less by £35,727, and this Company's, again, less by £7,982. However, the traffic appears to have now taken a turn, and may, therefore, again work up to something like the old figure. It depends pretty much upon the activity of those classes of trade and business which give rise to the exchange of telegrams. The service has been such as to give the greatest encouragement to the development of the traffic, because the working of the lines of the Indian Government, and over their wires on the Indo-European system, as well as over the Company's wires, has been most excellent. Distinguished

Digitized by Google

services have, indeed, been rendered to Indian communications by the complete efficiency of the lines from end to end of the systems of the Government and of the Company. You will have gathered from the newspapers that the perseverance and energy of Sir John Pender have succeeded in bringing about an arrangement with the colonies of Australia for the introduction of a low rate for messages exchanged between Europe and Australia under the principle of a guarantee. As you are no doubt aware the basis of the arrangement is that any loss occasioned is to be borne one-half by the Australian Colonies, and the other by the Government lines and Companies' lines in proportion to their interests in the present revenues. Of course, this large measure has been a work requiring conciliatory views and careful consideration on the part of several important interests. For instance, our own Company had to obtain the consent of Germany and Russia. His Excellency the Post-master-General of Germany, Dr. von Stephan, has been long recognised as a leader in all postal and telegraph reforms, and responded to the exigencies of the position at once on behalf of Germany; the Russian Director-General of Posts and Telegraphs, His Excellency General von Besak, likewise liberally conceded the assent of Russia. The Indian Government, through Sir Juland Danvers; this Company, through the Managing Director, and the Eastern and Eastern Extension Companies, through Sir John Pender and the Managing Director, always subject to the respective Boards, together with the Colonial representatives, were all engaged in the work, and in the end all difficulties, and they were many, were surmounted, and the reduced tariff will be applied on and from the 1st of May next. Of course you will say that the results of lowering the Indian tariff are not an encouraging introduction to the reduced Australian rates, but then the circumstances are not the same. The Australian communities are growing, and are enterprising and active to an extraordinary degree; and it can only be said that if low rates to these progressive countries are not a success the experiment of low rates will at least have been tried under the most favourable conditions. The message traffic with Australia has always been an increasing quantity year after year without reference to tariff, and has always shown a decided tendency to rapid development. Some increment is pretty certain from the operation of this natural increase. We must hope for the best, and that a commensurate increase will be obtained on account of the low charges over and above the natural increase. The experiment of these reduced rates is to be confined to the period of one year. To myself, and I think you will agree with me, this seems insufficient to fully test the question, and I should not be surprised if an extended period were to become necessary. In any case, I may say that the Company's participation in the measure, whatever may be the result, will not affect the dividend. There is nothing more to be added, except that on the conclusion of the ordinary business a resolution will be proposed to which I venture to anticipate your unanimous support will be given; our Managing Director has hitherto had only a consultative voice at the Board, and no vote; it is now proposed that as regards responsibility as a Director he should be placed upon the same footing as the other members of the Board, and shall be on the same footing as to the action of the Board. He concluded by moving the adoption of the report and accounts, and the declaration of the dividend recommended.

Mr. H. WEAVER seconded the motion.

Mr. JACKSON wished it to be known that some of the shareholders did not think the reduction of tariff to Australia was anything extraordinary. He believed that the business public could now send a telegram at the rate of 1s. 7d. per word 7,000 miles across the Atlantic and the United States to the Pacific Coast. They ought to bear in mind the fact that the Indians were as much subjects of the Queen as the colonists, and if they desired to encourage and develop traffic he trusted that the 4s. rate would never be receded from. If it did diminish their dividend, it could do so only in a minute degree. He was glad to see that Sir John Pender had wakened up to the fact that monopoly would not do in these days, and that Eastern telegraphs might meet with a competitor as Western ones had done, and, therefore, it was necessary to be abreast of the times in such enterprises. The reduction of the tariff was a most important question, and even if, at the end of the year, it was found that it did not pay, he trusted that they would not revert to the old rates. He wished to say that their line was only about half the length of that to San Francisco—that was to say, 3,600 miles.

The CHAIRMAN pointed out that a comparison of lines between Australia and San Francisco would be very misleading, for they had to bear in mind the comparative length of land lines and cables involved. He need not say that the initial cost of deep-sea cables was very much heavier than that of land lines. He did not think that the reductions of tariff were likely to affect their dividends.

The resolution was carried unanimously.

Mr. C. W. EARLE proposed, and Mr. C. HOLLAND seconded, the reelection as Directors of Mr. J. Herbert Tritton and Major-General Tremenheere, R.E.

The motion was agreed to *nem. con.*

Mr. WELLS proposed, and Mr. WOODWORTH seconded, the reappointment of the auditors, Messrs. C. F. Kemp, Ford, and Co., which was carried unanimously.

The CHAIRMAN: Now, gentlemen, we come to the last resolution of which notice has been given:—

"*That in addition to the regulations of the Company, as contained in the Articles of Association, the following new regulation (to be numbered 116A) be adopted, that is to say—*

"*That the present Managing Director of the Company shall be a member of the Board, having all the privileges and being subject to all the obligations of an ordinary Director, except that he shall not receive extra remuneration as a Director, nor shall he retire from office by rotation. If the Directors think fit, this provision shall apply to any future Managing Director whom they may appoint.*

"*The other regulations of the Company shall be treated as qualified so as to give full effect to this new regulation.*"

It gives me a considerable amount of satisfaction to be the medium of moving this resolution. There are few men in the business world who have done more for the companies which they represent than Mr. Andrews has done for the Indo-European Telegraph Company. His qualifications are known throughout the world, I may say, as a highly efficient telegraph official. It is only giving to him a portion which is his due that we ask him to be made a member of the Board like ourselves.

Mr. WEAVER seconded the motion.

Mr. JACKSON thought that it was due for the shareholders to state that Mr. Andrews' 21 years management of the Company had placed them in a very exceptional position as a telegraph company. Unfortunately for him (the speaker) he had been largely interested, for his small means, in telegraphs, a large portion of his income being dependent on telegraph securities, and he must say that the position of this Company was a most gratifying exception in point of the returns yielded on his investments. He thought that Mr. Andrews' 21 years' experience entitled him to the confidence of the Board, and certainly more than entitled him to the confidence of the shareholders—even their gratitude; and he thought it was a very good principle indeed that an expert should be on the Board. In Mr. Andrews they had a thoroughly qualified man who understood his business. There was one thing he would like to ask Mr. Andrews, however, at which he hoped that gentleman would not take offence. Mr. Andrews was Chairman of two companies, and a Director of two others. He (Mr. Jackson) did not object to that, for the reason that Mr. Andrews' knowledge and experience qualified him for the work; but he wished to ask whether, in carrying out the views of the Directors, there would be any embarrassment on Mr. Andrews' part, having regard to his many other duties?

The resolution was carried unanimously.

Mr. ANDREWS said he was quite sure that if any inducement were needed in the case of any individual, whoever he might be, for the due performance of his duty, nothing would tend more to the continued exertions of such a person than the proceedings which had just taken place. He felt, and he desired to express, his grateful appreciation of what had been done and of the way in which it had been done. In reference to the very proper question of Mr. Jackson—referring to the fact that one's offices might be unduly multiplied, he might say that in his particular case the work he did was of a similar kind to that which he did in this Company. It added, if anything, to his experience, and the man who extended the area of his survey—so long as that survey was confined to a particular direction—was sure to become more efficient in his service. He begged to inform Mr. Jackson that in no way would he allow other engagements at any time to interfere with the performance of the obligations which he owed to this concern, and which for a period of 21 years had been performed with satisfaction to them.

A vote of thanks to the Chairman and Directors terminated the proceedings.

## Metropolitan Electric Supply Company (Limited).

Sir John Pender, K.C.M.G., presided over the fourth ordinary general meeting of this Company, which was held at Winchester House, Old Broad-street, on April 29, 1891.

The SECRETARY (Mr. E. Cunliffe-Owen) read the notice convening the meeting, and the report of the Directors was taken as read.

The CHAIRMAN: As this is an important meeting, at which it is desirable that the shareholders should clearly understand the position of the Company, dealing as it does with the finances of the Company for 15 months, I propose to put before you a statement which will be available in the future as a record of the past. One of the first points which will occur to you in connection with the report is the form in which, for the first time, the accounts are presented, a form which, as you will have learned from the report, is in accordance with the requirements of the Board of Trade, who, under the provisions of the Electric Lighting Act, have power to prescribe in what manner the accounts of all electric light undertakings are to be furnished to them for public information. The balance-sheet which accompanied the report to September 30, 1889, dealt with a period which ended only a few weeks after the granting of the orders under which we were then working, and covered the expenditure attendant upon the starting of the Company's operations, and the commencement of its working, which at that time only included a few customers. Although it was known that the Board of Trade possessed the powers to which I have referred, the Company were at that time without information as to what would be required. Acting under the advice of the Company's auditors, the accounts were prepared and laid before you in the ordinary form of a company's balance-sheet. Since then, however, the Board of Trade have prescribed a form of account, which, although not yet finally settled, being still under discussion in some minor particulars, is sufficiently comprehensive for the purpose required, and has been followed as closely as possible in the accounts now before you. I may say that we were given to understand by the Board that they would be content with a detailed account for the period commencing with the date of the last balance-sheet, dealing with the expenditure prior to that date as a lump sum, but on carefully going into the matter, we found that such a mode of dealing with the figures could not be a satisfactory one, and the whole of the accounts from the commencement of the Company have therefore been reconstructed in order that the present and future balance-sheets might give a clear record of what the Company has done and is doing. The accounts speak for themselves, and you will, from them, be able to form a fair idea of the amount of work which has had to be carried out, and the time and care, as well as money which has had to be expended, to bring the Company's various undertakings to their present condition of practically complete working. There is one item of detail to

Digitized by Google

which I ought to refer: I allude to the apportionment of management and general expenditure between capital and revenue. During the fifteen months over which the accounts extend, the direct capital xpenditure amounted to £195,000, while the total turnover revenue which has been handled was only £27,000, from which it will be evident that the time and attention of the Board and staff, with the exception of the actual station staffs, which, of course, are wholly paid for out of revenue, have been mainly occupied with capital details. In view of this fact, the Board have considered that the proportion of management and general xpenditure shown in the accounts as chargeable to revenue is a liberal one, and it is satisfactory to find that with this charge, the revenue which has been mainly earned during the latter portion of the period shows a profit, though, of course, only small. The Board are fully alive to the fact that as capital expenditure decreases, the proportion of charge to revenue must very largely increase, until in a little while the whole load of management has to be borne by revenue, but making all allowances for this increase of charge, the revenue is now growing so satisfactorily that future success seems assured. With regard to the interim dividend of 2s. per share for the three months ending March 31st last, I am glad to be able to tell you that the income for that period shows an actual increase on that for the December quarter, although we have, of course, had to deal with brighter weather and individually smaller requirements than in October, November, and December. Our expenditure has not proportionately increased, and, making a full allowance for management expenses, we have no hesitation in saying that the profits for the quarter amply justify the interim distribution which we have had the pleasure to announce, and which is a tangible proof that the anticipations which we have held out at previous meetings are in a fair way of being fulfilled. The remarks which I made when I last had the pleasure of meeting you in November will, I think, be sufficiently fresh in your minds to obviate the necessity of my dealing at any great length with the period which the report embraces. It may, however, be interesting for you to realise the difference of our position at the commencement and the close of this period, and for this purpose I would remind you that in October, 1889, we had just opened the first portion of our Sardinia-street station, and had run temporarily a few overhead lines to connect up our first customers. Our Rathbone-place station was also supplying a few customers by means of overhead wires, and the small plant which we had then lately purchased with the building from Messrs. Pritchett. The erection of the Manchester-square station had not even been commenced. Our Whitehall station was then, as it is now, doing good and steady work. The total number of lamp-connections was, on October 1, 1889, 6,111; it is to-day 60,000. Our customers then numbered 37, and now amount to 480, and as our report informs you our revenue, which for the quarter ending December 31, 1889, was £2,866. 15s. 7d., amounted for the corresponding period of 1890 to £10,726. 19s., an increase of 275 per cent. During this period the plant at Sardinia-street has been duplicated, the new plant at Rathbone-place has been installed, the Manchester-square station has been erected and fully equipped, and an elaborate network of underground mains, about which I will speak to you later on, has been laid down. With the growth of our capabilities of supply has also grown our business. And with the growth of our business we are pleased to say that the demand for the light also appears steadily to grow, so that I fully believe that at our next year's meeting we shall be able to report to you a lamp connection of well over 100,000. And you must remember that this, and an even greater, increase in our business can be amply dealt with by our existing machinery, and, as I endeavoured to explain to you at our last meeting, the greater our production the less in proportion will be our expense of production. Therefore, if we can show a profit when supplying 50,000 lights, we can proportionately show a much larger profit when supplying 100,000 lights. I have had a diagram prepared for you which will show you at a glance the present position of our business. On this diagram each black mark represents a consumer's house, and you will at once realise that we are still only on the threshold of our work and that, even when our present output is doubled, much, very much, remains to be done. Looked at from this point of view a map of London forcibly reminds me of a map of Africa; and we, like my friend Mr. Stanley and so many others, are engaged in filling up the blank spaces, and in illuminating the darkness which is still but too apparent. Our work is still essentially a pioneering one, and if we can make a pioneering business pay it augurs well for our profits hereafter. And here I would like to make a few remarks as to the choice we have made of the system for supplying electricity to the public. The system we have mainly adopted is that known as the alternate-current transformer, which we work at the extremely moderate pressure of one thousand volts. We elected to adopt it under the very best practical and scientific advice, as being the system best fitted for pioneering work. We have every reason to be satisfied with our choice, for it has enabled us to cover our large areas at infinitely less cost than any other known system would have done. The advocates of other systems have been lately doing their best to disparage the merits of the alternating current, and have endeavoured to make a strong point out of the loss of energy, which, to a certain extent, undoubtedly occurs in connection with the transforming apparatus, but allow me to remind them that this loss is insignificant when compared with the heavy initial outlay which the use of the continuous current necessitates. And I would, moreover, point out that any loss which we have to bear will be reduced to a minimum so soon as the increasing density of our lighting warrants the establishment of transformer sub-stations. This question of transformer sub-stations, or, as the Americans say, of banking transformers, has for a long while been receiving our careful attention, and we have all along had in view their ultimate adoption as soon as our business is sufficiently developed to ensure their being worked economically. Another great advantage of our system over all others adopted in London is that each of our alternate-current stations can assist or be assisted by any other—indeed, it is our usual practice at present to shut down one of our stations entirely during the hours when the load is lig[illegible], and during the summer it is quite possible that we shall fin[illegible]e station adequate to deal with the requirements of the whole [illegible] our areas during the hours of minimum demand, thus gaining considerable economy in working. In speaking to you of our systems of supply, I dare say you all have in your minds that adopted by another great London supply company. We must all admire the indomitable pluck with which the difficulties inseparable from the achievement of such a scheme have been faced; we must all admit the genius of the engineer who is responsible for such a gigantic design, and most heartily do I wish him success, and we must acknowledge the accustomed skill displayed by my friend the chairman of that company, in his recent review of their position and prospects. We sincerely trust that not only for their own sake, but for the sake of the cause of electric lighting generally, their success is now assured, and we are glad to think that we were able to be of some assistance to them in their hour of need. But as the Chairman could not avoid attempting to make a point at our expense in dealing with their anticipated immunity from vibration difficulties, so I venture to repeat the friendly warnings which I have often uttered before, namely, that it is dangerous to put all your eggs in one basket. One of the principal arguments brought by the London Corporation in establishing one large central station outside London was based on the fact that the Gas Light and Coke Company had done the same at Beckton, and, what the Gas Company did after fifty years and more working on a more modest scale, our friends have done after three or four years of purely pioneering work. Of the two examples we prefer to follow that of the former, and to walk before we run. When our figures can show something like the returns of the Gas Light and Coke Company with its 200,000 customers and its million tons of coal, which is, I believe, yearly required to meet the demands upon them, then will be the time for us to consider whether economy and efficiency will best be served by the erection of a great outlying generating station, or whether our present policy of smaller plants which can render one another mutual assistance, thus reducing the risk of failure of supply to a minimum, will even then be the soundest one. With regard to this vibration question to which Mr. Forbes refers, it is of course inevitable that the erection of large machinery works in the midst of a great town like this should give rise to complaints. We have of course had to deal with grievances respecting ancient lights, alleged noise, and what not, about which I would say more but for the fact that we have at present two cases *sub judice*. I may, however, say this, that every precaution has been taken to prevent the possibility of any noise or vibration occurring, and as a practical proof that such precautions can be taken with success I would inform you that you are now sitting within a very few yards of a powerful plant which is working at this very moment, and which supplies the electricity and other requirements for the whole of this vast building. There is one other point in Mr. Forbes' remarks to which I would like to allude. In answer to a question respecting the amount receivable per lamp per annum he is reported to have replied that £1 per light "is not enough, and that his Corporation would now refuse to take a contract at such a rate." If this applies to their customers as a whole I must congratulate the London Corporation on their experience, which is quite at variance with that of ourselves or, I believe I may safely add, of any other London Supply Company. We can fully admit that there are classes of customers with whom a contract on such terms would be out of the question, whose consumption would need a far larger contract price than 20s. But against these classes have to be set what we may style the private customers, whose demands on our supply are comparatively small, and from whom it would be impossible and indeed unfair to obtain so high a price per light. I am speaking now of our experience as gained by our supply of current by meter, for I may inform you that the larger proportion of our customers are now charged by this means. Our experience of the average revenue obtained for each 8 c.p. lamp connection per annum places it at about 12s., and I believe that even this figure is a better one than is obtainable by companies whose area of supply is of a more purely residential character than ours. In making these remarks I do not wish you to think that we are losers by this experience. If you will reflect a moment you will readily understand that the less each lamp in our system is used the greater may be the number of lamp connections our plant can safely deal with. We are therefore in a position to supply a far larger number of lights than we originally believed our plant was capable of meeting, and hence our operations are considerably widened, and we shall gain by number what we have lost by rate. Our policy is to give the light at the lowest price consistent with a fair dividend. as this policy will more quickly develop the use of the light, and while we must always bear in mind that we have a formidable competitor in gas; still, looking to the advantages which the electric light has over that illuminant, I feel that with anything like a price approaching that of gas, our light must eventually take the lead. Our stations have, as is stated in the report, worked very satisfactorily, and this is the more gratifying as they commenced to supply current before all the fittings and accessories were completed. With regard to our system of underground mains, I may state that the length of conduits at present laid amounts to 40 miles. The whole of this work has been executed under the immediate supervision of our own staff, and by our own workmen, a more efficient and economical plan than that of employing a contractor. Into these conduits we have drawn 90 miles of mains, and it is a matter of deep satisfaction for me to inform you that not one single fault or leakage has yet occurred in any one of our circuits. Anyone who realises what this means will readily agree as to the excellence of the cable employed and to the skill and care with which our staff has manipulated it. It also tends to strengthen our conviction that the system we have adopted for our mains is the proper one. I must not omit to testify to the Board's appreciation of the loyalty and energy which has been displayed by our engineering staff, and to the skill with which they have

Digitized by Google

overcome the many difficulties which have of necessity arisen in working new plants under trying conditions. I should also like to remind you that we have always made it a practice ' e a constant supply by night and by day, and although at any rate at firs l during the small hours of the night the demand has scarcely justified us in doing this from an economical point of view, we have, nevertheless, always believed it to be our first duty to honourably carry out the responsibilities which have been imposed upon us by our Parliamentary obligations, and to prove to our customers that electric lighting is no less than gas, reliable whenever wanted. We have had from some of our leading customers very satisfactory and encouraging letters. I may read one as a fair illustration of many others:—"Dear Sir,—It gives me very great pleasure to be able to testify to the admirable way in which I have been supplied up to this time with the electric light by the Metropolitan Supply Company. I have indeed nothing but praise for it. From the opening of this theatre, two years ago, not a hitch has occurred, and the light has been pure and steady throughout." That is from Mr. John Hare, of the Garrick Theatre. You cannot have anything more satisfactory than that. It is very good evidence of what we have done. I am reminded that we have had letters of a similar kind from Mr. Henry Irving, Mr. George Edwards, Mr. Augustus Harris and Mr. Sedger. All this is most encouraging, because to these gentlemen a few moments' darkness would be something terrible. It is most satisfactory to us, and is also a compliment to our staff; but, after all, an efficient staff is what makes an efficient system. With regard to our Paddington concession, which, you will remember, was granted to us last August, we are already making great progress in this district with our mains, and are already supplying upwards of 2,000 lights from our Manchester-square station. Indeed, had it not been for the exceptionally severe winter, which stopped our works for at least two months, our progress would have been still more marked. The large demand for light in this important parish renders it necessary for us to proceed at once with the erection of a station on the wharfside premises which we have acquired, and as the bulk of the machinery is already completed and the building works to be commenced in a few days' time, we have every reason to believe that the station will be completed in time for next winter's lighting. You will observe from the report that, as far as we can at present estimate, the erection of this station with the supply mains and the completion of the present system of mains in our other districts will, as nearly as possible, absorb our present issue of capital. We shall, therefore, soon issue notices for the payment of the final call of £1 per share, and I think that we shall be meeting the wishes of shareholders in this respect, as there will then be no further liability on the shares, which will therefore improve their already favourable position on the Market, and will tend to add to their attractiveness as a sound investment. Now, gentlemen, as I told you at the beginning of these remarks, we have given you a report of the past. We have fulfilled to the letter the promise that we made, namely, that we were not going to adopt a speculative system, but one which had been proved successfully in America. We are adopting a system which will be extended by fresh installations, but we shall still be working all our installations singly or as a whole. We told you in the prospectus that we took up this question because we thought the time had come when electric lighting should be taken in hand by practical people. A very large amount of money had been spent previously on speculative paper installations. I believe that every shilling of our money has been well spent, and we have established what I believe will be in the future a thoroughly sound investment. If our future grows as the past has done, success will come at a very early day indeed. I am pleased with the result so far, because, when I was examined before the Commissioner on Electric Lighting, I made this statement—I believe I have made it before in this room, and I shall repeat it to-day—that, looking from the standpoint of the present moment, judging from what we have seen in the past, I believe that, before we have done, we shall have installations which will cost us over £2,000,000. So satisfied am I of the progress of the light—and I believe the experienced gentlemen sitting by me think the same—that we look forward to developing this industry into something far larger than I dare venture to prophesy to-day. As I stated in my previous remarks, we are declaring our dividend now simply upon three months' earnings, and with 50,000 lights; but before I meet you again we shall have at least 100,000 lights, and probably considerably more. I believe our installations are capable of giving us a very much larger amount, but we want to be prudent and to err on the safe side. When you are getting a respectable dividend, and we find that the way is clear, and the demand continues to grow, we shall not be backward in meeting that demand, and I do believe that we shall not have the slightest difficulty in getting any money that may be required for our extensions. Until, however, we have proved that what we have done at present is not only sound in principle, economical in working, and profitable to our shareholders, we shall make no step in that direction. I went round the stations yesterday, and I wish that some of the shareholders would spend an afternoon in visiting them. I think they would be pleased with what they would see. The stations are compact and thoroughly efficient. They are everything which a man who takes an interest in a progressive thing is pleased at. I was thoroughly pleased, and I believe that we have not only good installations, but that we have also very good men to work them. I believe that no money in any concern of this kind has been more carefully or better expended than yours has been during the last 18 months. My friend, the Chairman of the London Company, paid a very high compliment to the Board of Trade; and I wish to repeat pretty much the words he used. Of course, that Department has to be guided, more or less, by the Acts of Parliament, and we find in these Acts that provisions exist which we may call obstructive, but as long as there is a desire on the part of the Board of Trade to remove difficulties we can only say that they are so far doing as much as they possibly can to help us. For this I feel personally obliged to them. I cannot but venture to add a hope that one of these days they may find it possible to recommend improvements being made in the Electric Lighting Acts. Now, gentlemen, I have only a few more words to say. We have a broad field to supply, and as you see by this map behind me, our space is a very large one, and as this great City of London is growing and extending hand over hand, I think the field before us is not only a wide one, but one which is also very encouraging indeed. In these times if there is anything new—anything that will enable a trader to display his goods to greater advantage, or to prevent injury to his stock—depend upon it the traders will adopt it. When I drove along Oxford-street yesterday I asked as we went along how many of the Oxford-street shops were supplied, and I was astonished to find that the number was perfectly insignificant. All these tradesmen will, however, be obliged eventually to use the light, and as our system is equal to very large expansion, I look forward to a very rapid development of it in that quarter. A great deal has been said about gas and the electric light. I believe that there are some people who are using the electric light for a price even less than that of gas; but I do believe this, that even if the cost is a little more, the electric light must take its place in all homes and in all places of business where comfort, cleanliness, and economy are desired. I may add that Mr. Gordon, who has been a Director of the Company from the beginning, now retires from the Board. He has had a great deal to do as our electrical engineer during the time we have been building the works to carry out our system. Mr. Gordon finds that the demands now made upon his time owing to the growth of his business are such that he can no longer serve us as a Director, and therefore he does not offer himself for re-election. He has done good work for us. He will continue with us as a consulting engineer, and I wish him good speed in the more extensive sphere into which he is now entering. With these remarks I beg to move:

"*That the report of the Directors and the accounts for the period commencing December* 1, 1889, *and ending December* 31, 1890, *submitted to this meeting, be and the same are hereby approved and adopted.*"

Sir GEORGE ELLIOT, Bart., M.P.: Gentlemen, I have great pleasure in seconding the motion for the adoption of the report and accounts.

The CHAIRMAN then expressed his readiness to answer any questions, but no shareholder rising to address the meeting he put the resolution in the usual way and declared it carried unanimously. On the motion of the Chairman, seconded by Sir James Anderson, the retiring Directors, Sir R. N. Fowler, Bart., M.P., and Mr. J. C. Parkinson were re-elected, and subsequently Messrs. Deloitte, Dever, Griffiths and Co. were re appointed auditors to the Company. A cordial vote of thanks was then passed to the Chairman and Directors for their successful administration of the affairs of the Company.

The CHAIRMAN, in reply, observed that since they first met the shareholders a rather anxious time had been experienced by the Board, and a great amount of work had been done. He thought they could all be congratulated, and that he might take credit for the Board and the staff that the work which had been done had been done well. The dividend now declared was small but it was only on three months' earnings, and every additional 1,000 lights—and their number ought to increase daily—would add to their exchequer. He thought the shareholders could now sit down quietly and watch the progress of this business.

The meeting then separated.

## Reuter's Telegram Company, Limited.

The ordinary general meeting of the shareholders of this Company was held on Wednesday at the offices, 24, Old Jewry, under the presidency of the Right Hon. Sir John C. D. Hay, Bart., K.C.B.

The SECRETARY (Mr. Bradshaw) read the notice convening the meeting and the Report of the Directors.

The CHAIRMAN: Gentlemen, I have now to move the adoption of the Report. In doing so, I think I have reason to congratulate you on the results shown in the balance sheet. Our revenue, when compared with the preceding years, shows a substantial increase. The expenditure, you will also observe, has, at the same time, been considerably augmented. We have reason to believe that our efforts to maintain our service in the highest efficiency are being appreciated generally by the press. We certainly shall not suffer in the long run from any exceptional or temporary sacrifice that we may make to attain that efficiency and accuracy which distinguish our agencies. Roughly speaking, our telegraphic outlay has been £5,000 in excess of 1889, which alone is sufficient to account for the slightly diminished dividend. In these times 5 per cent. may be considered a fair return for capital invested, and as we carry forward nearly £1,000, I trust the shareholders will feel that they have reason to be satisfied. As the High Court has sanctioned the modification in the Memorandum of Association, which was unanimously approved at the Extraordinary General Meetings in December, we have now been able to commence our advertisement business, which we anticipate will eventually yield highly profitable results. We have opened a separate office for this purpose in the immediate vicinity. I must, however, again warn shareholders that large profits cannot be expected at once. But no great pecuniary risk is involved, and if we do not at once realise large profits, we have not to fear losses. The extra current and preliminary expenses incidental to starting our new business will be the only fresh outlay for which we have to provide. I am happy to inform the shareholders that Mr. George de Reuter and Mr. Frederick J. Griffiths have joined the Board as Directors. In Mr. George de Reuter we have an associate, who, in addition to his hereditary claims to our respect and confidence, has shown, not only at the Bar, but as Director of the Bank of Persia, business-like ability of no ordinary character. Mr. Griffiths by his indefatigable zeal in your service, as secretary for more than a quarter of a century, has made himself master of the details of our business, and though

Digitized by Google

after his long service as secretary he had a perfect right to devolve his arduous duties upon his worthy successor, Mr. Bradshaw, we consider ourselves most fortunate in securing Mr. Griffiths' knowledge and services to the Company as our associate in the direction.

Baron DE REUTER seconded the resolution, which was carried unanimously.

On the motion of the Hon. MARK NAPIER, seconded by Mr. FREDERICK J. GRIFFITHS, the retiring Director, Baron de Reuter was unanimously re-elected.

Baron DE REUTER having briefly acknowledged his re-appointment,

The Auditors, Messrs. Welton, Jones and Company, were re-elected, and a vote of thanks accorded to the Chairman and Directors.

## Elmore's Foreign and Colonial Patent Copper Depositing Company (Limited).

An extraordinary general meeting of this Company was held at the registered office, 64, Cannon-street, on Monday, Mr. F. L. Rawson in the chair, when the subjoined resolution, which was passed by the Company in general meeting on the 6th ult., was submitted for confirmation as a special resolution.

Resolved: That the Articles of Association be altered in manner following:—

(a) *Article 109 shall be cancelled.*

(b) *In place thereof the following Article shall be substituted, namely, "(109) All dividends shall be payable out of profits only; but such dividends may be declared and paid either in cash or by the distribution of specific assets taken at their par value, and in particular of shares, debentures, or other securities of any other company, or partly in one way and partly in the other."*

(c) *Article 110 shall be altered by inserting after the words "until they have received a return" the words following (namely) "in cash;" and by inserting after the words "and in addition 100 per cent. premium" the words following (namely) "also in cash;" and by substituting the word "Founders" for the word "Reversion."*

The SECRETARY (Mr. J. Shurmer) read the notice convening the meeting, in full.

The CHAIRMAN then said: Gentlemen, it will be unnecessary for me to say more than that these resolutions are the same that were actually passed on the 6th inst., and that the effect of these resolutions is this—that after the priority shareholders have received a second £5 per share, making an amount of £10 per share in cash, the Directors will have the power of distributing the assets of the Company at par value, giving the proportionate amount to the priority shares and the founders' shares. He then moved the confirmation of the first resolution.

Mr. J. J. ATKINSON seconded the motion, which was carried unanimously; as were the other resolutions.

The proceedings then terminated.

## Brazilian Submarine Telegraph Company (Limited).

The following is the report of the Directors for the half-year ended December 31, 1890, to be submitted to the thirty-fifth ordinary general meeting of the Company, to be held on Wednesday, the 6th inst., at Winchester House, Old Broad-street, E.C., at 12 o'clock:—

The revenue for this period amounted to £143,363. 13s. 1d., and the working expenses to £18,106. 2s. 9d. After providing £12,880 for debenture interest and sinking funds, and £1,960. 11s. for income tax, there remains a balance of £110,416. 19s. 4d.; to this is added £2,416. 18s. 1d. brought forward from 30th June last, making a total of £112,833. 17s. 5d. First and second interim dividends amounting to £39,000 have been paid, and £50,000 transferred to the Reserve Fund, leaving the sum of £23,833 17s. 5d. to be carried to the next account. Of this amount the Directors intend distributing £13,000, or 2s. per share to the shareholders, in addition to the usual quarterly dividend of 3s. per share, payable on June 24th next.

The receipts for the half-year include the sum of £1,500 dividend to June 30, 1890, on the Company's shares in the African Direct Telegraph Company (Limited).

The Directors deeply regret that the Right Hon. Viscount Monck, who has occupied the position of Chairman of the Company since its formation in 1873, and Sir Thomas Fairbairn, Bart, who has been a Director since 1874, desiring to reduce their engagements, have resigned their seats on the Board of the Company.

The Board have elected Sir James Anderson Chairman of the Company.

The vacancies on the direction created by the retirement of Viscount Monck and Sir Thomas Bairbairn, Bart., have been filled by the Board, by the appointment of Lord Sackville Arthur Cecil and Mr. John Denison Pender.

A serious fault appeared in the 1874 cable, about two miles off Lisbon, on December 18, 1890, which was repaired by the Telegraph Construction and Maintenance Company's s.s. "Britannia." The same cable was reported interrupted about 18 miles from Madeira on January 7, 1891. Arrangements were immediately made for the despatch of the Telegraph Construction and Maintenance Company's s.s. "Scotia," and the necessary repair was accomplished after laying in 25 knots of new cable. The cost of effecting these repairs will appear in the accounts for the current half-year. The shore end of the Lisbon-Madeira 1882 cable broke on March 8, 1891, close to Madeira. The Directors have much pleasure in stating that this cable was effectively repaired by the Company's Madeira staff. Neither of the foregoing operations caused any interruption to the transmission of messages, the traffic having been carried by the duplicate cable.

In accordance with the provisions for repayment of the First Issue of Debentures, dated July 31st, 1884, 160 Bonds, representing £16,000, were drawn on the 24th instant, for payment at par on July 31st next. This, with the previous drawings, will make a total repayment of £96,800, leaving £53,200 of the first issue of debentures outstanding.

The various sections of the Company's line are in good working order.

## The Kensington and Knightsbridge Electric Lighting Company (Limited).

The following is the Report of the Directors of this Company to the end of the year 1890:—

The whole of the compulsory area has had its streets, with the exception of about three-quarters of a mile, supplied with mains, and in 2½ miles of streets, external to this area, mains have also been provided, making the total length of streets down which mains have been placed, 10 miles, about 4 miles of which have been executed in the year 1890. It is computed that there are about 1,300 houses fronting on these mains, and on the 31st December last only 291 were taking current. During the year the number of houses and shops connected with the system has increased from 147 on December 31, 1889, to 291 on December 31, 1890; while the number of lamps calculated on the usual basis of eight candle-power has increased from 11,794 to 25,535.

The battery station in Queen's Terrace-mews, which was in the course of construction at the time of the last Report, has now been completed and at work for some months with most satisfactory results. The plant at both Kensington-court and Chapel-place stations has been increased, not only to meet the extra lighting obtained during the year, but also to provide power for a large increase of demand. It may be found, however, that the demand will increase with sufficient rapidity to necessitate the execution during the current year of larger extensions than the Company's present funds would enable them to provide. To guard against such a contingency the Directors think it would be well that they should be in a position to issue some further Preference shares, those of the first issue having been already taken up, with the exception of about £2,000. They will therefore submit to the shareholders the requisite resolution for creating further Preference shares, the date and conditions of their issue being left to be determined by the Directors when the money is wanted.

The dividend on the Six per Cent. Preference shares was duly paid to June 30, 1890, and out of the balance standing to the credit of the net revenue account on December 31, 1890,—£1,804. 2s. 2d.—the sum of £922. 18s. 3d. has been appropriated for the payment of the Preference dividend to that date, leaving £881. 3s. 11d. available for the next account.

Sir Charles Grant retired from the Directorship during the year, and Mr. George H. Hopkinson was appointed by the Directors to fill the vacancy. In accordance with the articles of association, Mr. Granville R. Ryder and Mr. R. W. Wallace retire from the Directorship, and, being eligible, offer themselves for re-election. The auditors, Messrs. Lovelock, H. W. Whiffen, and Dickenson, offer themselves for re-election.

## Submarine Cables Trust.

The following is the report of the Trustees to the twentieth ordinary annual meeting of the certificate holders, to be held at the offices of the Trust, Winchester House, Old Broad-street, E.C., on the 5th inst., at 2 o'clock:—

The revenue for this period, including the balance of £431. 8s. 11d. brought from the previous accounts, amounted to £24,098. 3s. 3d. The coupons due on April 15, 1890, were paid on October 15, 1890, and the coupons due on October 15, 1890, were paid on April 15, 1891. The expenses of the Trust amounted to £1,175. 7s. 6d., and the payments on account of the coupons to £20,286, together £21,461. 7s. 6d., leaving a balance of £2,636. 15s. 9d. to be carried forward. This balance, which is equivalent to 15s. 7d. per cent. on the value of the outstanding certificates, the trustees propose to distribute to the certificate holders on the 15th proximo, together with a small amount to be taken from the current year's revenue, so as to admit of the payment of £1 on account of the coupon due on 15th instant.

The meeting will have to elect two auditors for the current year; Mr. John G. Griffiths and Mr. John Gane offer themselves for re-election.

A table showing the original and present investments of the Trust is appended to the trustee's report.

## NEW COMPANIES REGISTERED.

**CORIFACT SYNDICATE (LIMITED).**—Registered with a capital of £15,000 in £1 shares. Object, to carry on business as manufacturers of artificial leather, leather board, electrical apparatus, &c.

**CUTTRISS, WALLIS, AND CO. (LIMITED).**—Registered by Vincent and Vincent, 20, Budge-row, E.C., with a capital of £10,000 in £5 shares. Object, to acquire the Elmwood Electrical Works, Camp-road, Leeds, and also the business of E. C. Wallis, of 1, Bond-place, Leeds, in accordance with an agreement made between Thomas Cuttriss and St. Wells Cuttriss of the first part, Edwin Cooper Wallis of the second part; and Richard Wilkinson Graham, on behalf of the Company, of the third part, and to carry on, under the style of Cuttriss, Wallis, and Co. (Limited), the business of electrical apparatus manufacturers. There shall not be less than three nor more than five Directors. The first are Thomas Cuttriss, St. Wells Cuttriss, Edwin C. Wallis, and John William Bannister, all of Leeds. Qualification, £150. Remuneration, £50, divisible.

**LONDON ELECTRICAL TRAMWAYS COMPANY (LIMITED).**—Registered by Hurrell and Mayo, 165, Queen Victoria-street, E.C., with a capital of £150,000 in £1 shares. Object: to acquire the tramway system of the

Digitized by Google

North London Tramways Company, and to carry on and develop and extend the same. The first subscribers are :—C. J. Westwood, 3, Adelaide-place, E.C. ; F. C. Winby, 3, Adelaide-place, E.C. ; C. Docwra, 3, Adelaide-place, E.C. ; B. Laucler, Chigwell, Essex ; E. J. Relf, 12, Humber-terrace, Westcombe-park, S.E. ; R. Krugh, Hermon-Hill, Wanstead ; A. W. Hurrell, 165, Queen Victoria-street, E.C. There shall not be less than three nor more than seven Directors ; the first are the signatories to the Memorandum of Association. Qualification, £100. Remuneration to be determined in general meeting.

## CITY NOTES, &c.

**BRAZILIAN SUBMARINE TELEGRAPH COMPANY.**—Our advertisement columns contain a list of the numbers of the Five per Cent. Debentures (1884 issue) which were drawn on April 24th, and will be paid off at par on July 31st next. The receipts of this Company for the past week amounted to £5,998.

**CITY AND SOUTH LONDON RAILWAY COMPANY.**—The traffic receipts of this Company for the week ended April 26th amounted to £784.

**COWLES SYNDICATE.**—The members of this syndicate held a private meeting at Winchester House, Old Broad-street, E.C., on Wednesday.

**ELECTRIC TRACTION IN PARIS.**—At the fourth ordinary general meeting of the Continental Metropolitan Tramways Company (Limited), held yesterday under the presidency of Mr. B. H. Van Tromp, who stated that: —"It was with feelings of the ve y greatest disappointment that he had to come before them that day without being able to announce that they had any system of electrical traction upon their tramway lines in Paris ; but with all the tramways companies in England, none of them showing courage enough to go for an electrical system, he thought that the shareholders must not be surprised that they had not a scheme in view for Paris. He might, however, state that they had been in negotiation in regard to this matter, and at the present moment they had under consideration a proposal made to them by the Lineff Company, whose system could be seen at work at Chiswick. He had seen it at work there, and, as far as he could judge from a non-scientific point of view it was simplicity itself, but it was a question whether a system that worked well in a yard or a siding of 90, 100, or 150 feet would be equally satisfactory when in practical working on an ordinary road and where the conditions would not be quite so favourable. That was a matter that had yet to be decided, but he might tell them that they had had certain proposals made to them, and he had just had placed in his hands a telegram from the Chairman of the syndicate to which he had referred the willingness to lay down in Paris on a part to be decided between them, an experimental line of one, two, or three miles in length as might be arranged, and to incur every expense which might be necessary for such an undertaking at a price of so much per mile, run with a guarantee of a certain mileage per day. Of course they must guarantee such a minimum mileage giving a certain fixed income or otherwise it would not be worth while for an electric traction company to undertake the work. They had given the most serious consideration to some half a-dozen systems, and he might say that their line in Paris was at the present time being inspected with a view to electrical traction, but he wanted to point out that in adopting any system it would be only adopted on the grounds that this Company would undertake no expense in the matter, and that they would undertake no risk, but all must devolve upon the Electric Company, who must be willing to guarantee this Company against all claims that might be made either by the city authorities or by other people. He repeated that they would only undertake an experimental working of electricity upon their system upon a basis of arrangement freeing them from all expense and from all risk or loss."

**ELMORE COPPER.—A CHALLENGE.**—Considerable correspondence has appeared in some of our financial contemporaries regarding the Elmore process of copper deposition. The correspondence itself has not been of a particularly edifying character, consisting chiefly of *tu quoque* arguments, but we think the challenge contained in Mr. William Elmore's letter in the *Financial Times* of Wednesday may probably clear the atmosphere. After referring to the letter of Mr. Alexander Watt in our contemporary, in which the Elmore process is stated to be at least unreliable and incapable of standing a severe test, Mr. Elmore proceeds :—"I am willing to deposit with any approved bank or person the sum of £500 provided Mr. Watt or any champion of his does the same, and I will undertake to make an Elmore tube under the supervision of any well-known expert ; and I will forfeit this sum to Mr. Watt, or to a recognised charity, if this tube shows any sign of foliation or lamination even when subjected not only to a 'moderate heat,' but to a temperature up to the point of fusion—Mr. Watt to likewise forfeit the same sum in the event of his contention being proved wrong. As a matter of fact, by the Elmore burnishing process the copper is made perfectly homogeneous, but, by a modification of conditions, the copper may be deposited in superposed layers upon one mandrel, and it may be laminated to any extent at will. We take advantage of this latter fact in our patented process for the manufacture of copper sheets."

**THE FRENCH SUBMARINE TELEGRAPH COMPANY.**—Continental papers contain the prospectus of an issue of 7,100,000fr., in 14,200 bonds of 500fr. each (say, £284,000), of the French Submarine Telegraph Company (Société Francaise des Télégraphes Sous-Marins). The capital of this Company is 11,000,000fr. (say, £440,000). The present issue of bonds, which bear 5 per cent. interest, is made by the principal French banks at the price of 97½ per cent., and subscriptions are invited for Saturday, May 9th next. The prospectus states that this new issue of bonds is for the purpose of finishing the last section of the system of 6,754 kilometres, for which the Company are the concessionaires. The completion of the system is to be carried on by the Société Générale des Téléphones.

**ORIENTAL TELEPHONE COMPANY (LIMITED).**—Under the heading "A Nice Point in Company Law," *The Statist* of Saturday last contained an interesting article on the case recently before Mr. Justice Kekewich, a report of which appeared in our last issue.

**STOCK EXCHANGE.**—The Committee have appointed Tuesday, May 5th, a special settling day in the National Telephone Company (Limited), provisional certificates for £350,000 Four and a-Half per Cent. Debenture Stock ; and have ordered these securities, and Six per Cent. Preference Shares, Nos. 63,417 to 69,995, and Ordinary Shares, Nos. 63,417 to 77,978, of the Brush Electrical Engineering Company (Limited), to be quoted in the official list.

**SUBMARINE CABLES TRUST.**—Notice is given that on and after May 15th a payment of £1 will be made on account of the coupon due on the 15th inst. by Messrs. Glyn, Mills and Co., of Lombard-street, between the hours of 10 a.m. and 2 p.m. The coupons should be left with the bankers for examination four clear days before payment. They will be stamped with the words "£1 paid," and returned to the holders. Due notice will be given when the trustees have sufficient money in hand to pay the balance of £2 per coupon.

**SWAN UNITED ELECTRIC LIGHT COMPANY.**—The Directors of this Company have resolved to pay an ad-interim dividend at the rate of 6 per cent. per annum for the half-year ended March 31, 1891, to be distributed in accordance with the articles of association. The dividend will be paid upon the register as it stood on April 28th, and the dividend warrants will be issued on May 21st.

**WESTERN AND BRAZILIAN TELEGRAPH COMPANY.**—The traffic receipts of this Company for the week ended April 24, 1891, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £4,726.

PATENT
SILICIUM BRONZE AND SILICIUM COPPER WIRE.
The best for overhead Telephone and Telegraph Lines,
AND ALL ELECTRICAL PURPOSES.
Hard Drawn High Conductivity Copper Wire.
ROLLED AND DRAWN PHOSPHOR BRONZE.
PHOSPHOR BRONZE VULCAN PHOSPHOR DURO METAL
PHOSPHOR BRONZE BEARINGS, BUSHES, AND OTHER PARTS OF ELECTRICAL MACHINERY
SOLE PROPRIETORS of the British, Indian and Colonial Patents,
THE PHOSPHOR BRONZE COMPANY (Limited),
87, Sumner Street, Southwark, London, S.E.
WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

Digitized by Google

# COMPANIES' SHARE LIST.

| Present Amount. | Amount of Share. | Last Dividend. | Name. | Previous Week's Price, April 22. | | Price Wednesday, April 29. | | Rate per Cent. Yielded £ s. d. | Dividend Due. | Business Done During Week Ending April 29 Highest. | Lowest. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **TELEGRAPHS.** | | | | | | | | |
| £1,381,38( | Stock | 15/0 | Anglo-American ....xd | 47 | 48 | 46½ | 47½ | 5 19 0 | Jan., Apr., July, Oct | 48 | 46½ |
| £2 809,31( | Stock | £0/) | Do. Preferred ....xd | 84½ | 85½ | 84 | 86 | 6 15 4 | " " | 86 | 84½ |
| £2 809,31( | Stock | .. | Do. Deferred .... | 11 | 11½ | 11½ | 12 | .. | .. | 11⅞ | 11 7/16 |
| £250,000 | 100 | 4% | African Direct, Telegraph 4% Debentures .... | 9) | 102 | 99 | 102 | 3 18 5 | January and July .. | 101 | .. |
| 130,000 | £10 | 3/0 | Brazilian Submarine .... | 11½ | 12 | 11½ | 12 | 6 5 0 | Mar., June, Oct., Dec. | 11⅞ | 11½ |
| £84,500 | £100 | 5% | Do. 5 per Cent. Bonds .... | 100 | 103 | 101 | 104 | 4 16 2 | January and July .. | .. | .. |
| £75,000 | £100 | 5% | Do. 5 per Cent. Bonds (2nd Series, 1906).... | 103 | 107 | 104 | 108 | 4 12 7 | June and December | .. | .. |
| $7,216,000 | $100 | 7% | Commercial Cable Capital Stock .... | 108 | 110 | 108 | 110 | 6 7 3 | April and October .. | .. | .. |
| 16,000 | 10 | 8/0 | Cuba Submarine .... | 10½ | 11½ | 10½ | 11½ | 6 19 2 | February and August | .. | .. |
| 6,000 | 10 | 10% | Do. Preference 10% .... | 16½ | 17½ | 16½ | 17½ | 5 14 3 | " " | 16 13/16 | 16½ |
| 12,931 | 5 | 2/4½ | Direct Spanish (£4 paid) .... | 3¾ | 4¼ | 3¾ | 4¼ | 6 11 9 | April and October.. | 4 | .. |
| 6,000 | 5 | 10% | Do. Preference 10% .... | 9 | 10 | 9 | 10 | 5 0 0 | " " | .. | .. |
| 60,710 | 20 | 8/6 | Direct United States ....xd | 10½ | 10⅞ | 10 | 10½ | 6 16 7 | Jan., Apr., July, Oct | .. | .. |
| 4 ,,000 | 10 | 2/6 | Eastern .... | 14½ | 14⅞ | 14½ | 14¾ | 4 9 8 | " " | 14 7/16 | 14½ |
| 70,000 | 10 | 6% | Do. 6 per Cent. Preference .... | 15½ | 15¾ | 15½ | 15¾ | 3 16 2 | " " | 15½ | .. |
| £1,2 ,,, | Stock | 4% | Do. 4 per Cent. Mort. Debenture Stock.. xd | 108 | 111 | 106 | 1'9 | 3 13 5 | May and November | 109 | 1 8 |
| £200,000 | 100 | 5% | Do. 5 per Cent Debentures, 1899 .... | 107 | 110 | 107 | 110 | 4 10 11 | February & August | .. | .. |
| 250,000 | 10 | 2/6 | Eastern Extension ....xd and Bonus | 14¾ | 15¼ | 14¾ | 15¼ | 4 13 4 | Jan., Apr., July, Oct. | 15½ | 14¾ |
| £320,000 | £100 | 4% | Do. 4 per Cent. Debenture Stock .... | 105 | 108 | 105 | 108 | 3 14 1 | .. | .. | .. |
| £91,800 | 100 | 5% | Do. 5 p. c. (Austin. Gov. Sub.) Debs. 1900 .... | 103 | 106 | 103 | 106 | 4 14 4 | January and July .. | .. | .. |
| £145,300 | 100 | 5% | Eastern & S. African 5 per Cent. Mor. Deb., 1900.. | 103 | 106 | 103 | 106 | 4 14 4 | " " | .. | .. |
| 180,227 | 10 | 1/9 | Globe Telegraph and Trust .... | 9½ | 9⅝ | 9½ | 9¾ | 5 9 4 | Jan., Apr., July, Oct. | 9⅝ | 9½ |
| 180,042 | 10 | 6% | Do. 6 per Cent. Preference .... | 14⅝ | 15 | 14½ | 15¼ | 3 19 4 | " " | 15 1/16 | .. |
| 150,000 | 10 | 7/2 | Great Northern ....xd | 17½ | 18 | 17¾ | 18¼ | 4 13 2 | Jan., April, and July | 18 | 17¾ |
| £15,000 | 100 | 5% | Do. 5 per Cent. Debentures, 1881 .... | .. | | .. | | .. | January and July .. | .. | .. |
| £,,,,,, | 100 | 5% | Do. 5 per Cent. Debentures, 1883 .... | 104 | 107 | 105 | 108 | 4 12 7 | March & September | .. | .. |
| 17,000 | 25 | .. | Indo-European.... | 41 | 43 | 42 | 44 | 5 13 8 | May and November | 43¾ | 42¾ |
| 38,348 | 10 | 2/6 | London Platino-Brazilian .... | 6½ | 7½ | 7 | 8 | 5 0 0 | " " | .. | .. |
| £100,000 | 100 | 6% | Do. 6 per Cent. Debentures .... | 105 | 108 | 106 | 109 | 5 10 1 | March & September | .. | .. |
| 9,000 | 8 | 4/0 | Reuter's .... | 9 | 9½ | 8¾ | 9½ | 5 8 8 | April and October.. | .. | .. |
| 3,381 | £100 Cert. | 6% | Submarine Cables Trust 6% ....x Oct. Coupon | 113 | 118 | 115 | 120 | 5 0 0 | " " | 117 | .. |
| 15,609 | 10 | 4/0 | West African Telegraph .... | 8 | 9 | 8 | 9 | 5 11 1 | January and July .. | .. | .. |
| £290,900 | 100 | 5% | Do. 5 per Cent. Debentures .... | 98 | 101 | 98 | 101 | 4 19 0 | March & September | .. | .. |
| 30,000 | 10 | 3/0 | West Coast of America .... | 2½ | 3½ | 3 | 4 | .. | January and July .. | 3½ | .. |
| £150,000 | 100 | 8% | Do. Debentures 8% 1902 .... | 92 | 97 | 94 | 99 | .. | June and December | 100 | .. |
| 88,321 | 10 | 9d. | West India and Panama .... | 2¾ | 3 | 3⅜ | 3⅝ | .. | .. | 3 5/16 | 3½ |
| 34,563 | 10 | 6/0 | Do. 1st Preference 6% .... | 11½ | 12 | 11¾ | 12¼ | 4 16 0 | May and November | 12⅜ | 11¾ |
| 4,669 | 10 | £3 | Do. 6 p. c. 2nd Pref.... | 11½ | 12½ | 11½ | 12½ | 4 16 0 | " " | .. | .. |
| 64,174 | 15 | 6/0 | Western and Brazilian .... | 12 | 12½ | 12½ | 13 | 4 13 0 | " " | 13 | 12⅝ |
| 27,873 | 7½ | 6/0 | Do. 5 per Cent. Cumulative Preferred .... | 6¾ | 7½ | 6¾ | 7½ | 5 4 2 | – | 7 1/16 | 6¾ |
| 27,873 | 7½ | 4/6 | Do. 5 per Cent. Deferred .... | 5½ | 5¾ | 5½ | 6 | .. | .. | 5 13/16 | 5 9/16 |
| £300,000 | 100 | 6% | Do. 6 per Cent. Debs., Series "A" 1910 .... | 103 | 106 | 103 | 106 | 5 13 2 | February & August | .. | .. |
| £250,000 | 100 | 6% | Do. 6 per Cent. Mort. Debs., Series "B" 1910 | 103 | 106 | 103 | 106 | 5 13 2 | " " | .. | .. |
| $1,830,000 | $1,000 | 7% | Western Union 7 per Cent. 1st Mortgage .... | 120 | 125 | 120 | 125 | 5 12 0 | May and November | .. | .. |
| £175,100 | £100 | 6% | Do, 6 per Cent. Sterling Bonds .... | 100 | 104 | 100 | 104 | 5 15 5 | March & September | .. | .. |
| | | | **TELEPHONES.** | | | | | | | | |
| 224,850 | 14/0 | 0/4½ | Consolidated Telephone Const. & Maintenance. .. | 7/16 | 9/16 | 7/16 | 9/16 | .. | May and November | .. | .. |
| 220,000 | £1 | 3½% | Oriental (11s. paid) ....xd | ½ | ⅝ | ½ | ⅝ | 5 2 11 | Yearly .... | .. | .. |
| 438,984 | 5 | 2/6 | National .... | 4½ | 4¾ | 4½ | 4¾ | 6 2 3 | June and December | 4 7/16 | 4½ |
| 15,000 | 10 | 6/0 | Do. 6 per Cent. Cumulative 1st Pref. .... | 13 | 13½ | 13 | 13½ | 4 8 11 | " " | 13 | .. |
| 15,000 | 10 | 4/9¾ | Do. 6 per Cent. Cumulative 2nd Pref (£8 pd) .. | 10 | 10½ | 10 | 10½ | 4 11 7 | " " | .. | .. |
| .. | .. | .. | Do. Debentures 4½% Prov. Cert. (fully paid).. | .. | | 102 | 104 | 4 6 7 | " " | .. | .. |
| 10 ,750 | 1 | ½% | South of England, Ordinary .... | ⅛ | ¼ | ⅛ | ¼ | .. | .. | 103½ | 103 |
| 2 ,000 | 5 | 2/1 | Do. 6 per Cent. Cumulative Pf. (£3 10s. pd).. | 3 | 3½ | 3 | 3½ | .. | – | .. | .. |
| 58,000 | 5 | 1/0 | United River Plate .... | 2½ | 3½ | 2½ | 3½ | .. | January and July .. | .. | .. |
| £146,128 | Stock | 5% | Do. 5 per Cent. Debenture Stock .... | 85 | 95 | 85 | 95 | 5 5 3 | .. | .. | .. |
| £3,,,, | 100 | 7% | Do. 7 per Cent. Debentures .... | .. | | .. | | .. | – | .. | .. |
| | | | **ELECTRICITY SUPPLY COMPANIES.** | | | | | | | | |
| 1,000 | £50 | .. | City of London Electric Lighting Shares (£25 pd).. | 27 | 29 | 32 | 31 | .. | .. | .. | .. |
| 19,900 | £5 | .. | Electricity Supply Co. of Spain .... | 4½ | 5 | 4½ | 5 | .. | .. | .. | .. |
| 5,322 | £5 | .. | House to House Electric .... | 4¾ | 5½ | 4¾ | 5½ | .. | .. | .. | .. |
| 30,000 | £5 | 3½% | Liverpool Electric Supply (£3 paid) .... | 2½ | 2⅞ | 2⅝ | 2⅞ | 3 13 1 | .. | .. | .. |
| 111,060 | 5 | .. | London Electric Supply .... | 2½ | 2¾ | 2½ | 2⅞ | .. | .. | .. | .. |
| 43,900 | 10/0 | 2/0 | Metropolitan Electric Supply (£9 paid) .... xd | 9 | 9½ | 9 | 9½ | 4 5 4 | – | 9⅝ | 9⅜ |
| 7,730 | £5 | .. | St. James' and Pall Mall .... | 6 | 6½ | 5¾ | 6½ | – | – | .. | .. |
| .. | .. | .. | Do. 7% Preference .... | .. | prem. | ⅝ | ⅞ | .. | – | .. | .. |
| 42,853 | 5 | .. | Westminster Electric Supply (£4 paid) .... | 4¾ | 5½ | 4¾ | 5½ | .. | .. | 5 1/16 | 4 11/16 |
| | | | **ELECTRIC MANUFACTURING, &c., COMPANIES.** | | | | | | | | |
| 63,416 | 3 | .. | Brush Electrical Engineering.... | 2½ | 2¾ | 2⅝ | 2⅞ | .. | .. | 2 9/16 | 2⅝ |
| 63,416 | 2 | 1/1 | Do. 6 per Cent. Preference .... | 1⅝ | 1⅞ | 1⅝ | 1⅞ | 6 8 0 | June and December | .. | .. |
| 20,000 | 5 | 3/6 | Crompton and Co., 7 per Cent. Pref. Shares .... | 4½ | 5½ | 4 | 5 | 7 0 0 | January and July .. | .. | .. |
| 17,130 | 5 | 15% 1890 | Edison and Swan United .... | .. | | .. | | .. | .. | .. | .. |
| 45,000 | 10 | 6% | Electric Construction .... | 5 | 6 | 5 | 6 | .. | – | .. | .. |
| 70,000 | 2 | 10/0 | Elmore's Patent Copper Depositing .... | 2¾ | 3½ | 2¾ | 3½ | .. | – | .. | .. |
| 20,000 | 5 | .. | Fowler-Waring Cables (£4 paid).... | 2½ | 3½ | 2½ | 3½ | .. | – | 2¾ | .. |
| 41,600 | 10 | 10/0 | India Rubber, Gutta Percha & Telegraph Works.. | 18¾ | 19¾ | 18½ | 19¾ | 5 2 7 | February & August | 19½ | 18¾ |
| £200,000 | 100 | 4½% | Do. 4½ per Cent. Debentures, 1896 .... | 102 | 104 | 102 | 104 | 4 6 7 | March & September | .. | .. |
| 11,334 | £10 | 6/1 | International Okonite Limited Ordinary .... | 7½ | 8½ | 7½ | 8½ | 11 15 3 | .. | .. | .. |
| 11,334 | £10 | 5/0 | Do. Preference .... | 9½ | 9¾ | 9½ | 9¾ | 8 4 1 | .. | .. | .. |
| 78,949 | 5 | 4/10½ | Swan United (£3. 10s. paid) .... | 4¾ | 5½ | 4¾ | 5½ | 6 13 4 | May and November | 4 13/16 | 4¾ |
| 37,350 | 12 | 36 0 | Telegraph Construction and Maintenance.... | 45 | 47 | 45 | 47 | 5 0 0 | March and July..... | 46½ | 45½ |
| £150,000 | 100 | 5% | Do. 5 per Cent. Bonds, red. 1894 .... | 102 | 105 | 102 | 105 | 4 15 3 | January and July . | .. | .. |
| .. | £5 | .. | Woodhouse and Rawson Ordinary £2. 10s. .... | 2¼ | 2¾ | 2⅝ | 2⅞ | .. | .. | .. | .. |
| – | £5 | .. | Do. Preference .... | 3½ | 4½ | 3⅝ | 4⅛ | .. | .. | .. | .. |
| | | | **RAILWAYS.** | | | | | | | | |
| 5),000 | £10 | .. | City and South London Railway .... | 5½ | 6½ | 5½ | 6½ | .. | .. | .. | .. |


# THE NON-CONDUCTOR OF ELECTRICITY.

WAREHOUSE.

## VULCANISED FIBRE,

PATENTED.

This new material is supplied in two qualities, Flexible and Hard.

The FLEXIBLE is a substitute for Leather, Rubber, Gutta Percha, &c., and is extensively used by Brass Founders, Axle Makers, Hydraulic, Sanitary, and other Engineers, Pump Makers, Carriage Builders, &c.

It makes the best Hot and Cold Water Packings, and for Axle Washers of all kinds it is unequalled.

The HARD is a substitute for Metals, Hard Wood, Ivory, Vulcanite, Ebonite, &c., and is a good Insulator.

Sold in sheets, 5ft. 6in. by 3ft. 6in., varying in thickness from 1-50in. to 1in.

FACTORY.

FLEXIBLE, 2/- per lb.; HARD, 2/3 per lb.

**MOSSES & MITCHELL.** 70, Chiswell-st., London. E.C.


Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

Princeton University Library
32101 050973591

Digitized by Google